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Learning Disabilities

Neurobiology, Assessment, Clinical Features and Treatments

Edited by Sandro Misciagna

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Contributors
Enoch Leung, Hagit Friedman, Marina Jodra, Alok Sharma, Nandini Gokulchandran, Hemangi Sane, Sakshi Desai, Pooja Kulkarni, Prerna Badhe, Rajendra Kunwar, Radhika Mohan, Takeo Kubota, Isaías Martín- Ruiz, Maria-Jose Gonzalez-Valenzuela, Mourad Ali Eissa Saad, Vinutha U. Muktamath, Priya R. Hegde, Samreen Chand, Sambhu Prasad, Rajesh Sagar, Argnue Chitiyo, Saad Salman, Fahad Hassan Shah, Song Ja Kim, Laiba Zakir, Aqsa Ehsan, Sohail Riaz, Muhammad Sulaiman, Dale H. Schunk, Maria K. DiBenedetto, Charles Potter, Audhild Løhre, Rogayah Razak, Xing Lin Loke, Mohd Azmarul A.Aziz, Ayodeji Olayemi Obafemi, Nadia Rousseau, Michelle Dumont, Carl Beaudoin, Aya Adel, Marwa Mahmoud Saleh, Sandro Misciagna

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Meet the editor

Dr. Sandro Misciagna received degrees in Medicine and Neurology from Catholic University, Rome, in 1995 and 1999, respectively. From 1993 to 1995, he was involved in researching cerebellar functions. From 1994 to 2003, he worked in the Neuropsychological Department, researching cognitive and behavioural disorders of the same university. From 2001 to 2003, he taught neuropsychology, neurology, and cognitive rehabilitation. In 2003, he obtained a Ph.D. in Neuroscience with a thesis about the behavioural and cognitive profile of frontotemporal dementia. Dr. Misciagna has worked in various neurology departments, Alzheimer's clinics, neuropsychiatric clinics, and neuro-rehabilitative departments. Since 2016, he has worked at the Neuroscience Department of Belcolle Hospital, Viterbo, dealing with the diagnosis and treatment of epilepsy.

Contents

Preface

Learning disabilities are heterogeneous conditions characterized by failure to acquire, retrieve, and use information competently. Definitions and classifications of learning disabilities remain in a state of evolution. The most common forms of learning disorders involve verbal functions such as difficulties in listening, speaking, reading comprehension, and written expression (dyslexia and dysgraphia). More uncommon are nonverbal learning disabilities such as disabilities in arithmetic calculation or mathematics reasoning (dyscalculia). This book is organized into four sections that discuss neurobiology, assessment, clinical features, and treatment of learning disabilities.

The first section of the book consists of three chapters covering the definition, classification, and etiological hypothesis of learning disabilities.

Chapter 1 by Mutktamath et al. describes historical research about learning disabilities, beginning with studies on brain-injured children conducted in Germany. The authors explain the concept of learning disorder as a neurodevelopmental disorder whose origin includes the interaction of genetic, epigenetic, and environmental factors. They debate diagnostic criteria and classification of specific learning disabilities, suggesting that they represent not a single category of disability but rather a general category composed of disabilities in different cognitive domains.

Chapter 2 by Kubota presents a biological hypothesis about neurodevelopmental disorders such as autism, ADHD, and learning disabilities. The author suggests that these disorders could be explained by social and biological factors. Mutations in genes encoding molecules that facilitate communications between neuronal cells play a crucial role. In addition to intrinsic epigenetic deficits, the author examines extrinsic environmental factors such as malnutrition, drug use, and mental stress during the neonatal period.

Chapter 3 by Schunk regards the roles of self-regulation and self-efficacy in learning disabilities. Self-regulation consists of self-generated cognitions, while self-efficacy refers to capabilities to learn and perform actions. The author exposes social cognitive theories according to which individual function is based on reciprocal interactions between personal, behavioural, and environmental factors that are reciprocally influenced.

The second section of the book consists of four chapters about the assessment of children with learning and behavioural disorders.

Chapter 4 by Misciagna is about neuropsychological assessment. The author explains how understanding of cognitive and mental problems of children with learning disorders is an interesting challenge and discusses the various approaches that have been applied for their study, including medical, genetic, educational, epidemiologic, and experimental psychology methods. The chapter provides a descriptive review of a specialized neuropsychological approach for the assessment of learning disabilities.

Chapter 5 by Leung focuses on correlations between learning disabilities and other identities in a program conducted in schools. The author describes an approach to identifying students with learning disorders, taking account of social and cultural factors, since cultural and linguistic features influence the processes of learning.

Chapter 6 by Salman et al. discusses psychological assessment. The authors present a study evaluating the psychosocial and clinical features that can predict suicide attempts in adolescents with major depression within 28 weeks of follow-up. They selected 15 clinical trials and conducted a meta-analysis of 1211 adolescents with major depressive disorders. They analysed patients' suicidal thoughts and behaviours using different psychiatric tools. The major causes of suicide among participants were identified as lost friends, drug abuse, living alone, sexual abuse, and other related problems.

Chapter 7 by Mohan discusses counselling techniques. According to the author, families play a crucial role in children's development and the approach to them must be based on resilience which is the ability of individuals to bounce back from adversity through psychological, social, cultural and physical resources.

This concept is explored in the context of Indian society where the research was conducted. The author presents real-life case studies of difficult situations involving physical, financial, and emotional aspects.

The third section of the book consists of eight chapters about clinical features of learning and neurodevelopmental disorders.

Chapter 8 by Prasad is a brief review of dyslexia, a specific learning disability characterized by difficulty in reading, fluent word recognition, spelling, and deficits in phonological processing. The author presents definitions, diagnostic criteria, and characteristics of dyslexia according to the *International Classification of Diseases* (ICD-10) and *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5) in studies conducted mainly in Asian countries.

Chapter 9 by Adel and Saleh examines characteristics of phonological deficits in developmental dyslexia, which is a learning disorder characterized by specific deficits in reading acquisition in absence of intelligence deficits or neurological damages. The authors discuss the classification of phonological errors as errors of phoneme sequence (assimilation, migration, metathesis, deletion, insertion) or errors of identity (substitutions), giving examples of common errors in dyslexic children.

Chapter 10 by Valenzuela and Martin-Ruiz is a review of the neuropsychological approach to dyslexia. The authors discuss controversies about dyslexia definitions proposed by scientific societies. They describe major clinical and cognitive-linguistic manifestations of dyslexia according to two types of patterns: "phonological dyslexia" and "visual dyslexia."

Chapter 11 by Razak et al. considers dyslexia in Malaysia, which affects about 13% of primary school children in the country. The authors describe research conducted in Malay children with dyslexia using neuropsychological tests. They demonstrate that performances are poorer in grammatical understanding and sentence repetition tests as well verbal short memory and phonological memory tests.

Chapter 12 by Potter discusses dyslexia, dysgraphia, and dyscalculia with an evidence-based approach. The author discusses past classifications based on the interrelationship between a wide range of variables. The author categorizes possible types of learning disabilities in dyslexia, auditory processing problems, language processing problems, reading comprehension deficits, dysgraphia, visual perceptual and visual motor deficits, non-verbal learning deficits, and dyscalculia.

Chapter 13 by Kunwar is about dyscalculia, a learning disorder present in 3–7 percent of school-age children. The author speaks about the meaning of the term "dyscalculia" and describes the possible problems in children with dyscalculia, such as verbal, lexical, graphical, ideognostical, semantic, and memory problems, as well as difficulties with core numbers, reasoning, or visuo-spatial abilities.

Chapter 14 by Lohre is about attentional deficits in learning disabilities. The author discusses empirical and theoretical questions and explains that attention is a cognitive function that makes an organism receptive to an external stimulus. Executive functions that consist in an overlap of sub-functions, such as the ability to register information, allocate attentional resources to a specific task, maintain attention on some aspect of the environment for an interval of time, and flexibility in changing from one idea or activity to another, all depend on the ability to pay attention.

Chapter 15 by Friedman covers autism spectrum disorders (ASDs), which are neurodevelopmental disorders characterized by impairment in social interactions, motor abilities, and psycho-behavioural abilities. The author presents a hypothesis about the pathogenesis of ASD, highlighting the importance of biological factors (synapse formation, genetic factors), environmental factors (social communication, emotional and cognitive functions), and other causes (drug use, neurodegeneration, infections).

The fourth and last section of the book consists of six chapters that review treatment strategies for children with learning and emotional disorders.

Chapter 16 by Chitiyo is about evidence-based strategies in learning disabilities, particularly reading difficulties. The author describes common evidence-based strategies and interventions to improve cognitive abilities such as corrective reading (direct instructions to teach reading skills), concept mapping (creation of the visual organization in reading texts), use of direct instructions (an approach that breaks down learning into smaller steps), and peer-mediated instructional approaches (variation of instructions to solve problems).

Chapter 17 by Rousseau et al. concerns the use of assistive technologies (AT). The authors present their research in which they analyse the relationship between the use of AT in writing situations and academic self-perception and exam anxiety in French-speaking school students aged 12 to 13 years with dyslexia and dysorthographia. The study was based on the administration of standardized questionnaires and interview protocols. Results confirm the use of AT is associated with benefits in self-perception as well as feelings of self-efficacy.

Chapter 18 by Obafemi examines the use of smartwatch technologies in individuals with learning disorders. Many wearable and computer-based technologies are available such as jewellery, eyewear, or clothing such as shoes and jackets. The author describes a pilot study conducted on Nigerian students to demonstrate how wearable technologies can improve potential, promote equality of educational opportunities, and reduce social barriers.

Chapter 19 by Ali presents a model of a social approach to children with the neurodevelopmental condition known as attention-deficit/hyperactivity disorder (ADHD), which is characterized by motor hyperactivity, impulsivity, limited inhibitory control, and inability to focus, shift, and sustain attention. The author proposes Cassady and Justin's functional model for emotional information processing as a useful tool to observe, explain, and predict human response to different emotional scenarios in a study conducted on ten first-graders with ADHD.

Chapter 20 by Jodra considers educational intervention in ASDs. The author describes the characteristics of ASDs, placing special emphasis on difficulties observed in social skills. The author discusses intervention programs in the socio-emotional area in children with ASD on the basis of socioemotional competence assessment instruments. The author also describes strategies for teaching and improving socio-emotional competences in children with these disorders.

Chapter 21 by Sharma et al. is a review of the potential use of stem cell therapy in the treatment of learning disabilities. The authors describe experimental studies conducted on autism, intellectual disability, cerebral palsy, and other neurodevelopmental disorders. They discuss biological bases, ways of administration, and bases of the neuroprotective mechanism of action. They present a study of stem cell transplantation in a population of twenty patients presenting with learning disorders. Results showed an improvement of clinical status in about 95% of patients at follow-up at 26 months.

Sandro Misciagna
Neuroscienze Department,
Belcolle Hospital,
Viterbo, Italy

Section 1

Definition, Classification and Etiological Hypothesis

Chapter 1

Types of Specific Learning Disability

Vinutha U. Muktamath, Priya R. Hegde and Samreen Chand

Abstract

The chapter "Specific Learning Disability and its Types" is an effort to educate the readers, specially the educators about a developmental disorder that begins by school age, although it may not be recognized until later. It involves on-going problems learning key academic skills, including reading, writing, and math. The chapter makes an attempt to bring about understanding of SLD, brief historical perspective and its classification. The chapter elaborately discusses the seven types of specific learning disability according to Learning Disabilities Association of America. The chapter centers around seven learning disabilities namely, dyslexia, dysgraphia, dyscalculia, auditory processing disorder, language processing disorder, non-verbal learning disabilities, visual perceptual deficit; their causes and symptoms to give a holistic understanding about the disability for the teachers and parents to understand the individual differences.

Keywords: specific learning disability, dyslexia, dysgraphia, dyscalculia, auditory and language processing disorders, non-verbal and visual perceptual deficits

1. Introduction

Learning disabilities and Attention Deficit Hyperactivity Disorder (ADHD) has been the topic of study interest for more than 100 years. Over time, more and more people have become aware of these differences due to the brain research (1930–1960) that became the foundation of the field of learning disabilities.The terms such as brain-injured child was first used by Alfred Strauss and Laura Lehtinen. Although many researchers have contributed to the field, the seminal works of two important scientists are phenomenal even today. Adolf Kussmaul (1877), a German neurologist was the first to identify reading disability and coined the term "word blindness." He defines it as "complete text blindness … although the power of sight, the intellect, and the powers of speech are intact." Almost after 10 years after the term "word blindness" appeared, the term 'dyslexia' was used by Berlin (1887) to define reading challenges [1, 2].

The other influential researcher, who has made great contributions to the Learning Disability (LD) construct and develops understanding of the various issues related to LD was Pringle Morgan in the united Kingdom. The article by Pringle Morgan entitled "A Case of Congenital Word Blindness" (Morgan, 1896) in the British Medical Journal encouraged researchers and formed a basis for research to study other cases of LD to further explore studies on the definitions and identification tools of LD. Samuel A. Kirk was the first Psychologist to use the term "learning disability" in the year 1963 in Chicago at an education conference. ADHD first appeared in 1968 in the Diagnostic and Statistical Manual (DSM) as "hyper-kinetic impulse disorder." Ever since 2000, awareness and research of learning disabilities and ADHD issues has taken off and in the year 2013 DSM-5 broadened its definition of the term "specific learning disorder" [1, 2].

Learning disability is referred to as a hidden disability as children with learning disabilities do not look handicapped and their difficulties are not obvious. Hence, learning disabled children are often misunderstood and accused of not listening, being lazy or clumsy resulting in low self-esteem, confidence and motivation. So we can consider the child to be suffering with learning disability when he/she displays an educationally significant discrepancy between his/her estimated intellectual potential and actual school performance that cannot be explained in terms of intellectual potential. These children may have a combination of difficulties in speaking, listening, reading, comprehension, spelling, arithmetic calculations, writing and concepts. Children with a learning disability have average and sometimes above average intelligence.

LD is a neurodevelopmental disorder that are not due to hearing or vision problems, social-economic factors, cultural or linguistic differences, lack of motivation, insufficient or unsatisfactory instruction. It is due to the interaction of genetic, epigenetic, and environmental factors with a biological origin that affects the brain's ability to perceive and/or process verbal and non-verbal information efficiently and accurately.

Learning disabilities are multifaceted and go beyond the stereotypical perceptions of the disorder as simply reading difficulties, or letter problems. They differ significantly, both in terms of the meanings they impact and the rigorousness of the impact experienced. The proper accommodations depend upon the individual's strengths as well as his/her detailed difficult situations [3].

2. Difficulty in classifying the specific learning disabilities (SLD)

SLD is a clinical condition which is not always synonymous with "learning disabilities" as defined by the educational system: not all children with learning c deficits diagnosed by the school system would fit the definition for a DSM-5 clinical diagnosis of SLD [4].

Learning disabilities (LDs) are diagnosed using both educational and medical perspectives [5]. The most commonly used definition from an educational perspective, is found in the federal special education law, the Individuals with Disabilities Education Act (IDEA). Diagnostic and Statistical Manual for Mental Disorders (currently the DSM-5 and previously the DSM-IV) published by the American Psychiatric Association defines LD from the medical perspective [6]. A considerable overlap in the definition of LD used by professionals in educational and medical settings can be observed [5].

A specific learning disability is defined by the Individuals with Disabilities Education Act (IDEA) as a disorder in one or more of the basic psychological processes involved in understanding or using language, whether spoken or written, that manifests itself in the inability to listen, think, speak, read, write, spell, or perform mathematical calculations. Perceptual impairments, brain damage, mild brain dysfunction, dyslexia, and developing aphasia are all included in this category. It clearly establishes that specific learning disabilities are not primarily the result of visual, hearing, motor disabilities, mental retardation, emotional disturbance, or of environmental, cultural, or economic disadvantage [7].

3. DSM-5 diagnostic criteria for specific learning disabilities

SLD is a form of Neurodevelopmental Disorder, according to the DSM-5, that inhibits the ability to learn or apply specific academic abilities (e.g., reading, writing, or arithmetic), which are the foundations for all other academic learning. Difficulties in learning are "unexpected," although the rest of the child's development appears to be normal. Though early indicators of learning impairments (such as trouble learning letters or counting items) may occur in preschool, they can only be diagnosed reliably after formal education begins. The way the SLD manifests clearly implies that it typically persists into adulthood and is understood to be a cross-cultural and chronic condition albeit with cultural differences and developmental changes in children [8].

According to DSM-5, the diagnosis of a specific learning disorder includes the following symptoms:

1. During formal years at school, persistent difficulties in reading, writing, arithmetic, or mathematical reasoning skills can be identified by symptoms such as inaccurate or slow and effortful reading, poor written expression, difficulties remembering number facts, or inaccurate mathematical reasoning.

2. Current academic abilities must fall far short of the typical range of scores on linguistically and culturally relevant reading, writing, and arithmetic examinations. As a result, a dyslexic person must read with significant effort and not in the same way that a regular reader does.

3. Learning problems originate in the early years of schooling.

4. The individual's difficulties must markedly impair academic success, occupational performance, or daily activities, and they must not be explained by developmental, neurological, sensory (vision or hearing), or motor disorders [6].

In both basic research and clinical practice, categorical classification schemes are applied to select groups of children for further study or clinical intervention. DSM does not limit the diagnosis to reading, math, or written expression but more generally describes problems in achieved academic skills with the potential for specification of the more traditional areas by taking a different approach to LDs by broadening the category into a single overall diagnosis [6]. Diagnosis of SLD according to DSM-V is made based on a clinical review of an individual's history, teacher reports and academic records, and responses to interventions. To categorize the child in LD group, difficulties must be persistent, scores must be well below the range on appropriate measures, and the problems could not be better explained by other disorders. The interference in achievement, occupation, or activities of daily living must be significantly present [9].

4. Classification of learning disorder

Learning difficulties are classified at multiple levels, including categorizing children as LD, usually achieving, or mentally inferior, and within LD, as reading versus math impaired. LD is distinguished from types of low achievement that are expected due to emotional disturbance, social or cultural disadvantage, or inadequate instruction, and is identified as a particular type of "unexpected" low achievement across classes of presumed childhood conditions that produce underachievement [10].

LD is rarely conceptualized as a single disability in any federal or non-federal classification; rather, it is represented as a broad category that includes difficulties in any one or a combination of academic disciplines. The federal definition of 1968 specifies seven domains: (1) listening; (2) speaking; (3) basic reading (decoding and word recognition); (4) reading comprehension; (5) arithmetic calculation; (6) mathematics reasoning; and (7) written expression. The inclusion of these seven aspects of impairment in the federal classification assures that the LD category encompasses a wide range of learning issues and that the very diverse learning problems should be grouped together. Even today, many studies simply label groups of students as "learning disabled," despite mounting evidence that LD correlates with poor reading, math, and other subjects [9].

5. Types of learning disability

Many mental health professionals, including the Learning Impairments Association of America, consider the seven disorders listed below to be unique learning disabilities. They identify Autism Spectrum Disorder (ASD) and Attention Deficit Hyperactivity Disorder (ADHD) as related but distinct learning disorders that impact learning [6].

1. Dyslexia

2. Dysgraphia

3. Dyscalculia

4. Auditory processing disorder

5. Language processing disorder

6. Nonverbal learning disabilities

7. Visual perceptual/visual motor deficit

5.1 Dyslexia

Dyslexia (also known as reading disability) a specific learning disability that affects reading and related language-based processing skills is the most common learning disability accounting for at least 80 per cent of all LDs. It can affect reading fluency; decoding, reading comprehension, recall, writing, spelling, and sometimes speech and can exist along with other related disorders. However, the severity can differ in each individual and dyslexia sometimes is referred to as a Language-Based Learning Disability.

The word "dyslexia" is of Greek origin, meaning "impaired". Lyon et.al (2003) defined dyslexia as a SLD that is neurobiological in origin and characterized by difficulties with inaccurate word recognition and poor spelling and decoding abilities. These difficulties typically result from a deficit in the phonological component of language" [10].

Reading impairments are thought to be caused by phonological processing problems, according to study (i.e., processing the sounds of speech). Individuals with reading impairments frequently struggle to decode words into separate sounds and/or blend sounds together in order to read words fast and properly. These decoding issues frequently lead to reading comprehension issues [10]. During reading, Magnetic resonance imaging (fMRI) reveals a different brain activation profile confirming the etiology of Dyslexia to be neurological and genetic causes. The left side of the brain is activated by three systems: an anterior system in the left inferior frontal region that affects phoneme production (articulating words silently or out loud), a left parietotemporal system that analyses the written word, and a left occipitotemporal system that performs automatic word recognition. Dyslexic youngsters, on the other hand, show decreased activation in both posterior systems (left temporoparietal, left occipitotemporal), as well as increased activity in the left inferior frontal gyrus, right temporal, and tempoparietal regions. As a result, individuals continue to struggle to read unexpected words because they rely more heavily on right-sided posterior brain regions to read via memorization rather than sound–symbol links.

According to research, RD is highly familial and heritable. Up to 50% of children with RD have the disorder, and 50% of siblings of a child with RD have it as well. Twin studies have revealed strong concordance rates for RD, indicating that genetic variables account for 69 to 87 percent of the prevalence while environmental factors account for 13 to 30 percent.

5.1.1 Dyslexia symptoms in preschoolers

- Delayed speech, problems with pronunciation.
- Problems with rhyming words and learning rhymes.
- Difficulty with learning shapes, colors and how to write their own name.
- Difficulty with retelling a story in the right order of events.
- Lack of interest in playing games with language sounds (e.g., repetition, rhyming)
- Failure to recognize letters in their own name
- Trouble remembering names of letters, numbers, or days of the week [11–13].

5.1.2 Symptoms of dyslexia in school going kids

5.1.2.1 Early graders

- Reading well below the expected level for age
- Problems remembering the sequences
- Difficulty in seeing similarities and differences in letters and words
- Difficulty in spelling words
- Receives reports of “not doing well in school”

	Word level	Sentence level
Normal reader	Reading	It is easy to read this sentence
Reader with dyslexia	Reabing	If is easy to reab fhis senfence

Table 1.
Reader with dyslexia [17].

- Unable to read one-syllable words, such as “mat” or “top”
- Problems in connecting sounds and letters (e.g., “big” for “got”)
- Difficulty in sequencing numbers and letters [11–13].

5.1.3 Senior graders

- When writing, frequently mistakes letters such as ‘d’ and ‘b’ or’m’ with ‘w’ **Table 1**.
- Writes words backwards the majority of the time, such as writing ‘pit’ when the word ‘tip’ was intended.
- Grammar issues, such as acquiring prefixes and suffixes.
- Avoids reading aloud in class and reading-related activities
- Requires lot of effort to reads single words and connected text
- Has trouble pronouncing multisyllable words
- Needs repeated reading to understand it on a regular basis [11–13].

5.1.4 Assessment tools

The reading subtests useful are

- Woodcock-Johnson Psycho-Educational Battery- Revised, and
- The Peabody Individual Achievement Test-Revised
- Test of Word Reading Efficiency (TOWRE);

5.2 Dysgraphia

Dysgraphia is a specific learning disability diagnosed in childhood that affects a person’s handwriting ability and fine motor skills. It is characterized by poor writing skills that are significantly below for the child’s age, intelligence, and education, and cause problems with the child’s academic success or other important areas of life. Dysgraphia is also sometimes referred as spelling disorder and spelling dyslexia. Problems may include illegible handwriting, inconsistent spacing, and poor spatial.

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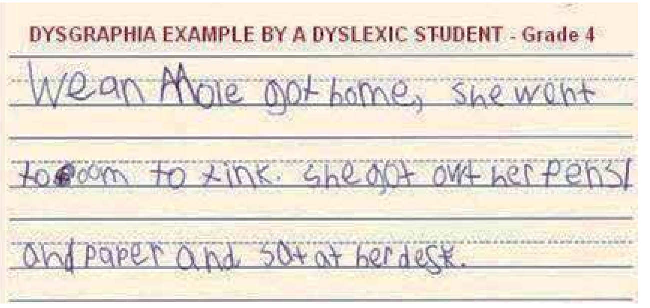

Figure 1.
Dysdraphia example by a dyslexic student [17].

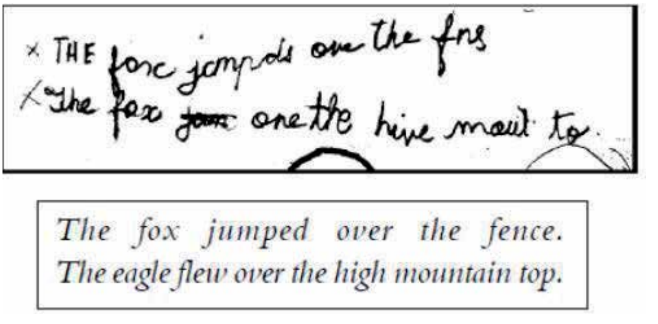

Figure 2.
Sample writing of Dysgraphic child [17].

planning on paper, poor spelling, and errors in grammar, punctuation, and poor handwriting. The children find difficulty composing writing as well as thinking and writing at the same time. This is linked to problems with visual-motor integration or fine motor skills.

Writing skills include both transcription and composition (text generation). Neuropsychological factors like difficulties in any one area (e.g., transcription, listening or reading comprehension, working memory) can delay skill development and efficient functioning in another. Research also throws light on role of genetics through twin studies and molecular genetic studies (**Figures 1** and **2**) [14–16].

5.2.1 Dysgraphia symptoms in children

- Avoiding written work
- Producing only a few words or sentences at a time when other pupils are completing many paragraphs
- Excessive difficulties in composing a text (output failure)
- Numerous technical faults of punctuation, grammar, word usage, sentence structure, and paragraph structure is observed
- Omitting words frequently in sentences or unfinished sentences
- Failure to capitalize the first letter of the first word in a sentence

- Poorly organized written work (e.g., weak paragraph organization; poor sentence cohesiveness)
- Illegible handwriting; incorrect use of upper- and lower-case letters, inverted characters; mixing of printing and cursive writing
- Basic written activities, such as taking notes, are challenging as they require simultaneous listening.
- Letters or sounds that are too similar are confused (e.g., "jumpt" for "jumped"; "caterpault" for "catapult")
- Inability to choose the correct spelling from two reasonable options (e.g., successful/succesfull; conscious/ consious; necessary/necessery)
- Use of non-permissible letter strings consistently (e.g., "egszakt" for "exact"; discuss/diskus; "freeeqwnt" for "frequent")
- Inconsistent page positioning in terms of lines and margins
- Uneven spacing between words and letters
- Cramped or odd grip; holds the writing instrument very near to the paper, or holds thumb over two fingers and writes from the wrist (**Figures 3** and **4**) [17].

5.2.2 Standardized tests for assessing written expression

- Wechsler Individual Achievement test (WIAT-II).
- Test of Written Language (TOWL; 3rd edition).
- Test of Early Written Language (TEWL; 2nd edition).
- Test of Written Spelling (TOWS; 4th edition).
- Test of Written Expression (TOWE) [14–16].

5.3 Dyscalculia

It refers to a type of specific learning disability that affects a person's ability to understand numbers and learn math facts and difficulty in learning arithmetic. Individuals with this type of LD may also have poor comprehension of math symbols, may struggle with memorizing and organizing numbers, have difficulty telling time, or have trouble with counting. Problems with number or basic concepts are likely to show up early and problems related to reasoning appear in the later grades in students. Dyscalculic children may also be unable to sort important superfluous information, recognize the proper computing technique, or assess whether the solution they acquire is appropriate (Jordan & Hanich, 2003). Mathematical challenges are typically the most severe obstacles in the academic path of individuals with LD, and they frequently persist into high school (**Figure 5**).

Various psychological, neurological, genetic, environmental and emotional factors are responsible for dyscalculia. Inferior parietal sulcus plays a dominant role

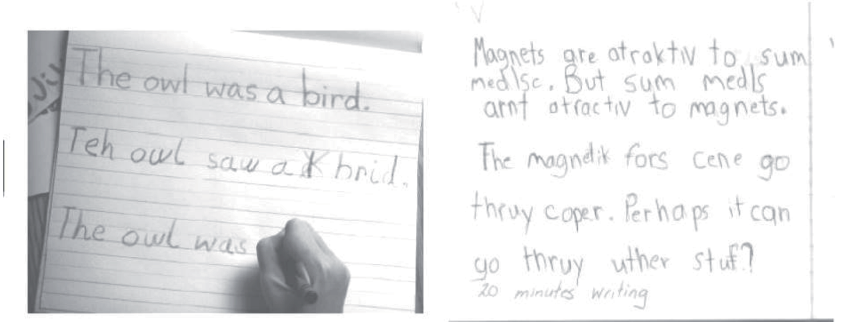

Figure 3.
Sample writing of Dysgraphic child [17].

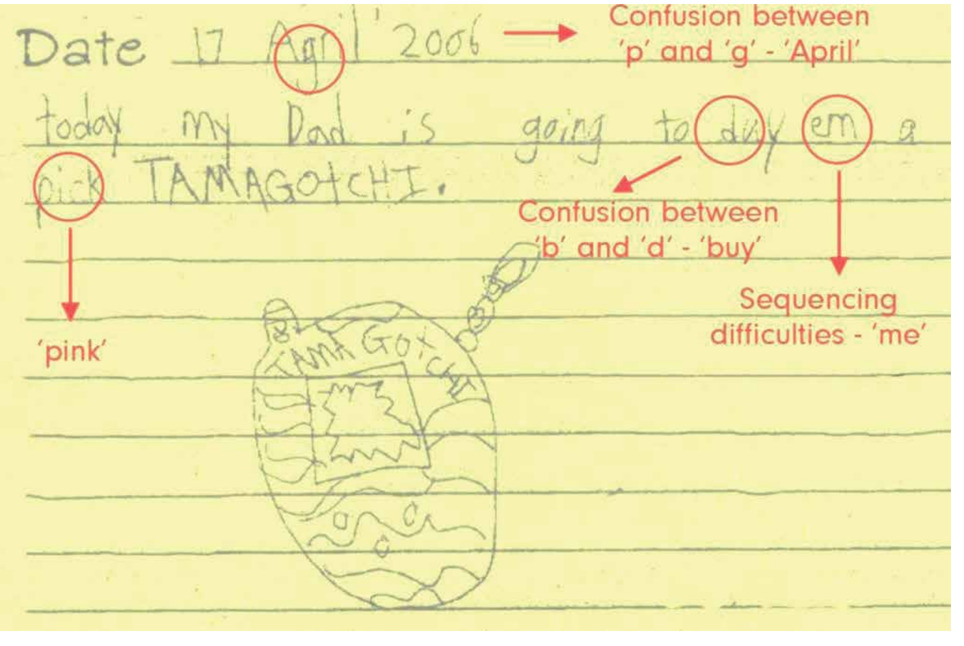

Figure 4.
Sample writing of Dysgraphic child [17].

in numerical processing. MRI studies have shown decreased gray matter in the left parietal lobe of children suffering from Dyscalculia. Environmental factors like schooling, low-income households and affective factors like anxiety and motivation are some of the causal factors of poor mathematical abilities and psychosocial adversities in children.

5.3.1 Dyscalculia symptoms

A child with inadequate arithmetic skills may just rely on rote memorization for the first 2 or 3 years of primary school. As mathematics problems include discrimination and manipulation of spatial and numerical relationships, a youngster with math challenges will be impacted negatively sooner or later.

- Individuals might have difficulty reading clocks to tell time, counting money, identifying patterns, remembering math facts, and solving mental math.

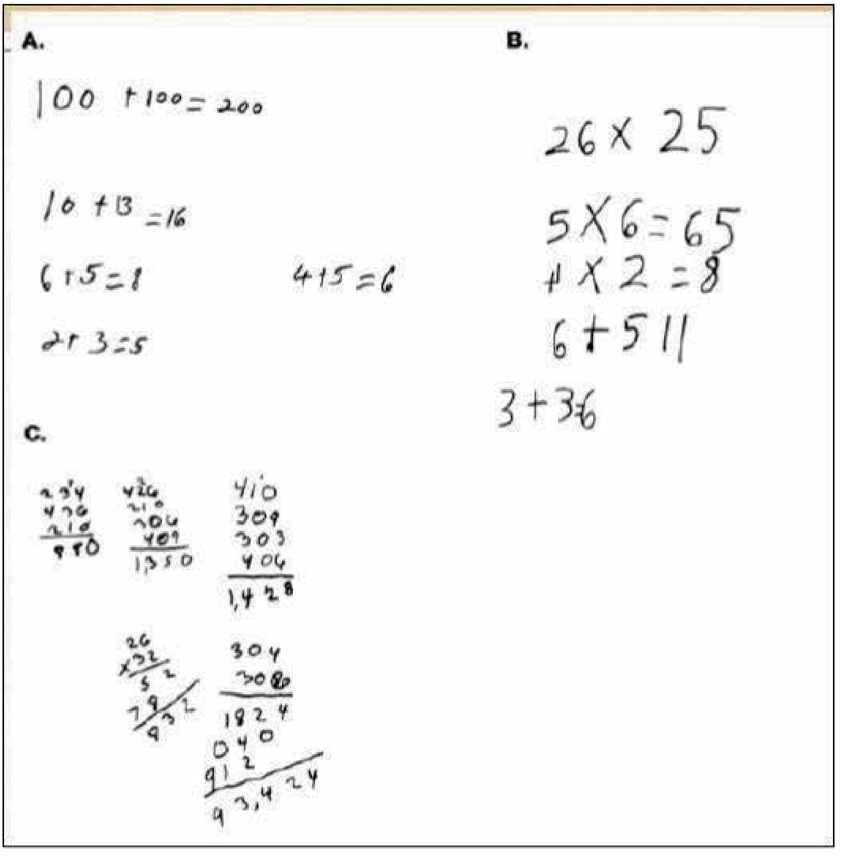

Figure 5.
Sample writing of Dycalculia [17].

- Counts with fingers because of difficulty with counting
- Problems with differentiating between left and right
- No alignment of digits and completing the arithmetic procedure in the wrong direction (e.g., left to right; top to bottom).
- Poor comprehension of fractional concepts (1/2)
- In older children (i.e., third grade and above), major impairments are evident in solving more complex arithmetic problems. And rapid retrieval of number facts (e.g., 4 × 9) and
- Difficulty keeping scores or remembering score procedures in games, like bowling, etc. Often loses track of whose turn it is during games, like cards and board games. Has limited strategic planning ability for games, like chess [18].

5.3.2 Assessment tools

Standardized tools to measure dyscalculia are,

- The Keymath Diagnostic Arithmetic Test assesses understanding of mathematical content, function, and calculation, among other things. It is used to assess students in grades one through six.Woodcock–Johnson Achievement Battery-III

- Test of Early Mathematical Abilities
- Teacher Academic Attainment Scale (TAAS)
- Child self- reported math anxiety scales. [11 items];
- Mathematics Anxiety Scale for Children [11–16].

5.4 Auditory processing disorder (APD)

APD is a deficit in neural processing of auditory stimuli that is not due to higher order language, cognitive or hearing loss and yet it is associated with difficulties in learning disorder [19, 20].

It is not a problem with understanding meaning but it means the brain of the affected child does not "hear" sounds in the usual way. It's also known as Central Auditory Processing Disorder, and it's a disorder that makes it difficult for sound to pass freely through the ear and be processed or interpreted by the brain. Even when the sounds are loud and clear enough to be heard, people with APD are unable to distinguish minor variations between sounds in words. They may be unable to filter distinct noises or mistake the order of sounds. In APD, the brain misinterprets the information received and processed from the ear [21].

5.4.1 Symptoms

APD can affect the way the child speaks as well as their ability to read, write, and spell. Affected children may drop the ends of words or mix up similar sounds and may find hard to talk with other people. They may not be able to process what others are saying and cannot come up with a response quickly. The child may find it hard to,

- Understand speech in the presence of competing background noise or in resonating acoustic environments
- Inability to localize the source of a signal
- Issues with hearing on the phone
- Inconsistent or inappropriate responses to requests for information
- Difficulty following rapid speech
- Frequent requests for repetition and/or rephrasing of information
- Unable to follow directions
- Difficulty or inability to detect the humor and sarcasm made by subtle changes in intonation.
- Difficulty learning a foreign language or novel speech materials, especially technical language
- Difficulty maintaining attention [11–16].

5.4.2 Causes

Although the actual causes of APD are unknown, it is thought to be associated to illness like chronic ear infections, meningitis, or lead poisoning. APD can develop in patients who have neurological system illnesses such multiple sclerosis and also be caused by premature delivery, low weight, head injury, and genes (APD can run in families) [11–16].

5.4.3 Assessment

An audiologist can diagnose APD by conducting a series of advanced listening tests in which the child will listen to different sounds and respond when they hear them. However, children usually aren't tested for APD until age 7 because their responses to the listening test may not be accurate when they are younger [14–16].

5.5 Language processing disorder (LPD)

LPD is a type of Auditory Processing Disorder (APD) in which people have trouble putting meaning to the sound groups that make up words, phrases, and stories. While an APD affects how the brain interprets all sounds, a Language Processing Disorder (LPD) only impacts how language is processed [6]. This disorder arises when an individual has specific challenges in processing spoken language that impacts both receptive and expressive language. These language-related issues could be caused by a variety of circumstances, including a limited vocabulary, a concrete thinking style, difficulties remembering and keeping track of what is said, or difficulties organizing one's thoughts. For example, children with a language-based LD may find it difficult to locate the appropriate words and phrases or to follow a fast-paced conversation. Language-based LDs also can make it difficult to write effectively: it might be difficult to organize ideas or determine the main topic of a written message [10].

5.5.1 Common problems

5.5.1.1 Expressive language

Children with expressive language difficulties exhibit slow vocabulary growth, pronunciation difficulties, difficulty in expressing (single words, poor/wrong retrieval of words, poor answering, narrative and conversational skills) and grammatical difficulties. They will often use a less appropriate word because the right word will not come to them. They have problems understanding complex sentence structures and responding to questions (**Figure 6**) [17].

Difficulty with ***word retrieval***	Whilst narrating a story
4.5 year old boy	**They escaped the tiger from getting eaten.**
Teacher: "What do you want Karim?"	On a hot day:
K: (pointing to car)"that"	**I am shivering, put the fan on!**
T: What is "that"	Father comes home late from work
K: (still pointing to car) That, want that	**Why are you so early Papa?**

Figure 6.
Expressive language difficulties [17].

5.5.2 Receptive language difficulties

- Trouble with processing sounds affects, with sequencing, linking thoughts, and concepts
- Need extra time to process incoming information
- Miss nonverbal language cue
- Do not understand jokes and laugh inappropriately or at the wrong times
- Problems doing group work
- Have difficulties giving or following directions
- Conversations will be marked by long silences
- Lack skill in responding to statements and questions (Hallahan & Kauffman, 2003) (**Figure 7**)

Difficulty with usage

9 year old English speaking boy asked to write 10 - 15 lines for an essay. Tells mother "why 10 - 15 lines, it should be 1-15 lines"

"We start from 1st line to 15, not from 10 to 15"

Figure 7.
Expressive language difficulties [17].

5.6 Nonverbal learning disabilities(NLD or NVLD)

Almost 65% of all communication is conveyed nonverbally. NLD is a disorder which is usually characterized by a significant discrepancy between higher verbal skills, weaker motor, visual–spatial and social skills. While it may sound like nonverbal learning disabilities (NVLD) relate to an individual's inability to speak, it actually refers to difficulties in decoding nonverbal behaviors or social cues. Children with NVLD are often well-spoken and can write well, but struggle with subtle social cues and comprehension of abstract concepts or the nonverbal aspects of communication [1, 21, 22].

5.6.1 The signs and symptoms are

- The typical characteristic of an individual with NLD (or NVLD) is having trouble interpreting nonverbal cues like facial expressions or body language, tone of voice and poor coordination. Hence they will have difficulty to make and keep friends
- Struggle with life skills that require an understanding of spatial relationships, such as recognizing how parts fit together into a whole, completing jigsaw puzzles and building with blocks, learning routes for travel, and manipulating objects in space.
- Difficulty in developing fine-motor skills those results in poor handwriting, difficulty learning to tie their shoelaces, and problems using small tools and utensils.

- Are weak in executive functions or will find hard to sustain attention. They may have trouble handling new tasks, solving problems and remaining flexible in their thinking. They may also have difficulty staying focused, completing multi-step instructions, organizing tasks and materials and controlling their impulses.

- Exhibit difficulty with reading comprehension or mathematical problem solving

- Physically clumsy, often bumps into objects or people

- Struggles with metaphors or abstract concepts and thinks of things in literal terms [21–23].

5.7 Visual perceptual or visual motor deficit

5.7.1 Visual motor and perceptual deficits

Individuals with visual perceptual/visual motor deficits have poor eye-hand coordination, lose their position frequently when reading, and struggle using pencils, crayons, glue, scissors, and other fine motor skills. When reading or completing tasks, they may also confuse similar-looking letters, have difficulty navigating their surroundings, or display atypical eye activity [8]. It impairs a person's ability to grasp information that they see, as well as their ability to draw or copy and understand information collected by visual means. Due to faults in the way a person's eyes move, sensory data gained through sight may be affected. These children's visual impairments limit reading comprehension skills, cause a short attention span, and make it difficult to draw or copy information.

The brain can process visual information in a variety of ways, as per National Center for Learning Disabilities (2003) and individuals with this disability may experience difficulty in a variety of areas, and they are not limited to experiencing difficulties in just one of the categories listed below [23].

5.7.2 These are some of the categories

Visual discrimination: Visual discrimination refers to a person's capacity to use their eyes to detect and compare the characteristics of different items in order to distinguish one item from another. An individual with issues in this area may have difficulty distinguishing between two similar letters, objects, or patterns.

Visual figure-ground discrimination: It entails determining the difference between a figure and its surroundings. A person who struggles in this category may have trouble finding a specific piece of information on a page full of words or numbers. They may also struggle to notice an image if there is distracting background.

Visual sequencing: The is the ability to tell the difference between symbols, words, and images. Individuals with problems in this category may be unable to stay in the correct spot while reading (skipping lines or re-reading the same line over and over), struggle with using a separate answer sheet, reversing or misreading letters and words, and have difficulty understanding mathematical equations.

Visual motor processing: It is the feedback from the eyes that allows other body components to move in coordination. Individuals may struggle to stay between the lines while writing (or coloring), copying from a board onto paper, moving about without tripping over things, and playing sports that involve timed and exact space motions.

Visual memory: Visual memory problems can be divided into two categories. The first has to do with recalling something that happened a long time ago. The second is the ability to recall something that has recently been viewed. A person may have trouble remembering and spelling common words, remembering phone numbers, reading comprehension, and typing on a keyboard or pad.

Visual closure: Refers to the ability to determine what an object is while only a portion of it is visible. An individual may have difficulty recognizing an object in a picture that is not presented in its entirety (for example, portraying an elephant without a trunk), identifying a word with a letter missing, and recognizing a face with only one feature missing (such as the ears).

Spatial relationships: It refers to the skill to identify an object in space and relate it to oneself. According to National Center for Learning Disabilities, 2003, an individual child with this difficulty will have trouble going from one place to another, spacing of words and letters on a page, judging time, and reading maps [23].

5.7.3 Signs and symptoms of visual perceptual motor deficit

- Difficulty with activities such as printing or copying, or learning to tie shoelaces.
- Find hard to write, may put more pressure on a pencil or pen to control the motor movements, and may take much longer to write and experience fatigue with writing.
- Have trouble orienting their body in space and may need more help to learn dressing or may confuse left and right.
- Reversing superficially similar letters such as ‘p’ and ‘q’ or ‘m’ and ‘w’
- Difficulty navigating around school or campus
- Turns head while reading or hold paper at odd angles and closes one eye while reading
- Often loses place while reading
- Unable to recognize a word if only part of it is shown
- Struggles with cut and paste
- Shows poor organization on the page, messy words, irregular spacing, and misaligned letters [10, 23].

5.7.4 Co-morbidity in children with specific learning disorders

Learning impairments are usually linked to mental health issues. One of the most common disorder affecting school-aged children is specific learning disorders (SLD). According to the American Psychiatric Association (APA), SLD affects 5–15 percent of school-aged children from various languages and cultures. SLD frequently coexists with other neurodevelopmental and mental abnormalities, as well as psychiatric disorders. Many studies have found that children with SLD have both internalizing and externalizing psychiatric problems. There is a substantial link between ADHD and reading problems among the children with externalizing psychiatric disorders. Children with SLD are five times more likely to develop conduct disorder (CD). Despite the fact that there is a link between SLD and internalizing disorders in the literature, recent research have indicated a higher incidence of internalizing symptoms, with anxiety and depressive disorders at the top of the list. These mental comorbidities with SLD are either a direct result of the same central processing pattern deficiencies that produce learning problems, or they are a source of frustration and academic failure. These issues are said to be part of a vicious cycle that leads the child towards severe cognitive and social–emotional impairment [24–27].

6. Conclusion

SLD, previously known as a learning disorder includes a heterogeneous group of disorders manifested by significant difficulties in the acquisition and use of reading (dyslexia), writing (dysgraphia), or mathematical (dyscalculia) abilities despite intact senses, normal intelligence, proper motivation, and adequate socio-cultural opportunity. DSM-5 combines reading disorder, mathematics disorder, disorder of written expression and learning disorder into a single diagnosis under the classification of Specific learning disorder.

The Learning Disabilities Association of America and many other mental health practitioners regard the seven disorders as specific learning disabilities i.e. dyslexia, dysgraphia, dyscalculia, auditory processing disorder, language processing disorder, nonverbal learning disabilities and visual perceptual disabilities. The major causes of learning disabilities are inherited cause, genetic cause, neurobiological or brain injury, co-morbid disorders, environmental factors. They recognize autism spectrum disorder (ASD) and attention deficit hyperactivity disorder (ADHD) as related disorders that impact learning, though not specific learning disorders.

Dyslexia is characterized by difficulties with inaccurate word recognition and poor spelling and decoding abilities resulting from a deficit in the phonological component of language. Dysgraphia is characterized by poor writing skills like poor spelling, errors in grammar and punctuation, and poor handwriting. Mathematics disorder refers to impairment in the development of arithmetic skills, including computational procedures used to solve arithmetic problems and the retrieval of basic arithmetic facts from long-term memory. Language Processing Disorder (LPD) relates to the difficulties in processing of expressive language and/or receptive language. Non-verbal learning disability refers to problems in understanding nonverbal cues like facial expressions or body language. Visual processing disorder includes trouble drawing or copying, inability to detect differences in shapes or letters, and letter reversals.

SLD could cause complications if not remedied earlier. Intense and focused instruction may in fact alter the brain activation profiles observed in children with SLD.

Hence there is a need to advocate for intense and focused instruction in each of the affected academic domains.

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Author details

Vinutha U. Muktamath*, Priya R. Hegde and Samreen Chand
Department of Human Development and Family Studies, College of Community Science, University of Agricultural Sciences, Dharwad, Karnataka, India

*Address all correspondence to: vinumuktamath@gmail.com

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Chapter 2

Biological Understanding of Neurodevelopmental Disorders Based on Epigenetics, a New Genetic Concept in Education

Takeo Kubota

Abstract

Neurodevelopmental disorders, such as autism spectrum disorder, attention deficit hyperactive disorder, and learning disabilities, are heterogeneous conditions that are thought to have a multifactorial etiology including congenital genetic abnormalities and acquired environmental factors. Epigenetics is a biological mechanism that controls gene expression based on chemical modifications of DNA and chromosomal histone proteins. Environmental factors, such as severe mental stress, have been demonstrated to alter gene expression by changing epigenetic chemical modifications in the brain. Therefore, epigenetics is not only involved in congenital autism spectrum disorder-like conditions (e.g., Prader-Willi syndrome and Rett syndrome) but may also be involved in acquired attention deficit hyperactive disorder-like conditions (e.g., via child abuse and neglect). In this chapter, we introduce the basis of the epigenetic mechanism and the recent biological understanding of neurodevelopmental disorders based on epigenetics, which is a new genetic concept not only in medicine but also in education, which bridges internal brain mechanisms and external environmental factors.

Keywords: epigenetics, environmental factor, neurodevelopmental disorder, ASD, ADHD, child abuse, neglect, reversibility, education

1. Introduction

The number of children with autism spectrum disorder (ASD) is reportedly increasing by 10,000 cases per year in Japan [1], with similar increases observed in other countries, including the USA [2–4] and Korea [5]. These increases can be attributed, in part, to social factors, such as diagnostic substitution whereby children formerly diagnosed with mental retardation are now diagnosed as ASD. However, they cannot be explained fully by such diagnostic substitutions [6], and it is possible that biological changes in the brains of children may also play a role.

Thanks to advances in genomic DNA research, a number of genes associated with ASD have been identified. Mutations in genes encoding synaptic molecules, which facilitate communication between neuronal cells, have been identified in a subset of children with ASD [7, 8]. However, the increase in ASD is unlikely to be simply a result of genetic factors because there is no reason to suspect that mutation rates have suddenly increased in recent years. Rather, a more likely explanation is that environmental factors are involved.

Epigenetic mechanisms are one of the ways by which gene expression is controlled in higher vertebrates. These mechanisms are essential for normal development during embryogenesis [9] and for the differentiation of various types of cells including neural cells [10, 11]. Therefore, it is important to gain an understanding of epigenetic mechanisms, which include chemical modifications of genetic components such as DNA, histone proteins, and microRNAs. Furthermore, the failure of epigenetic mechanisms results in neurodevelopmental disorders [12–15]. Actually, a number of congenital neurological and mental disorders are reportedly caused by epigenetic abnormalities [16–22].

Epigenetic modifications offer one mechanism by which environmental factors might lead to changes in population health [12]. This is partly supported by studies in twins showing that environmental factors contribute to the occurrence of autism [23–25]. These findings led us to propose the hypothesis that "various environmental factors can change the epigenetic status and alter the expression of a number of neuronal genes (namely synaptic genes), resulting in abnormal brain function (aberrant synaptic function) associated with some neurodevelopmental disorders."

In this chapter, on the basis of such scientific evidence, we review the current understanding of congenital neurodevelopmental disorders caused by epigenetic abnormalities and also provide a basic description of acquired neurodevelopmental disorders caused by environment-induced epigenetic alterations. Finally, we discuss the future directions of medical and educational interventions for neurodevelopmental disorders (namely ASD).

2. Epigenetic abnormalities in "congenital" neurodevelopmental disorders

Epigenetic gene control is an essential mechanism for normal brain development. Abnormalities in the molecules associated with this process cause various congenital diseases. It is notable that defects in epigenetic phenomena and epigenetic molecules involved in gene regulation result in congenital neurological features and mental retardation. Here, we show four examples.

2.1 Genomic imprinting

Genes are believed to be expressed equally between the maternal and paternal chromosomes. However, an exceptional phenomenon, i.e., genomic imprinting, has been discovered that is the result of an epigenetic gene regulation mechanism. For an imprinted gene, one of the two parental alleles is active and the other is epigenetically inactivated (**Figure 1A**). Therefore, a defect in the active allele of the imprinted gene results in the loss of expression. This has been found in some neurodevelopmental diseases, including Angelman syndrome, which is characterized by severe mental retardation and epilepsy, and Prader-Willi syndrome, which is characterized by neurocognitive deficits, excessive daytime sleepiness, muscle hypotonia, short stature, small hands and feet, hypergonadism, hyperphagia and obesity that leads to type 2 diabetes [26].

2.2 X chromosome inactivation

The X chromosome has a large number of genes, whereas the Y chromosome has relatively few. Thus, females (XX) have more genes than males (XY). To minimize

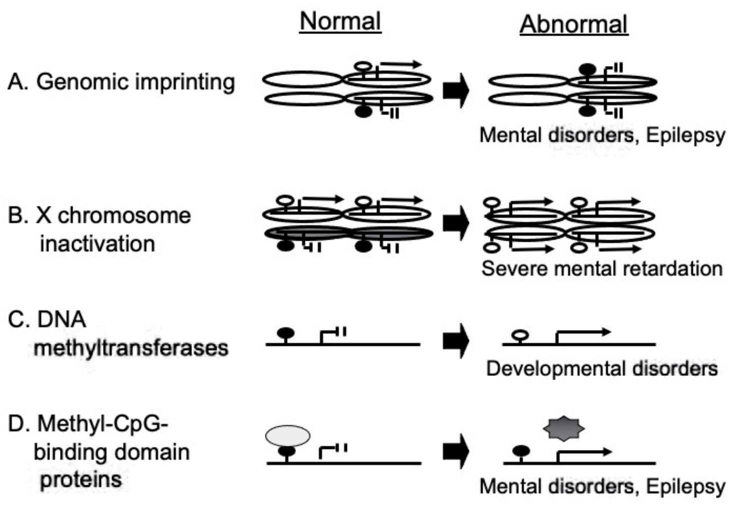

Figure 1.
Mental disorders caused by epigenetic abnormalities. A: Abnormal suppression of the active allele of imprinted genes causes genomic imprinted disorders. B: Abnormal activation of the inactive X chromosome in females causes X-chromosome inactivation disorders. C: Mutations of the genes encode DNA methyltransferase deficiency causes insufficient DNA methylation, which leads aberrant expression of the target genes. D: Mutations of the genes encode methyl-CpG binding proteins causes abnormal regulation of the target genes.

this sex imbalance, one of the two X chromosomes in females is inactivated by an epigenetic mechanism [27]. Improper X chromosome inactivation is thought to be an embryonic lethal condition [28, 29].

When X chromosome inactivation does not occur in women with one normal X chromosome and a small X chromosome due to a large terminal deletion, an over-dosage effect of X-linked genes derived from the small X chromosome leads to severe neurodevelopmental delay [30]. This indicates that proper epigenetic gene regulation is essential for normal development (**Figure 1B**).

2.3 DNA methyltransferases

DNA methylation is a fundamental step in epigenetic gene regulation that is regulated by DNA methyltransferases, which are enzymes that add a methyl group (CH_3) to CpG dinucleotides within human genomic DNA. A defect in a DNA methyltransferase causes ICF syndrome, which is characterized by immunodeficiency, centromere instability, facial anomalies, and mild mental retardation (**Figure 1C**) [18–20].

2.4 Methyl-CpG-binding domain proteins

Methyl-CpG-binding domain proteins are also important molecules in the epigenetic control of gene expression. Abnormalities in the methyl-CpG-binding protein 2 (*MECP2*) gene cause Rett syndrome, which is characterized by seizures, ataxic gait, language dysfunction, and ASD-like behavior [21, 22]. Therefore, abnormal MECP2 expression in the brain is considered to result in the neurological features of Rett syndrome. In fact, several studies have shown that MECP2 controls a subset of neuronal genes [29–33], suggesting that epigenetic dysregulation of neuronal genes may cause the neurological features of this disease (**Figure 1D**).

3. Epigenetic abnormalities in "acquired" neurodevelopmental disorders

In neurodevelopmental disorders such as ASD, both environmental factors (e.g., environmental chemicals and infections) and genetic factors (e.g., defects in synaptic molecules) have historically been discussed [4, 8]. However, the biological links between these two groups of factors have not been identified. Epigenetics may bridge these factors in normal and disease development [12].

3.1 Epigenetic bridge between genetic molecules and environmental factors

Besides *intrinsic* (congenital) epigenetic defects (described in Section 2), several lines of evidence suggest that *extrinsic* (environmental) factors, such as malnutrition [34, 35], drugs [36–40], mental stress during the neonatal period [41], and neuronal stimulation [42], alter the epigenetic status, thereby affecting brain function. Therefore, it is intriguing to think that acquired neurodevelopmental disorders, including child abuse- and neglect-induced ADHD-like phenotypes, may be the result of epigenetic dysregulation caused by environmental factors (**Figure 2**).

3.2 Environmental factors that affect brain function via epigenetic mechanisms

Short-term mental stress after birth may alter gene expression in the brain and result in persistent abnormal behavior (**Figure 2**).

In rat pups from mothers exhibiting low levels of maternal care, an epigenetic DNA modification in the promoter of the glucocorticoid receptor gene was increased in the hippocampus, leading to the suppressed expression of this gene within the first week of life (**Figure 3** right). Conversely, this promoter DNA modification was decreased in the brains of offspring who received high maternal care during the same period (**Figure 3** left) [41].

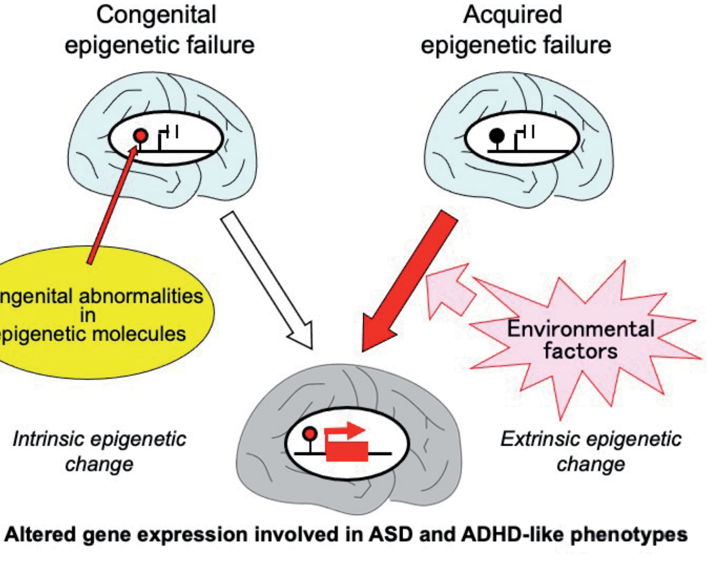

Figure 2.
Current understanding of intrinsic and extrinsic mechanism for neurodevelopmental and mental disorders. Congenital epigenetic disorders are caused by intrinsic mechanism through mutations in the proteins associated with epigenetic gene regulation or epimutation (e.g., de novo *DNA methylation) during spermatogenesis and oogenesis. Acquired epigenetic disorders are caused by extrinsic mechanism via various environmental factors.*

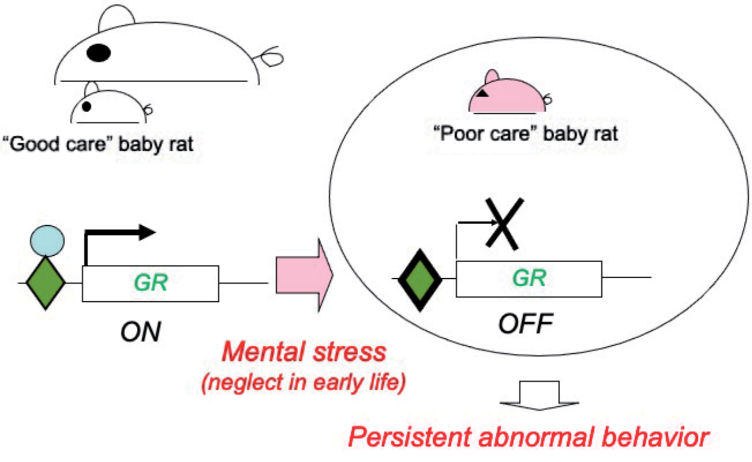

Figure 3.
Mental stress-induced DNA methylation changes. Maternal separation-stress during the first week of life induced hypermethylation in the glucocorticoid receptor gene promoter in the mouse hippocampus, and this environment-induced epigenetic changes persists life-time long with abnormal behavior.

This rat experiment provided a putative animal model for childhood neglect and maltreatment in humans. In fact, in a human study, postmortem analysis of the hippocampus of suicide victims with a history of childhood abuse revealed the hyper-modification of the neuron-specific promoter of the glucocorticoid receptor gene in combination with its decreased expression [43]. These findings suggest that the adverse effects of early-life stress on the DNA methylation program may last throughout life [44], and also indicate that neurodevelopmental problems may arise from epigenetic dysregulation caused by environmental factors in early life (**Figure 3**).

A similar epigenetic mechanism is also likely to be relevant in drug addiction. Gene expression in the dopaminergic and glutamatergic systems is mediated by epigenetic mechanisms, and cocaine and alcohol can alter the epigenetic state, which may be associated with permanent behavioral consequences [45, 46].

3.3 Environment-induced epigenetic changes

The above findings were mainly obtained from animal studies, and there is little evidence from humans. However, the fact that epigenomic differences are larger in older monozygotic twins than in younger twins suggests that epigenetic status may be altered during aging by environmental factors in humans [47].

Likewise, the epigenomic patterns of monozygotic twins with discordant severity of Rett syndrome differ and they show differences in the expression of neuronal genes [25]. This indicates that environmental factors may alter the human epigenome and the resulting epigenomic differences may create phenotypic differences between twins.

Birth weight has decreased over the past 20 years, which is thought to be a result of the popularity of dieting among young women and of the recommendation by obstetricians to minimize pregnancy weight gain to reduce the risk of medical problems during pregnancy [48]. According to epidemiological studies of populations affected by famines in the Netherlands and China, offspring with low birth weight are expected to have an increased risk of not only metabolic disorders (e.g., obesity and diabetes mellitus) but also mental disorders [49–51]. Recent studies have demonstrated that malnutrition during the fetal period causes a hypomodification of the peroxisome proliferator-activated receptor alpha (*PPARa*) gene in the rat liver [52]. Similar epigenetic changes have been identified in people who suffered malnutrition during a period of famine in the Netherlands [53]. The use of assisted reproductive technologies by women, which are now used widely due to increases in the age at which individuals wish to conceive, reportedly decreases the epigenetic modification of DNA at multiple maternally imprinted regions [54, 55].

4. Medical interventions for epigenetics-associated neurodevelopmental disorders

The administration of folic acid to pregnant rats alters the DNA modification status of their offspring [56]. Furthermore, folic acid supplementation to pregnant rats under malnutrition conditions prevents the hypomodification of a hepatic gene in their offspring [57]. In addition to folic acid, various nutritional and other environmental factors, such as royal jelly [58], drugs for mental disorders [36, 38, 40], environmental chemicals [59, 60], and external stimuli (electro-convulsive treatment for psychiatric diseases) [42], have also been demonstrated to alter the DNA or histone modification status of the brain.

As mentioned above, mental stress in the first week of life causes epigenetic abnormalities in the brains of mice. Conversely, several mouse studies have demonstrated that appropriate educational conditions may ameliorate the features of neurodevelopmental disorders. Environmental enrichment, consisting of larger-sized home cages with a variety of objects including running wheels, improves motor coordination and decreases anxiety-related behavior in female mice with an *Mecp2* defect, a model of human Rett syndrome [61, 62]. Environmental enrichment also improves locomotor activity with reduced ventricular volume, and restores the expression of synaptic proteins in the hypothalamus and syntaxin 1a and synaptotagmin expression in the cortex of the brain of these mice [63, 64].

Children with congenital neurodevelopmental disorders caused by genetic defects are considered to be difficult to cure, because it is technically challenging to distribute gene products to the appropriate brain regions and at the appropriate time of development. However, it was recently demonstrated that Rett syndrome may be an exception, partly because MECP2 is not essential for brain structure, but rather encodes a “lubricant” that works at a relatively later period of brain development. As a consequence, the reintroduction of *MECP2* into mice with a defect in *Mecp2* after birth is sufficient to rescue Rett-like neurological symptoms [65, 66]. Furthermore, the restoration of MECP2 function in astrocytes substantially improves locomotion, anxiety levels, and respiratory abnormalities in mice with a defect in *Mecp2* [67]. These results suggest that the up-regulation of *MECP2*, possibly mediated by drug treatment, might help to improve the brain function of patients with Rett syndrome. Additionally, these results indicate that neurodevelopmental disorders caused by epigenetic abnormalities can be treated.

5. Educational interventions for epigenetic neurodevelopmental disorders

5.1 Evidence for epigenetic reversibility

Unlike DNA mutations, epigenetic modifications of DNA are reversible, since they are based on the attachment and detachment of chemical residues without any change to the DNA sequence. Therefore, environmental stress-induced epigenetic abnormalities are potentially reversible, and thus possibly treatable. Here, we show examples.

A mouse study demonstrated that chronic social defeat stress-induced epigenetic alterations can be reversed and brain-derived neurotrophic factor gene expression in the brain can be activated with a commonly used antidepressant (imipramine) by inducing histone acetylation via the down-regulation of histone deacetylases, which ameliorates depression-like behavior [36].

As mentioned above, malnutrition during the fetal period induces the chemical modification of *PPARa* in the peripheral blood of individuals who suffered malnutrition during a famine in the Netherlands [53] and in the liver of rats fed a protein-restricted diet [52]. However, the protein-restricted diet-induced hypomethylation of *PPARa* in the offspring could be avoided by supplementation of the diet of maternal rats with folic acid (an essential substrate for methyl residues) [57].

Besides malnutrition, maternal smoking is known to have a negative impact on fetuses, e.g., stillbirth, low birth weight, and small for gestational age, and on offspring, e.g., sudden infant death syndrome, reduced lung function, bronchial asthma, and increased incidence of neurocognitive disorders, tobacco addiction, and obesity [68–70].

Recent cohort studies using cord blood samples originating from fetuses demonstrated that maternal smoking changes DNA methylation at several genes, including a CpG locus in the myosin IG (*MYO1G*) gene. Since *MYO1G* encodes a membrane protein of immune system-associated blood cells [71–74], epigenetic changes in DNA modification presumably down-regulate gene expression, which may be associated with a predisposition to bronchial asthma [73].

Whereas the epigenetic status of *MYO1G* is altered in individuals who smoke during pregnancy, this alteration is not found in individuals who stop smoking during pregnancy, suggesting that smoking-induced alterations in methylation can be reversed by smoking cessation or that they may be produced in a dose-dependent manner during pregnancy [72]. These findings further indicate that smoking cessation during pregnancy may be effective at preventing offspring from developing bronchial asthma (**Figure 4**). These findings also suggest that the epigenetic mechanism is reversible.

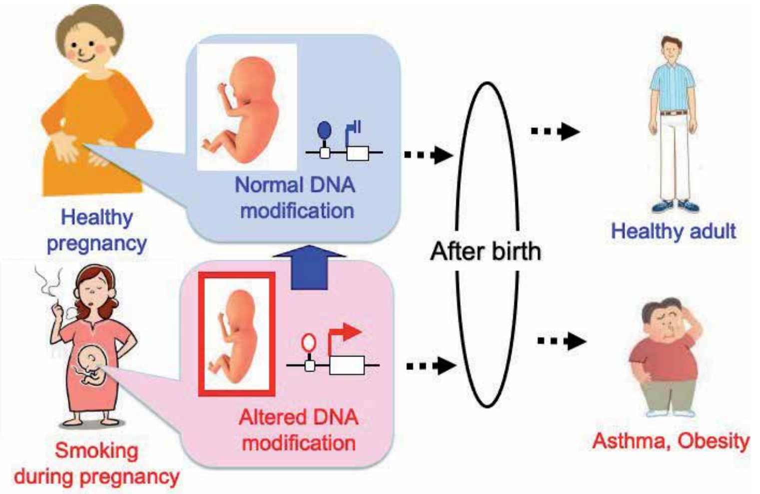

Figure 4.
Epigenetic effect of maternal smoking to the fetus. Maternal smoking changes epigenetic state in the fetus, which potentially cause various clinical features, such as bronchial asthma and obesity, in offspring.

5.2 Epigenetic-based early educational intervention

In this chapter, we describe environmental stress-induced epigenetic alterations and their associated disorders. We also discuss the reversibility of the epigenetic mechanism to recover gene expression and potentially ameliorate disease conditions. As a number of molecules associated with epigenetic gene regulation have been identified, pharmacological companies are developing drugs to target these molecules with an aim to correct aberrant gene expression, especially for neurodevelopmental and psychiatric disorders [75].

Besides medical approach, "educational intervention" is another way taking advantage of use of epigenetic reversibility especially for children, because enriched nurturing environment that urged exercise and stimulated brain function ameliorated neurological features, which is demonstrated in a mouse model of Rett syndrome that is an autistic disorder caused by failure of epigenetic gene regulation as mentioned above [62–64]. Therefore, understanding of the epigenetic reversible concept is important for all staffs in a preschool and a nursery school, because they are the caregivers who will be able to urge development of children who had an adverse experience before and after birth, by offering appropriate nurture and education.

6. Conclusion

It was reported that the number of children with ASD is increasing in various countries including US and Japan. When we think of biological mechanism for this increase, one can imagine that some factors in recent society increased ASD via epigenetic mechanism based on chemical modification of DNA and histone proteins which control gene expression in the children's brain.

It has been known that abnormalities in epigenetic mechanisms lead to congenital neurodevelopmental disorders, such as Rett syndrome characterized by seizures, ataxic gait, language dysfunction, and ASD-like behavior.

Besides congenital epigenetic abnormalities, several lines of evidence suggest that environmental factors also alter the epigenetic status of brain-function associated genes. Therefore, it is intriguing to think that child abuse and neglect-induced ADHD-like phenotypes, which are thought to be increased in modern society, may be the result of epigenetic dysregulation caused by mental stress in early life.

Recent medical research demonstrated that some nutrients and drugs for mental illness reversed the epigenetic state and recover healthy physical and mental condition, and revealed that epigenetics is a reversible and thus treatable mechanism.

Besides such medical approach, "educational intervention" is another way taking advantage of use of epigenetic reversibility especially for children, because enriched nurturing environment that urged exercise and stimulated brain function ameliorated neurological features in mouse experiments. Therefore, epigenetics, described in this chapter, will be essential concept that contribute to future nurture and education.

In conclusion, epigenetics becomes a new genetic concept not only in medicine but also in education, which bridges internal brain mechanisms and external environmental factors.

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Conflict of interest

The authors declare no conflict of interest.

Author details

Takeo Kubota
Professional Degree Course, Graduate School of Teacher Education, Seitoku University, Matsudo, Japan

*Address all correspondence to: kubota.takeo@wa.seitoku.ac.jp

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Chapter 3

Self-Regulation, Self-Efficacy, and Learning Disabilities

Dale H. Schunk and Maria K. DiBenedetto

Abstract

This chapter will discuss the roles of self-regulation and self-efficacy in students with learning disabilities. The guiding conceptual framework is based in social cognitive theory. In this theory, self-efficacy is a key motivational variable and self-regulation is a means for persons to develop a sense of agency, or the belief that they can exert a large degree of control over outcomes in their lives. Following a description of the theory, research is presented showing the operation of self-regulation and self-efficacy in students with learning disabilities. Future research directions are suggested, and implications of theory and research for educational practice are discussed.

Keywords: self-regulation, self-efficacy, motivation, learning disabilities

1. Introduction

In this chapter we discuss the roles of self-regulation and self-efficacy in students with learning disabilities. As used herein, *self-regulation* refers to self-generated cognitions, affects, and behaviors that are systematically directed toward attainment of goals, and *self-efficacy* beliefs are one's perceived capabilities to learn or perform actions at designated levels. This chapter's purpose is important because many students with learning disabilities do not adequately self-regulate their academic performances and hold a low sense of self-efficacy for learning and performing well in educational contexts, both of which can negatively affect their motivation and learning [1, 2].

We initially discuss social cognitive theory as a guiding conceptual framework and situate self-regulation and self-efficacy within this framework. We discuss some research with students with learning disabilities with these constructs to show that helping students to become better self-regulators and improving their sense of self-efficacy can help improve academic motivation and learning. We conclude with implications of theory and research for educational practice. The goal is that the suggestions we make will promote research and application of the principles to help students become more successful in schooling.

2. Background

2.1 Social cognitive theory

Bandura's [3] social-cognitive theory postulates that individuals' functioning involves reciprocal interactions between personal (e.g. cognitions, feelings, skills), behavioral (e.g. strategy use, help-seeking, actions), and environmental (e.g. classrooms, homes, work environments) factors [4]. These reciprocal influences can be illustrated using self-efficacy as a personal variable. Researchers have shown that self-efficacy beliefs influence such behaviors as choice of tasks, persistence, effort, and achievement [1]. In turn, students' behaviors can modify their self-efficacy. As students work on tasks, they observe their progress toward their learning goals. Progress indicators such as assignments completed convey to them that they are capable of performing well, which enhances self-efficacy for continued learning [1].

The hypothesized reciprocal influences between self-efficacy and environmental variables have been demonstrated in research on students with learning disabilities, many of whom hold low self-efficacy for learning [5]. Persons in their environments may react to them based on attributes typically associated with them rather than based on their behaviors. For example, a teacher may judge such students as less capable than other learners and hold lower academic expectations for them, even in areas where students with learning disabilities are performing adequately. In turn, teacher feedback can affect self-efficacy. Persuasive statements such as, "I know that you can do this," can raise self-efficacy.

Learners' behaviors and environments can influence one another. When teachers present information, they may ask students to direct their attention to a slide projected on the board. Environmental influence on behaviors occurs when students attend to the visual without much conscious deliberation. Students' behaviors can alter the instructional environment. If teachers ask questions and students give incorrect answers, teachers may reteach key points rather than continue the lesson.

Social cognitive theory stresses the idea that people strive to develop a sense of *agency* [6], or the belief that they can exert a large degree of control over important events in their lives. Self-regulation and self-efficacy are integral means for experiencing a stronger sense of agency. Students who use self-regulatory skills are apt to feel efficacious about learning and performing well, which in turn can boost their motivation, effort, persistence, and learning. Their perceptions that they are learning strengthen their agency beliefs.

2.2 Self-regulation

Zimmerman [7] conceived of self-regulation as comprising forethought, performance, and self-reflection phases. The forethought phase precedes performance. It is the time when learners set goals and decide on strategies to use to help attain the goals. Forethought also is the time when learners attend to the physical and social environments. They obtain materials they will need to perform the task and make arrangements for working with others if needed. Learners decide on when, where, and how they will work on the task.

Time management comes into play during forethought. Students decide on how much time to spend on the task and subcomponents of it. During forethought learners also motivate themselves to work on the task, such as by experiencing self-efficacy that they can be successful and reminding themselves of the value or importance of the task.

During performance, learners instruct themselves as they work on the task and monitor the outcomes of their efforts. They determine whether their strategies are working out well and whether they are making goal progress.

Periods of self-reflection may come when learners pause during learning or when the task is completed. Self-reflection is the time of self-evaluation when learners evaluate how successful they were. They decide if they need to change their strategy or establish better working conditions. They also make *attributions*, or perceived causes of their outcomes. Attributions address the "why" question—why was I successful or not successful. Based on their attributions and evaluations, they may decide to continue with the same strategy or change it.

Research with students with learning disabilities often shows problems in all three phases [8]. They may not devote sufficient time in forethought to carefully plan their goals and strategies and they may enter the task with low self-efficacy for performing well. During performance they may not attend carefully to the task or monitor their performance to determine goal progress. They also may not adequately evaluate their performance during self-reflection and make attributions that do not motivate. For example, if they had difficulty completing the task, they may attribute it to low ability rather than insufficient effort.

2.3 Self-efficacy

Researchers have shown that self-efficacy can affect choices, effort, persistence, and achievement [1]. Compared with less-efficacious students, those with self-efficacy for learning and performing well are apt to choose to engage in learning, expend effort to succeed, persist when they encounter difficulties, and achieve at higher levels. Students with learning disabilities are more likely to hold lower self-efficacy than students without disabilities, possibly because of an internalized history of repeated academic failures [9, 10].

Bandura [6] hypothesized that self-efficacy beliefs are formed based on four sources: actual performances, vicarious experiences, forms of social persuasion, and physiological and affective indexes. Actual performances constitute the most reliable source because they provide learners with evidence of their capability to succeed. Accomplishments require learners to adapt and adjust to different circumstances, and repeated successes in doing so can enhance self-efficacy. Teachers who provide students with opportunities to learn and perform successfully likely build students' self-efficacy for future similar tasks [11].

Vicarious experiences occur through observing others [6]. In general, observing others succeed raises observers' self-efficacy whereas observed failures can lower it. But perceived similarity of model to observer is important. Observers are more swayed when they perceive themselves to be similar to models.

Forms of social persuasion can raise self-efficacy including for students with learning disabilities [12]. Teachers telling students that they can do something is apt to raise the students' self-efficacy for succeeding. However, the effects of persuasive information can be outweighed by actual performances. Learners told that they are capable will not feel efficacious if they subsequently attempt the task and perform poorly.

Physiological and affective symptoms constitute a source of self-efficacy [6]. Students who experience anxiety or sweating when taking an exam may have low self-efficacy for success, whereas those who feel calm and anticipate performing well are likely to have higher self-efficacy. Students who feel anxious can attempt to gain control over the situation, thereby increasing their sense of agency.

Agency (or *perceived control*) is an important variable stressed by social cognitive theory. A responsive environment is needed for perceived control to exert its effects [6]. Students may believe that they can control their use of learning strategies, effort, and persistence, yet still hold low self-efficacy because they believe that the learning is unimportant and not worth the investment of time. Or they may hold high self-efficacy yet make little effort to learn because they believe that in their present environment learning will not be rewarded [1]. Research supports the importance of professional development to build self-efficacy and agency for teachers who work with students with learning and reading disabilities and ADHD [13, 14].

Self-efficacy applies to teachers as well as students. *Teacher self-efficacy* is the belief that a teacher can help promote student learning [15]. Teachers with higher self-efficacy should be more likely to develop challenging activities, help students succeed, and persist with students who have difficulties. Higher teacher efficacy also is associated with creating a positive classroom climate, supporting students' ideas, and meeting the learning needs of all students [15].

It is beneficial for self-efficacy to correspond closely to students' actual skills. Students who underestimate their capabilities may be less motivated to achieve, believing that they will perform poorly. Students who overestimate their capability are likely to encounter failures, which should lower their self-efficacy. Inaccurate assessments of capabilities, which often are found among students with learning disabilities [5], can hinder the quality and quantity of academic motivation and achievement. Students with learning disabilities may not fully understand the task demands which may lead them to make overly-high self-efficacy estimates [16]. Elementary school students with learning disabilities often have lower academic self-efficacy when compared to their typically achieving peers [17].

3. Self-regulation and self-efficacy research

3.1 Students with learning disabilities

According to the U.S. Federal guidelines for identifying students with disabilities, students must meet three criteria. They must demonstrate a severe discrepancy between intellectual ability and achievement. The difficulties they experience are not the result of any known condition. They must show a need for special education services [9]. These criteria are indicative of the learning differences found between students with and without learning disabilities.

Students with learning disabilities are more likely to demonstrate poorer self-regulatory skills and report lower self-efficacy beliefs than their peers without learning disabilities, which may be a consequence of internalizing a history of repeated failures, frustrations, poor social interactions, and lower levels of performance [9, 18]. This section summarizes some self-regulation and self-efficacy research with students with learning disabilities.

Students who are diagnosed with a specific learning disorder typically perform poorly in reading, writing, and mathematics, which are subjects considered critical for school success. Students with learning disabilities tend to have lower levels of self-efficacy and lower levels of hopeful feelings [10].

Lackaye et al. [10] compared 123 Israeli adolescents with learning disabilities with an equal of number of peers without learning disabilities. Students were matched by school grades, grade level, and gender. Variables such as academic self-efficacy, effort, hope, and mood were assessed. Results showed that students with learning disabilities reported lower levels of academic self-efficacy, which suggests that these students have fewer successful academic experiences than their peers. Students with learning disabilities also were found to have lower levels of effort, hope, and mood. Students who are self-efficacious are likely to engage in productive self-regulatory behaviors such as setting high goals, persisting, and expending effort when faced with challenges [1]. Conversely, students who have not had successful experiences are likely to hold lower self-efficacy about similar learning experiences [6, 8, 10]. These results highlight the challenges faced by students with learning disabilities. In addition to surveys, Lackaye and his colleagues interviewed students with learning disabilities who reported being aware of their difficulties, felt stressed over having to study many more hours than others appeared to need to study to obtain passing grades, and were less hopeful with depressive tendencies.

Klassen and Lynch [12] examined self-efficacy from the perspective of students with learning disabilities and their teachers. Students in grades 8–9 with learning disabilities participated in focus group interviews; teachers who were specialists in teaching students with learning disabilities were individually interviewed. Students and teachers acknowledged the role of self-efficacy beliefs in achievement, specifically indicating that lower levels of self-efficacy can hinder learning and achievement. The teachers noted the "fragility of the academic beliefs of their students" (p.498), indicating they put effort into helping students with learning disabilities build and sustain self-efficacy by reducing levels of frustration.

Interventions for building academic self-regulation and self-efficacy for students with learning disabilities are essential to foster academic success. Butler [19] conducted case studies on students with learning disabilities in postsecondary education programs. Participants ranged in ages from 19 to 48 and were diagnosed with disabilities in mathematics, reading, short-term auditory memory, abstract reasoning, and ADHD. The intervention consisted of need-based tutoring of 2–3 hours per week for two semesters. Tutoring sessions, which included cognitive coaching and modeling, focused on self-regulation by helping students become more metacognitively aware of: task demands and performance criteria; strategy selection, use and modifications; self-monitoring of performance; and self-evaluations and self-judgments. Results showed that the intervention raised students' performances, as well as their metacognition and self-efficacy beliefs.

Many students with learning disabilities struggle with reading (e.g., comprehension, spelling, writing), as well as with phonological awareness (sounds and words represent symbols) and phonemic awareness (words consist of sounds; [9]). Reading is essential for academic success and difficulties can lower learners' motivation and achievement across academic content areas. Most students with learning disabilities have difficulties in reading comprehension [20].

Schunk and Rice [21–23] conducted self-regulation and self-efficacy studies on children with reading disabilities. These studies demonstrated that through modeling, goal setting, self-directed practice, and feedback on the value of applying strategies, students' self-efficacy for reading comprehension and their performances could be increased. More recent studies have focused on specific self-regulated learning strategies such as self-monitoring to improve self-efficacy for students with reading disabilities [24]. Dyslexia constitutes 3–10% of reading disabilities [25]. These students face academic challenges including sustaining motivation to learn. Self-monitoring involves keeping track of whether one's targeted behavior has occurred. It is one of the most important and heavily researched strategies for self-regulated learners with disabilities [26].

Kanani et al. [24] randomly assigned students with dyslexia to an experimental condition that involved self-monitoring training or a control condition where they received small group instruction. Students in both conditions were pre- and post-tested on self-efficacy and achievement and an additional assessment was obtained two months after the intervention. Results indicated that students who received self-monitoring training showed increased self-efficacy and higher achievement compared with students in the control group. Keeping track of one's performance can have a powerful impact on reading achievement and self-efficacy among students with dyslexia.

Research on interventions to help increase self-regulation and self-efficacy for reading on students with reading disabilities is limited. Much of the research has focused on students with writing disabilities using the Self-Regulated Strategy Development (SRSD) program. Mason [27], for example, studied struggling readers' comprehension of expository texts. The intervention included teaching SRSD strategies for writing and strategies to improve reading comprehension. The SRSD involved six steps including processes such as self-monitoring, self-instruction, goal setting, and self-reinforcement. The TWA strategy (Think Before Reading, While Reading, After Reading) provided students with the framework for better reading comprehension. Teaching struggling readers strategies for writing and reading expository texts can lead to better understanding. Students who are able to read informative texts and monitor their understanding are more likely to feel self-efficacious to do so. Providing specific strategies to students with reading disabilities enhances their cognitive judgments of personal capability to comprehend when reading and reduces the likelihood of feelings of diminished self-worth due to repeated failed reading attempts [28].

Tabassam and Grainger [17] examined self-efficacy differences among elementary students with ADHD, with comorbidity (ADHD and a learning disability), and students without any disabilities. Students were administered measures of self-efficacy and attributions (beliefs about perceived causes of outcomes). Students with learning disabilities had been previously shown to attribute failures to internal causes such as low ability and successes to external causes such as luck. These students experience repeated failures and high levels of frustration. They compare themselves to other classmates who do not struggle in the same way they do. This internalization of feelings contributes to attributing their performance inward, toward themselves. Findings from this study revealed that both groups of students with disabilities experienced lower self-efficacy and attributional beliefs directed toward themselves than their peers without disabilities.

3.2 Sources of self-efficacy

Students with disabilities often struggle academically and are less likely to set high goals, persist when faced with difficulties, or attribute failure to effort and poor strategy use [29]. The sources of self-efficacy can help students with disabilities feel more self-efficacious. Teachers who give students opportunities for success (enactive mastery) can build self-efficacy by assigning moderately challenging tasks that the students can succeed at with effort [12, 30]. Students with learning disabilities tend to experience anxiety and nervousness. They are also often aware of the learning challenges they face. Teachers can provide models (vicarious learning) such as peers or others who can demonstrate skills and strategies to complete the targeted task. Teachers can also take advantage of access to the Internet by using YouTube videos or other video models. Videos provide learners with opportunities to repeatedly watch the model because they can stop and restart the video as often as needed. This can provide specific information about how to approximate the desired behavior.

Social or verbal persuasion provides learners with information that can help sustain motivation [6]. Teachers can use verbal persuasion by reminding students of what needs to be done as they encourage them to perform the activity [30]. Verbal persuasion must be genuine and credible and followed by constructive feedback upon task completion. Research shows the opposite can happen as well. Students who report feeling that their teacher did not acknowledge how hard they worked or who made comments that suggest their work was not up to par may feel lower levels of self-efficacy [12].

Students with learning disabilities may experience physiological and affective reactions. A history of repeated failures and frustrations can result in high levels of anxiety, frustration, distress, and learned hopelessness. These negative feelings and thoughts can trigger additional stress and agitation [28]. Teachers can provide students with relaxation training and refer them to counseling to help work through feelings of anxiety. Teachers and counselors can teach students strategies for coping with irrational or fear-of-failure thoughts, which can lower self-efficacy [30]. In addition, providing students with disabilities opportunities to practice and emulate tasks to be done with constructive feedback from the teacher may help reduce anxiety when the tasks are ready to be carried out for a grade [1].

3.3 Self-efficacy calibration studies

Students who can accurately estimate their skill for performing a task are considered accurate calibrators [31]. Exceptional students often overestimate their capabilities [16], which can result in exerting less effort in preparing for a task. Struggling students may miscalibrate their self-efficacy because they underestimate the task demands [16]. DiBenedetto and Zimmerman [32] found that students who were at-risk for learning science overestimated their capability to perform well on a designated test.

Crane et al. [33] examined calibration accuracy among special education students using academic (vocabulary words) and nonacademic (arranging six tiles to tell a story) tasks. Results indicated that even though students performed comparably on the academic and nonacademic tasks their self-efficacy was much higher for the nonacademic tasks. When tested on a completely new task, their calibration for completing the task worsened. They continued to report high self-efficacy beliefs even when they did not get any answers correct. These findings suggest that teaching metacognitive strategies—helping students determine when they know something and when they do not—might improve self-efficacy calibration [28].

In the Klassen and Lynch [12] study, adolescents with learning disabilities rated their self-efficacy higher than would be expected given their low performance. Each of the teachers who was interviewed indicated that the students with learning disabilities lacked an awareness of their strengths and weaknesses and that this lack of self-knowledge influenced their self-efficacy judgments. The teachers suggested that students overestimated their self-efficacy as a means of self-protection. Students with disabilities may have poor metacognitive awareness and feel they have personal limitations. These beliefs may lead them to overestimate self-efficacy to protect their self-images [28, 34].

4. Implications of theory and research for educational practice

Theory and research suggest implications for educational practice. Learners with learning disabilities may hold inaccurate self-efficacy beliefs. They may judge their learning capabilities lower than they actually are, or conversely, they may feel overly optimistic about what they can learn. Either situation can be problematic for motivation and learning.

One implication is that ways to convey information to students about their capabilities should be integrated into instructional approaches. Giving students practice with feedback provides performance information. Vicarious information can be conveyed through live or video models. Teachers can encourage students with verbal persuasion, and negative emotions that may lower self-efficacy can be addressed by showing students what they have accomplished.

Research also suggests several mechanisms whereby self-efficacy can be developed. Methods that are beneficial for self-efficacy development include having learners set realistic and short-term goals, teaching then strategies having them practice applying these, and having them monitor their learning progress. Although students with disabilities often need skill remediation, they also need information that conveys to them that they are capable of learning and performing well.

A sense of collective self-efficacy can be developed when students work in groups. It is important that students with disabilities contribute productively to the group. Teachers should structure group tasks such that all members have responsibilities and can demonstrate learning and performance accomplishments.

5. Future research directions

Existing research documents the importance of self-regulation and self-efficacy for academic performance and achievement among learners with disabilities. Future research directions should include sociocultural influences, technology uses, and out-of-school contexts.

5.1 Sociocultural influences

As schools become increasingly diverse, it is important to study self-regulation and self-efficacy development among students from different cultures. *Culture* refers to beliefs and value systems that can influence motivation and learning [35]. In a recent research review, McInerney and King [36] found that most studies do not use culture, race or ethnicity as independent variables; rather, countries outside of the U. S. accept self-regulation processes such as self-efficacy as part of a theoretical framework and examine these processes within different learning contexts. McInerney and King discuss the challenge with finding studies that examine cultural influences on core theoretical constructs that have been primarily established in the U. S.

A cultural dimension that has been explored widely in self-efficacy research and is relevant to self-regulation is individualism and collectivism. Individualistic cultures tend to stress independence and individual initiative, whereas collectivist cultures emphasize group identity and "we" consciousness [37]. The United States and Western European countries are high in individualism, whereas Asian cultures tend to be more collectivist. Researchers comparing these cultures typically find that individuals from collectivist cultures judge self-efficacy lower than do those from more individualistic cultures including when performances are equivalent or higher. Further, the lower self-efficacy beliefs are typically better calibrated with actual performances [37]. These results suggest that collectivist cultures may promote modesty in self-efficacy judgments. They also raise the issue of whether collective self-efficacy may be a better predictor of performance in these cultures than individual self-efficacy [37].

Classrooms have students from myriad cultural backgrounds. While self-regulation and self-efficacy may be universal, the challenge for educators is to understand how students' values, beliefs, and sociocultural experiences can affect self-regulation and self-efficacy. Researchers have not examined in depth the roles of cultural variables in self-regulation and self-efficacy among students with disabilities. More cross-cultural studies are needed examining the potential culturally-specific influences on learning, performance, and self-regulation.

5.2 Technology uses

Much research related to technology has focused on measuring students' self-efficacy for using computers [38]. A literature review of computer-based learning environments (CBLEs) examined relationships between computer self-efficacy, self-regulated learning processes, and performance outcomes, and found three significant outcomes [39]. The first is that there are both behavioral factors (e.g. familiarity with being in a CBLE) and psychological factors (e.g. positive attitude and curiosity about being in a CBLE) that are positively related to computer self-efficacy. Second, computer self-efficacy is positively related to self-regulated processes such as navigational strategies and metacognition. Third, computer self-efficacy is related to learning outcomes.

A new area of inquiry is game-based learning. Video gaming can be used to increase and sustain motivation and interest, and help students make connections to real-life situations [40]. Video games capture learners' attention, are fun and exciting to play, often involve cognitive flexibility and the ability to strategize, are familiar to many learners, and can be developed to target learning goals. Good instructional games can take advantage of learners' attention by allowing them to identify with avatars that represent the players or other characters (i.e. a marine biologist), which helps boost intrinsic interest in the learning.

The role that technology may play in the development of self-regulation skills and self-efficacy in various settings (e.g., CBLEs, gaming, online social media) should be investigated among students with disabilities. The motivational inducements afforded by technology may have the desirable effect of gaining and holding learners' attention on the learning situation, which should enhance their self-efficacy as they experience success. In addition, cell phones and other electronic devices may help students with disabilities self-monitor by setting alarms for due dates for assignments or reminders to be working on school assignments. But conversely, the extra features (audio, video) of technology may prove distracting and tax students' working memories, which would have the opposite effect. Added research is needed that explores variables associated with technology to determine how instructional conditions can be ideally structured for students with disabilities.

5.3 Out-of-school contexts

Most self-regulation and self-efficacy research has been done with learners in formal academic settings (e.g., classrooms). But much learning occurs outside of these settings such as in homes, during volunteer activities, and in the context of mentoring interactions. Homework—a key instructional variable—requires good self-regulatory skills to complete satisfactorily.

To test the roles of self-regulation and self-efficacy in motivation and learning among students with disabilities, more research is needed in nonacademic settings where students learn. For example, mentoring relationships can enhance mentees' self-regulation and self-efficacy [41]. Mentors are models who show how tasks are completed and what proficiency levels are required for successful completion of tasks. They demonstrate self-regulation and how to cope in challenging situations. Through the development self-regulation, mentors can foster mentees' self-efficacy and help them become independent, adaptable, and self-directed [42], but further research is needed on mentoring variables that may impact self-efficacy among students with disabilities such as the types of individuals who may make good mentors.

Another issue is that self-efficacy sources outside of school may conflict with those experienced in school. Students may develop self-efficacy beliefs in school through performance accomplishments, exposure to competent models, and teacher encouragement, but those same positive sources may not be present outside of school. An important research question is how students reconcile discrepant self-efficacy information. It may be valuable to provide instruction to parents and others outside of school who work with students with disabilities on how to inculcate self-regulatory skills and positive self-efficacy beliefs to foster motivation and learning.

Author details

Dale H. Schunk[1]* and Maria K. DiBenedetto[2]

1 Department of Teacher Education and Higher Education, School of Education Building, The University of North Carolina at Greensboro, Greensboro, NC, USA

2 Bryan School of Business and Economics, The University of North Carolina at Greensboro, Greensboro, NC, USA

*Address all correspondence to: dhschunk@uncg.edu

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Section 2

Assessment of Learning and Behavioral Disorders

Chapter 4

Neuropsychological Assessment of Children with Learning Disabilities

Sandro Misciagna

Abstract

Learning disabilities are a heterogeneous and common group of disorders that have a relevant impact on children's academic function. The most common learning disorders consist of dyslexia, dyscalculia, dysgraphia or other non-verbal learning disorders. These disorders are commonly associated with neurological or behavioral disorders such as attention-deficit hyperactivity disorders. Understanding of cognitive and mental problems of children with learning disorders is an interesting challenge, and various approaches have been applied for their study, including medical, genetic, educational, epidemiologic and experimental psychologist. Nowadays, clinical neuropsychological approach, which is based on neurocognitive models, is one of the best existing models for description and interpretation of learning disorders. This approach assumes that there is a strong relationship between the various learning deficits and brain functioning. This paper consists of a descriptive review about components of a specialized neuropsychological approach that can be applied for the assessment of children with learning disabilities.

Keywords: learning disabilities, learning deficits, learning disorders, dyslexia, dyscalculia, math disorders, dysgraphia, neuropsychology, neurocognitive model, neuropsychological assessment

1. Introduction

The term Learning Disability means a heterogeneous group of disorders in one or more psychological processes involved in understanding or in using language, do mathematical calculation [1], or deficits in other cognitive functions as attentional or perceptual deficits that can cause particular children learning difficulties [2].

Learning disabilities affect approximately 10% of US children and unfortunately are often unaddressed or incorrectly addressed by schools or family [3].

The most common learning difficulties regard language and consist of an imperfect ability to listen, speak, read, write and spell. Reading and/or spelling disorders are present in 3–11% of children worldwide in particular, combined reading and spelling disorders have a prevalence of 8%, isolated spelling disorders have a prevalence of 7%, while isolated reading disorders have a prevalence of 6% [4].

About 20% of children and adolescents with reading disorders develop emotional disorders, especially anxiety disorders and less frequently depressive or behavioral disorders [5]. Children with reading and spelling disorder, if not diagnosed and treated, often fail and do not go to school with relevant consequences for professional education and for psychological well-being during adult age [6].

Children with learning problems are generally first identified by teachers for their behavioral disorders, participation behaviors or cognitive difficulties [7].

One of the most common learning disabilities is dyslexia that is a learning disorder characterized by reading problems, a complex cognitive function that requires many abilities that include: letter identification skills, phonological skills (converting letters into sounds), grapheme skills (visual generation of sound on the bases of previous learned sounds), sequencing skills, short-term memory skills to retain information from written material [8].

The evaluation of children with Learning Disorders must consist of a clinical evaluation and a comprehensive assessment of all areas of suspected disability including sensory functions, behavioral and emotional factors, occupational skills, intellectual ability and cognitive functions [9]. A comprehensive evaluation can be conducted by medical doctors, psychologists, social workers, school nurses, speech pathologists, occupational and physical therapists. Child neuro-psychiatrist and developmental-behavioral pediatrician can conduct medical evaluations oriented to identify medical and mental health conditions that could be potentially treated such as primary sensory impairments, primary neuro-psychiatric conditions, or intellectual deficiency. Outside school, it is also important to conduct an evaluation of student's parents for the evaluation of other cultural or socioeconomic conditions that can contribute to learning disorders.

2. General cognitive assessment

It is commonly accepted that neuropsychological assessment is very useful for children with developmental disorders concerning particular learning and attention disorders. According to American Academy of Clinical Neuropsychology, cognitive evaluation helps clinics and therapists to identify how problems with the brain relate to difficulties at school and study neurological and psychiatric disorders. Neuropsychological assessment focuses on identifying if children have a problem with cognitive functions as reading, spelling, or math. Examination of cognitive functions of children with learning disabilities must examine in particular memory, attention, problem-solving functions, math skills and language functions. Cognitive psychologist evaluates these functions using a variety of methods specifically designed to identify why the child has learning or attention problems [10].

Cognitive and neuropsychological evaluations must be as part of a comprehensive assessment of learning disabilities even if only little evidence supports a routine assessment of cognitive functions for children with learning disabilities.

Neuropsychological and modern neuroimaging or neuro-functional studies conducted in particular on individuals with cognitive deficits have demonstrated the existence of neuronal networks so that deficits in specific cognitive functions have characteristic neural substrates [11].

Visual processing deficits are typically associated with abnormalities of occipito-parietal areas [12], while auditory deficits are secondary to dysfunction in temporal lobe areas [13].

Attentional and executive functions deficits are usually explainable by a dysfunction in neuroanatomical subsystems of prefrontal cortex of both hemispheres [14].

Word learning deficits are related with left temporal and in particular, hippocampal dysfunctions [15] while spatial learning and visuospatial deficits are usually associated with lesions of right parietal and occipital cerebral areas [16].

Children with math disorders have a prevalent dysfunction of connectivity in temporo-parietal and parietal areas of the right hemisphere [17], but also in connection between frontotemporal and parietal regions of left hemisphere [18].

Language functions are prevalently lateralized in dominant hemisphere (usually the left), while visuospatial functions are prevalently lateralized in non-dominant hemisphere (usually the right).

Consequently, children with verbal learning disabilities such as difficulties in reading or writing have a prevalent involvement in left hemisphere, while children that show nonverbal learning disabilities such as difficulties in perceptual reasoning or understanding math have a prevalent involvement in right hemisphere.

However, language learning reflects activation of complex neuronal networks: for example, frontal cortex and basal ganglia are relevant in learning phonology and grammar of a new language [19] or hippocampus, temporal lobe and putamen have dysfunction in subjects with dyslexia [20]. Specific cerebellar regions also contribute to cognitive functions in particular in reading development, verbal short-term memory and emotional behavior [21].

Studies on cerebral lateralization of motor functions, especially handedness, show that these appear to be related to the lateralization of language functions [22]. In fact left-handedness has been linked to dyslexia, other language learning disorders and autism.

Therefore, different tools have been successfully employed to assess lateral dominance for the eyes, hands and foot across different behavioral domains such as brushing teeth, cutting a paper, throwing a ball, kicking a ball. An example of one of these instruments suitable for adults is the Harris test of Lateral Dominance [23].

Psychometric assessment is essential for identification of correct cognitive treatments, permitting better treatment planning and interventions that match specific cognitive profiles and can be used as follow-up tool [24].

Examples of neuropsychological tests that can be used for a general cognitive assessment are represented by fixed batteries such as Halstead-Retain Neuropsychological battery [25], the Luria-Nebraska Neuropsychological Battery [26], the Boston process approach [27], Kaufman Assessment Battery for Children [28] or by specialized flexible batteries.

However, psychometric measures have many limitations. Neuropsychological tests are less reliable for identifying learning disorders in younger students (students in first or second degree) than in older since in early grades they do not participate in formal education process [29]. Some school teams compare student's performance using national norms, while others use local norms [30]. Student's performance on a psychometric measure cannot reflect the real performance in the classroom. For example, in a test setting, the evaluator is inclined to speak more slowly and gives more time to assure a correct execution of a psychometric task. Standardized measures test scores to determine presence or absence of a disability are chosen somewhat arbitrarily. The most used cut-offs are two standard deviations below mean standard score or a score below the 25th percentile, considering the average performance score as the 50th percentile [31].

Psychometric tasks not always have diagnostic stability that is the validity of the psychometric measure over time. Estimates of diagnostic stability range between 30 and 70% [32].

3. Visual processing assessment

Visual modalities are the primary bases of most academic learning. Consequently, visual processing must be taken in great consideration during the assessment of learning disorders. The first step of the assessment consists of ruling out peripheral visual problems. Neuropsychological visuospatial tests have the aim to assess integrity of visual system.

Specialized tests of visual processing are now widely used in clinical setting of children with learning disorders. According to Muriel Lezak [33], the examiner must explore six areas critique in visual perception that are: visual scanning, color perception, visual inattention, visual recognition, visual organization and visual interference.

In particular, visual scanning deficits are associated with cerebral lesions and acquired learning disorders causing deficits in reading, writing, performing calculation and telling time [34]. Other learning disorders associated with visual recognition disorders are: spatial dyslexia and dysgraphia with spatial disturbances [35].

4. Auditory processing assessment

As visual processing, also auditory processing is fundamental to learning.

Non-verbal auditory processing has a possible relationship to non-verbal learning disorders so that it has been described within a framework of non-verbal learning disorder [36]. For example, subjects who have an impairment in interpreting voice intonation or prosody may have non-verbal learning disorders that negatively affect their emotional functioning. Children with socio-emotional processing disorders have been considered by some neuropsychologists as affected by a subtype of learning disorders secondary to right hemisphere dysfunction [37]. Therefore, neuropsychologists must execute a specialized auditory assessment finalized to exclude peripheral and central auditory problems before the general clinical neuropsychological assessment of children with learning disorders.

Examples of neuropsychological instruments that can be used to assess auditory perception in terms of audition acuity, auditory discrimination, auditory inattention, auditory verbal and non-verbal perception are described in Lezak's manual [33].

5. Behavioral and socio-emotional assessment

Learning disorders can have comorbidity with many behavioral, social-emotional and psychiatric conditions. Distinction between cognitive and emotional domain is an unresolved issue in the assessment of children with learning disorders.

There are some evidences that socio-emotional processing deficits related to right hemisphere dysfunction could be considered a subtype of developmental learning disabilities [38].

The assessment of emotional functioning should focus first on psychiatric conditions that could be the primary cause of individual learning problems. During the decision-making process, neuropsychologists should realize an assessment of the mental status of the patient through observation of patient's behavior and use of a clinical interview. In the diagnostic process, neuropsychologist should determine the most relevant diagnosis depending on the background in psychopathology.

Same symptoms, especially behavioral problems, are highly recognizable, while common mental health problems of low mood and anxiety can easily get lost [39].

Psychiatric disorders that must be considered include personality disorders, mood disorders, anxiety disorders, somatoform disorders, thought disorders, dissociative disorders and eating disorders. If there is evidence of presence of a primary psychiatric condition, learning disorder diagnostic process must be delayed until completing a definitive psychiatric diagnostic process.

Antisocial personality disorders and conduct disorder are psychiatric disorders that include aggressive behavior that can causes school dropouts, juvenile delinquents and could be associated with learning disorders. However, different studies conducted on children with learning disorders have not found a clear relationship with antisocial personality disorders [40].

Anxiety, depression and obsessive-compulsive disorders are conditions that can produce behaviors and thoughts disorders; these disorders are often more difficult to recognize and diagnose.

Depression is probably the condition most investigated in children with learning disorders demonstrating that it is rather consistently represented [41].

According to the 'Cerebral Dysfunction Hypothesis' regarding relationship between learning disorders and socio-emotional disorders [42], it asserts that there are the same underlying mechanisms such as constitutional factors, prenatal, perinatal and postnatal factors that can account for both learning development and socio-emotional functioning. This neurobiological hypothesis, based on clinical observation of children, can explain the coexistence of such disorders in many individuals.

Some of the principal assessment approaches commonly used with children consist of investigation of psychiatric symptom severity and relative patterns, analysis of behavioral contingencies affecting behaviors, assessment of ecological interaction between child and outside world and assessment of quality of interaction between child and carers [39].

Psychiatric symptoms and disorders have been embodied in DC-LD (Diagnostic Criteria for psychiatric Disorders for use with adults with learning Disorders) and more recently in DM-ID (Diagnostic Manual of Intellectual Disability), which includes specifically adapted criteria for children and adolescents [43].

There are excellent clinical instruments that can be used for the assessment of emotional disorders, behavioral disorders and for an ecological approach. One of this is the Child and Adolescent Psychiatric Assessment Schedule (ChA-PAS) [44] which consists of a structured interview about children mental health problems. Other general symptom rating scales designed for use in child psychiatry are the Achenbach child behavior checklist [45] and the developmental behavior checklist [46] which is the only behavioral rating scale specifically designed for children with learning disabilities.

6. Intellectual abilities assessment

Intelligence tests are usually part of the assessment of cognitive skills, and the presence of a low Intelligence Quotient (IQ) is commonly a 'red flag' for a possible learning disorder even if IQ scores do not represent the capacity of a child to learn [47].

Neuropsychological assessment of intellectual abilities is useful to document whether there is a discrepancy between IQ and academic achievement and to make a differential diagnosis between learning disorders, mental retardation and other psychiatric conditions.

Most useful for the assessment of learning disorders are the performances in Verbal IQ and Performances IQ scores and the subtest score comparisons rather than the Full-scale IQ.

The so-called 'Verbal-Performance Split', consisting of a significant difference between Verbal and Performance IQ scores, suggests a difference in function between language dominant hemisphere (usually the left hemisphere) and non-language hemisphere (usually the right hemisphere).

It is well documented that the Verbal-Performance split can differentiate unilateral left and right brain damage groups of children even if it is not always indicative of a lateralized cerebral dysfunction in children with learning disorders [48].

Furthermore, according to the theory of multiple intelligences, human qualities such as personality, temperament and character are essential ingredients in achievement and cannot be measured with IQ [49].

Examples of tests to assess children intellectual abilities are: Leiter international Performance Scale [50], Standford-Binet Intelligence scale [51] and Wechsler Intelligence scale for children [52].

7. Attention assessment

Attention is a cognitive function on which depend most of cognitive functions. General attention is the ability to maintain a coherent thought, while selective attention is the ability to focus on a single stimulus to the exclusion of others. General attention is usually assessed in terms of mental status, while selective attention is generally assessed psychometrically and is often present as a symptom of Attention Deficit Hyperactivity Disorder (ADHD) in comorbidity with other learning disorders.

Selective attention is considered a necessary condition for most of school learning, ability to complete assignments, performance and even interpersonal relationship.

Some studies found a strong relationship between reading speed and visual, auditory and tactile reaction times in normal children [53]. Reaction times have resulted slower in particular in dyslexic children [54]. Other researchers found no differences between good and poor readers on a scanning task or a reaction time task, but a difference in overall time required to discern whether a word was one of two or three target words [55] so that they interpreted this finding as implicating long-term memory retrieval processes rather than reaction time.

Examples of neuropsychological tests used for an assessment of attention functions in children are: Conners' continuous performance test [56], Gordon diagnostic system [57], Children paced auditory serial addition test, [58] and test of everyday attention for children [59].

Many computerized tools have also been prepared to assess attention such as the test of variables of attention (TOVA) that is available to assess in particular sustained selective attention [60].

8. Executive functions assessment

Children with learning disabilities have frequent deficits in working memory and processing speed, which are basic cognitive process for executive functions.

Executive functions consist of ability to organize, plan, problem-solve, initiate or inhibit response, be flexible in relation to feedback and self-monitor mental control.

Deficits in executive functions are rather heterogeneous in nature and usually lead to difficulties with time management, organization of activities or losing things.

Children with ADHD have difficulties with some of these mental control functions such as organizational skills, complex problem-solving and self-monitoring [61].

Evaluation of executive functions is an essential moment of neuropsychological assessment to predict how well an individual will perform in a traditional environment.

Examples of tests generally employed to assess prefrontal functioning are: Children's category test [62], Delis-Kaplan executive functioning system [63], go-no go inhibition tasks [64], Stroop color-word interference task [65], Tower of London [66], trail making test part B [25], verbal fluency test [67], Wisconsin card sorting test [68] and controlled oral word test [69]. These measures, in combination with behavioral history and observation of behavior during the execution of the tasks, typically comprise assessment in this cognitive area.

9. Memory assessment

In the history of scientific thinking about memory, for a long time there was the assumption that memory was a unitary and monolithic entity [70].

In the 1960s and 1970s, it started to spread the notion of the existence of two distinct systems called short-term and long-term memory systems. Subsequently, in the 1970s, researchers started to explore multiple long-term memory systems regarding episodic and semantic memory [71].

From 1990s, also short-term memory was considered a multicomponent system consisting of a phonological loop, a visuospatial sketchpad and a central executive system [72].

In groups of children with learning disorders, researchers have often found short-term memory deficits [73] as well as long-term memory deficits [74]. Other researchers argued that children with learning disorders have more difficulties than non-disabled children in acquiring information, but once they have learned it, they do not differ in retaining the information [75].

Traditional memory assessment consists of what is now considered to be the hippocampal declarative memory such as episodes and facts [76] and typically consists of administration of memory testing that assess short-term (e.g., immediate recall of words), long-term (e.g. delayed recall of words or delayed execution of geometric figures) across auditory/verbal and visual/visuospatial modalities. In the assessment of long-term memory, neuropsychologists commonly use subtests of free recall and subtests of recognition with cues.

Most used tests to assess these aspects of memory include: the Wechsler memory scale [77], the California verbal learning test for children [78], children's memory scale [79], test of memory and learning [80], the wide range assessment of memory and learning [81], Rey auditory verbal learning test consisting of immediate and delayed recall of 15 words [82] and the memory condition of the Rey-Osterrieth complex figure drawing test [83]. Each of these tests has age norms and standard scores.

The interpretation of memory tasks in individuals with learning disabilities can be very complex since this function has many relationships with other neuropsychological functions and since memory performance may require language and auditory processing, visual/visuospatial processing and motor abilities. Memory performance is also more difficult to assess in children with associated behavioral disorders or psychiatric conditions.

10. Visuospatial assessment

Visuospatial function involves the ability to discriminate the position of objects in space and is a fundamental ability related in particular to reading function. An inadequate visual-spatial function can cause difficulties in many cognitive domains such as reading (involving spatial components of some letters such as b, d or p), math abilities (such as misaligning numbers) or handwriting (for example, in putting spaces between words). Deficits in visuospatial functioning can cause impairments in reading (spatial dyslexia) or in using math (spatial dyscalculia).

A deficit in this cognitive domain can cause other problems in school such as difficulties in reading a map, difficulties in assembling tridimensional objects as models or puzzles.

Visuospatial abilities often require integrity of other cognitive functions; for example, a drawing task usually used to assess visuospatial function requires integrity of motor skills than results in activation of both right and left hemispheres. In the years, learning disorders associated with visuospatial disorders have been labeled as non-verbal learning disorders [84], non-verbal perceptual-organization-output disability [85] and right hemisphere deficit syndrome [86]. More recently, these types of non-verbal learning disorders have been shown to be associated with symptoms of ADHD, depression [87] or other socio-emotional disorders [37].

In past years, performances in visual-perception have been extensively studied by using the Bender Gestalt test [88] or the Frosting developmental test of visual perception used to assess visual perceptual performances in children with developmental learning disorders [89].

More recent neuropsychological assessment of visuospatial functioning includes test that explores visual organization such as Hooper visual organization test [90], sensory-perceptual examination [91], test of copying simple or complex geometric figures such as Rey-Osterrieth complex figure test [83], free drawing objects as a clock, tasks of block assembling in two or three dimensions, tasks of puzzles assembling as the ones proposed in Wechsler intelligence scale for children [92].

11. Math abilities assessment

Math disabilities are less understood, and there are only few studies of individuals with math disorders if compared with those with dyslexia. The general terms 'acalculia' and 'discalculia' have been used to describe developmental and learning math disorders in children [93].

Different researchers have suggested the existence of two distinctive subtypes of math disorders in children with learning disabilities that regards children having only math disorders and children having both math, reading and spelling disorders [94]. Some authors hypothesized that children with isolated math disorders had only right hemisphere dysfunction while the combined group had a prevalent left hemisphere dysfunction [94], while a subsequent study replicated only some of these findings since it was not replicated in girls having math only disorders [95].

Errors most frequently found in children with math learning disorders consist of spatial error (such as difficulties in placing numbers in columns), visual errors (such as difficulties in reading arithmetic signs), procedural errors (such as omission or addition of a step of the arithmetical procedure, or application of a learned rule for a procedure to a different one), graph motor errors (as difficulty in forming the appropriate numbers), judgment errors (errors that imply impossible results, such as one in which the result of subtracting is bigger than the numbers being subtracted), memory errors (such as problems in the recall of multiplication tables or arithmetical procedures) and perseverations (such as difficulty in changing from one task to another one) [94].

Batteries used to explore math abilities commonly include some basic psychological and neuropsychological tests directed to assess not only calculation abilities, but also language, memory, perceptual abilities, concept formation and praxis abilities. Examples of arithmetical tests used are tasks that explore in general abilities to do written or mental arithmetical operations (additions, subtractions, multiplications and divisions) and to solve arithmetical problems.

The WAIS arithmetic subtest [96] is probably the most widely used instrument when testing for calculation abilities in neuropsychology even if it assesses just single aspects of numerical processing and is very difficult to administer to patients with language and memory disorders.

One of the best standardized neuropsychological batteries used to explore math abilities developed by a group of European neuropsychologists is known as EC 301 [97] and consists of subtests that explore: counting abilities, dot enumeration, numbers transcoding, use of arithmetical signs, magnitude comparison, mental calculation, calculation approximations, placing numbers on an analogue line, writing down an operation, written calculation, perceptual quantity estimation, contextual magnitude judgment, numerical knowledge.

Other tests have been proposed as model for testing calculation abilities, as an extension of the EC301 [98].

12. Language assessment

One of the most common learning disorders is dyslexia, which is the term sometimes used interchangeably with reading disorder and is considered a learning disorder related to reading, recognition of words and interpretation of what is seen visually or heard auditory [99].

Neuropsychological studies have shown that there is not a single reading disorder but many different subtypes.

According to Border, there are three subtypes of dyslexia: dysphonetic, dyseidetic and dysphonetic-dyseidetic [100]. The subgroup of individuals with dysphonetic dyslexia is the largest (>60%) and is characterized by disability in developing phonic and word-analysis skills; in fact, they are unable to decode written words or to write them using phonic or sound principles. These individuals recognize the words on the bases of visual patterns but confuse words with similar visual patterns or meanings. The subgroup of individuals with dyseidetic dyslexia is characterized by disability in recognizing words by their visual configuration, but they are able to use phonic skills to read or do a correct spelling. These individuals have difficulty in developing a correct vocabulary and have misreading that involves phonic renditions, or they do misspellings. Finally, the subgroup of individuals with dysphonetic-dyseidetic dyslexia is characterized by individuals that combine both types of deficits and are unable to develop a sight and phonic dictionary; consequently, they are alexic.

Border classification is similar to other classifications, in particular that of Johnson and Myklebust, who divided dyslexic individuals in two subgroups: dyslexic with primary impairment in visual processing and dyslexic with primary impairment in auditory processing [84].

Researchers can discern the subgroup of dyslexia deficit by using screening tests that assess their ability to discriminate between known and unknown words and their ability to recognize words by sight and to recognize words by sound.

Bradley and Bryant have developed an interesting approach initially reading independent that consisted of testing children's ability in sound categorization before they started to read. The task consisted of giving the children three or four words and asking them to pick out the word that did not share a phoneme in common with the others. By using this task, they found that children who were poor at sound categorization they start lately to read and become backward in reading and spelling [101]. They hypothesized that reading deficiency would be caused by deficiency in phonological awareness. They argued that the initial insensitivity to rhyme and alliterations caused a subsequent reading impairment; in fact, if children initially impaired were given a special training, their reading ability was less impaired. Rutter and Yule highlighted how dyslexia in associated with other cognitive deficits such as disorders in temporal orientation, difficulties in perception of spatial relations, directional confusion, right-left confusion, difficulties in naming colors, difficulties in recognizing the meaning of pictures, inadequate cerebral dominance, bizarre spellings, but it is not clear if these correlations are casual [102]. Vellutino proposed that only a deficit in verbal processing is related to dyslexia, and when verbal components of the tests are removed, there is an improvement in cognitive performances [103].

When studying patients with dyslexia, examiner must study in particular performance on specific *test of left hemisphere function* such as verbal memory, verbal fluency, spelling, reading and arithmetic skills. Neuropsychological assessment of children with learning disorders should offer insight into the abilities sensitive to all areas of brain function. In fact, usually these children are not dyslexic or dyscalculic alone, but have different associated cognitive disorders. Tests should also be able to distinguish individuals with central reading impairments and those who have problems caused by emotional or environmental causes.

Studies conducted using *intelligence quotient test* in dyslexic children show low scores on four tests: arithmetic, coding, information and digit span [104]. This profile was confirmed in many studies and is referred as the ACID profile. Dyslexic children typically have a mean IQ score of about 100 and a mean full-scale IQ that averages about seven points lower than that of control children. ACID profile is typical for dyslexic children over 8, whereas children younger than 8 may often not show deficit in arithmetic and information subscales. This finding suggests that cognitive deficits in older children and adults could be secondary to the underlying impairment that produces dyslexia [105]. Deficits in digit span and coding could be more directly related to underlying impairment that produces dyslexia. Other researchers did not find emerging deficits in arithmetic and information but the impairments they did find were not pronounced, and the groups studied were quite young [106]. Study on dyslexic individuals by using Wechsler intelligence scale for children (WISC) demonstrated that WISC patterns are not useful for the diagnosis of very young children. IQ of dyslexic children is average even if very high scores are not found.

Using the *test of left-right differentiation,* there was not significant differentiation between normal controls and dyslexic children if they were both younger than 8 years. On the contrary, the control children performed better than dyslexic children did after the age of 8 years [105]. Word fluency tests demonstrated that differences between dyslexic and control children did not occur at an age younger than 8 years, too [105]. These results suggest that control health children have increasingly improved fluency performances, while dyslexic children remain almost static. In a neuropsychological study by using composite test batteries using tests sensitive to left and right function and functions of different cerebral lobes, dyslexic children have performance below standard deviation except in test sensitive to frontal lobe (Wisconsin card sorting test) and right parietal function (the Mooney Faces Test) [105]. In the same study, largest differences occurred on tests of verbal IQ, performance IQ, memory quotient, left-right discrimination and word fluency that are test sensitive to the function of parietal lobes and in particular left parietal lobe [105].

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Language learning disorders can be associated with attention deficits as happens in ADHD syndrome. Children with ADHD commonly have dyslexia, and children with dyslexia have twice ADHD, so that it is difficult to establish the primarily condition. If ADHD precedes dyslexia, it can accentuate reading difficulty. For this reason, *psychological assessment* should be performed before cognitive assessment.

Examples of neuropsychological tests that can be used for a general language assessment of children are: Boston naming test [107], the comprehensive test of phonological processing [108], expressive vocabulary test [109], Peabody picture vocabulary test [110] and token test for children [111].

Neuropsychological assessment of children with dyslexia or other language learning disorders must also include specific language measures such as word recognition, reading comprehension, reading rate, writing and spelling patterns.

Word recognition consists of the ability to decode words either within a text or inn isolation. An example of a task that explores word recognition of isolated words is word recognition subtest of the wide range achievement test [112].

Reading comprehension consists of the ability to derive a meaning from a printed page. This process requires adequate word recognition, knowledge of semantic and syntactic rules, as well as attentional abilities, memory and motivational states [113]. An example of task to explore children's reading comprehension is the test of word reading efficiency [114].

Reading rate consists of time required for word recognition and reading comprehension. In fact, dyslexic children have been found to be slower than normal riders [115]. Reading comprehension rates can be assessed with instruments as the Reating rate subtest of SDRT [116] and the Nelson Denny reading test [117].

Writing assessment is clinically useful to distinguish writing problems that are language-based from writing problems that are motorically based. Assessment of writing consists of production of writing samples approximately of one or two pages. The analysis of these samples can give information about many functions such as language organization (grammar, semantics and syntax), organization of thinking and other psychological factors (as tangential thoughts, mood disorders, lack of insight).

Finally, combination of *spelling tasks* with words recognition tasks is useful to classify dyslexics in dysphonetic (unable to do a correct spelling, blend letters and syllables), dyseidetic (with a poor vocabulary probably due to problems with word gestalt) or with mixed dyslexia (with both dysphonetic and dyseidetic disorders). Assessment of spelling can be done with specific spelling tests designed to be used for children [118].

13. Conclusions

Learning disabilities cause cognitive difficulties in children that lead to less academic results than expected for individual potentials.

Cognitive assessment of children with learning disabilities and behavioral problems is very complex, but useful procedures have been planned to determine a correct diagnosis and provide modifications and interventions for optimize learning.

Identification of risk factors for learning disabilities, multifactorial evaluations with examination of potential neurologic or genetic conditions associated with learning disorders and correct diagnosing using appropriate neuropsychological tools are useful to formulate an individualized education plan that can prevent dropping out of school, enhance their life and support their families.

Further studies are needed regarding the study of neurocognitive framework and neuropsychological tools for the assessment and definition of neuropsychological profiles of children with learning disorders.

Author details

Sandro Misciagna
Neurology Department, Belcolle Hospital, Viterbo, Italy

*Address all correspondence to: sandromisciagna@yahoo.it

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Chapter 5

Examining Learning Disabilities in Schools through an Intersectional and Equitable Lens

Enoch Leung

Abstract

This book chapter examines the intersection between learning disabilities (LD) and other marginalized identities to understand the diverse experiences of students with LDs and the disproportionalities that exist in LD identification and support in schools. Largely driven by the history and evolution of inclusion of disabilities in schools, Response to Intervention (RtI) arose as a model designed to increase academic performance among students with and without disabilities. Though RtI is a model shown to minimize inappropriate identification of LDs, intersectionality must be taken into consideration to understand the disproportionate representation of culturally and linguistically diverse (CLD) students in special education. Data from the National Assessment of Educational Progress suggest social factors (e.g. socioeconomic disadvantages, racial and ethnic intersection) as a potential cause for disproportionate representation and points to a need to further understand the disproportionality of different groups of students being over- or under-identified to receive special education services.

Keywords: Learning Disability, Equity, Intersectionality, Education, Diversity, Culture

1. Introduction

Approximately 150 million students 18 years old and under have a disability label that qualifies them to receive special education services in schools [1]. In the United States, many students from minority groups (e.g., English learners, ethnic-racial minority, low social class) were overrepresented in special education. The primary reason for the overrepresentation is due to the teachers' lack of cultural knowledge and lack of culturally responsive instruction that is adequate and responsive to their diverse students' needs [2]. Though the Individual Disabilities Education Improvement Act [3] was established to address supporting students with disabilities in providing adequate education, the disproportionate overrepresentation of students from marginalized groups generate a needed discussion surrounding the inequities present in learning disability (LD) referral and identification.

Teachers' lack of cultural competence in their instruction leads to a broader issue surrounding culturally responsive instruction that has shown to be effective in responding to the needs of their diverse students [4]. The question arises whether the existence of LD is a result of neurobiological differences that lead to difficulties in learning [5] or social factors [6]. For example, dyslexia is increasingly being debated whether it is a valid difficulty [7]. One can consider the societal implications of being a poor reader or having inadequate mathematics skills. Rather than placing the disability limitation on the individual person's physical or mental limitation as postulated by the medical model of disability [6], the social model of disability focuses on the environment surrounding the individual, identifying systemic barriers, derogatory attitudes, and social exclusion making it difficult for the individual to function appropriately [6]. From this perspective, one questions the purpose of having a LD label as the basis for decision making in education. As there are multiple approaches to identifying and supporting students with LDs, it is critical to understand, through a social model of disability perspective, how an LD identification can benefit students with LDs.

As there is no "gold standard" to indicate what is or is not considered an LD, the approaches to identifying and supporting students with LDs do not appear to be strongly evidence-based. The social model of disability focuses on understanding how school processes such as LD identification result in inequitable assignments to specific groups of students including racial-ethnic and linguistic minorities, low socioeconomic class, and boys [6, 8]. However, looking at LD through a social lens brings to light further questioning on the issues surrounding LD identification such as the disproportionality of identification based on social circumstances such as intersectional identities of sex, class, and ethnicity. It may be problematic to simply identify and assign the LD label to students based on cognitive measures that may be subjective in nature and influenced by social factors. This book chapter attempts to understand the societal issues surrounding LD identification through an intersectional lens and its implication on education. This book chapter will be contextualized in the North American context (including both United States and Canada) to understand the social factors (e.g., socioeconomic disadvantages, sex differences, and racial and ethnic intersection) as a potential cause for disproportionate representation.

2. Learning disabilities

Learning disability (LD) is a label typically assigned to students based on their achievement levels, behaviors, or communication skills [9]. One federal disability category, 'Specific Learning Disability', encompasses all of the various LDs including disabilities like dyslexia (reading disability), dyscalculia (mathematics disability), dysgraphia (writing disability), and expressive language disability [9]. It is important to note that labels such as attention deficit/hyperactivity disorder (ADD/ADHD), autism spectrum disorder (ASD), and Down syndrome are not categorized under 'Specific Learning Disability'. Though LD is commonly misconstrued as students with low intelligence quotient (IQ), this can lead to a misperception equating LD with students with poor educational outcomes rather than an inequality in the school environment for students' learning opportunities [9, 10]. Due to the lack of gold standard in identifying LDs, the different approaches present in identifying LD brings into question what the LD label represents and whether placement into special education benefits students' learning opportunities.

Around the 2000s, there were three dominant cognitive discrepancy methods to identify LDs: 1) ability-achievement discrepancy model, 2) low-achievement model, and 3) intra-individual discrepancy model [11]. The ability-achievement discrepancy model assigns students the LD label when their achievement levels are lower than expected given their overall IQ. In this model, the discrepancy must not be attributable to the student's social background or behaviors [12]. The second model, low-achievement model assigns a LD label to students who are unexpectedly performing below a certain achievement level [12]. Lastly, the intra-individual discrepancy model assigns students a LD label if they show an uneven profile, defined as specific cognitive measures indicating strengths in some areas and weakness in others [12]. However, these three models have been criticized for not systematically identifying students who do have an LD as measures of achievement may not accurately assess ability but rather contextualized knowledge that have been shown to benefit White, middle-upper class students in attaining higher scores. As it is shown that LD identification approaches vary and lack a gold standard, many questions the existence of LDs [13].

Two major issues exist in defining and identifying LD. First, LD represents an unobservable latent construct that does not exist apart from its measurements (e.g., IQ, achievement) [14]. Second, there is a level of comorbidity with other developmental disorders that may explain the IQ-achievement gap necessary for a LD identification [14]. As achievement and IQ, both scores that can be understood as inequitable towards non-White, lower-middle class students, are used as a basis for LD identification, it can be construed that LD identification does not simply identify students with LDs (e.g., writing, reading, mathematics) but also the social inequities that are present in students' lives (e.g., class, sex, class) [9, 10]. One model that has attempted to move beyond simply identifying LDs is Response to Intervention, a model to better account for social factors (e.g., class, sex, class).

3. Response to intervention

Inclusive education (IE) is the idea that education is a basic human right for all students, following the principles of social justice [15]. The World Declaration on Education for All (EFA) defined general principles of IE as providing universal access to schools for everyone and promote equity, being proactive and predicting barriers in access to education and identifying recourses to eliminate such barriers [16]. IE is a process which increases the opportunities and capacity education to meet needs and interests of all learners. In the wake of the United Nations Convention on the Rights of Persons with Disabilities, IE has become increasingly important to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. One such framework, beyond the three cognitive-discrepancy approaches, is Response to Intervention (RTI). The three cognitive-discrepancy approaches focus on improving students with an IQ-achievement gap. However, there is evidence that the cognitive difficulties associated with LDs parallel the challenges experienced by students who have not received adequate instruction [17], leading to the question whether appropriate instruction is provided such that all students, regardless of the LD label, benefits in an opportunity to learn. This is the emergence of the Response to Intervention (RTI) model.

The RTI model consists of many different components broken down into three tiers. Tier 1 instruction consists of class-wide universal screening, defined as screening assessments to identify students likely to experience poor academic outcomes [18]. Tier 2 instruction involves small-group supplemental programs in addition to Tier 1 instruction with constant assessments conducted to determine whether students are responding to the more intensive Tier 2 instruction [18]. Tier 3 instruction involves individualized program instruction to supplement Tier 1 class-wide instruction [18]. Throughout each tier, progress monitoring is conducted to assess whether students are responding to the Tier 2 or Tier 3 instruction to ensure that the academic outcome gap is decreasing [18]. Though this model moves beyond LD identification for labelling purposes and attempts to support all students, with the focus on reducing the academic gap, the RTI model is still focused on outcomes that are socially influenced. As such, subjectivity may be present inherently by disadvantaging students with certain sociodemographic characteristics towards inequitable academic outcomes.

There have been increasing discussions surrounding a culturally responsive RTI model where RTI focuses on the contextual factors that impact achievement. In this scenario, although achievement is still the focus, RTI takes into consideration cultural factors that impact achievement [19, 20]. For culturally responsive RTI, teachers understand the cultural nature of learning, consider students' socio-cultural context of schools, and promote equity within school policies, decisions, and pedagogical practices. Therefore, though culturally responsive RTI is increasingly discussed, there appears to be difficulty in incorporating RTI taking into consideration students' intersectional identities, requiring significant amounts of support [21]. Across all LD identification methods, research has documented inconsistencies across schools, leading to the subjectivity inherent in LD identification and support, producing inequality by disadvantaging youth with certain sociodemographic characteristics [21, 22]. From the understanding of the issues surrounding LD identification across all methods, one questions the educational issues experienced by students with intersectional identities including, of which LDs are one of their social identities.

4. Intersectionality

Intersectionality is an analytical framework to examine how differing identities, such as race, sex, class, and sexuality, and how their combination plays out in different settings [23]. Though intersectionality examines different social identities, much of the literature has not, until recently, included disability to the list of social categories that marginalize individuals. Together, race-ethnicity, gender, disability, and social class are social identities that intersect with one another and result in oppression and discrimination [23].

Though there are increasing number of students who are being identified as having a LD, there appears to be a disproportionate number of LD identification towards students from racial-ethnic minority status, boys, and those who are from a lower socioeconomic status [9, 10]. Data from the National Assessment of Educational Progress (NAEP) suggests such social identities as potential causes for such disproportionate representation [24]. The over-identification of students with intersectional identities that receive special education services (e.g., students from diverse ethnicity and race, class, and sex) leads to question the responsiveness of LD identification approaches and the subjectivity inherent in identifying and labelling LD. The National Center for Learning Disabilities (NCLD) found similar evidence pointing to a higher risk for students of color. Specifically, their data indicated that American Indian/Native, Black/African American, Native Hawaiian/Other, Hispanic/Latinx, and those with more than one race/ethnicity all received special education at a higher identification rate compared to Caucasian students [25]. Interestingly, this was not the case for Asian students [25]. However, existing literature has found that English Language Learners (ELL) are similarly overrepresented as being identified as students with LDs [9, 10, 26]. As such, this poses an interesting intersection of racial-ethnic minority students and students who are learning English, as it is assumed that students who are ELLs can also contain Asian students.

An emerging body of literature has found an over-identification for English Language Learner (ELL) students to receive special education services, highlighting a need for cultural competence and responsiveness [10, 26, 27]. As ELLs and race/ethnicity are closely intertwined in their identities, this book chapter attempts to further examine other intersections between LDs and other identities to understand the diverse experiences of students with LDs and the issues surrounding the disproportionalities that exist in LD identification, and how relevant stakeholders can respond adequately in schools.

5. Educational issues for students with LD

Across the U.S., students with LDs constitute 34% of all students with disabilities, accounting for 4.5% of all students in schools [28]. For students without disabilities, 84% graduate, whereas 65.5% of students with disabilities graduate, indicating a need to further identify the necessary supports for students with LDs [28]. For example, after LD identification, students with LDs receive special education services, including learning in a separate classroom specifically designed for students with disabilities, a concept known as least restrictive environment (LRE) [29]. However, misidentifying students risk them being exposed to a less rigorous curriculum, lower expectations, and fewer opportunities to successfully transition them to postsecondary education [25]. Inappropriate LD identification can also result in social consequences, with students suffering from a loss of self-esteem, being exposed to greater stigma, and facing increased marginalization in classrooms (e.g., racial separation). Once misidentified, students are likely to stay in the special education program for the remainder of their academic trajectory [25].

Through an understanding of the social model of disability, labelling a student with LD is indicative that there are certain barriers in the classroom that is preventing them from performing at the same level compared to their peers without the LD label [6, 8]. Put into different words, students with LD are unfavorably biased against Caucasian middle-class norms of achievement. As labels such as LD are subjectively constructed based on unobservable latent construct of achievement, students with the LD label are perceived as deviating from the average or high IQ/achievement and is simply not receptive to the teaching practices that work for students without LD. In this manner, the LD label can be understood as a tool of inequality due to the lack of positive outcomes of being placed into special education placement.

LD label can also be understood as an intentional tool of inequality. From a social perspective in understanding LDs, LDs can be understood as a social construct that is defined relative to the context and situation, argued to be more prevalent in Western societies due to the emphasis on speed, literacy, and numeracy in the school system [30]. In other words, students labeled with LDs do not experience inequities due to their LD but the society that is structured to benefit students with normative qualities (i.e., Caucasian, middle-class). Due to the lack of objective and uniform diagnostic criteria in identifying LDs, variations across students can be understood as natural, with everyone possessing some level of 'disability' in different contexts relative to their peers [13, 30]. Therefore, LD identification can be understood as an inequity due to the societal emphasis on specific Western values (speed, literacy, and numeracy). This questions the validity of the LD identification as an inequitable perception in schools' responses to students with LDs. Moreover, there is evidence that having the LD label can have social psychological ramifications in their classroom experiences [9]. Below will be an exploration of inequalities experienced across different subgroups of LDs: 1) culture, race, and ethnicity, 2) sex, and 3) social class.

6. Inequalities of culture and LDs

Under a cultural identity, I have chosen to group cultural and linguistic identities together as they go hand in hand for cultures that do not speak English primarily in their country. However, predominant literature on inequities in LD identification have focused on students learning English, also known as English Language Learners (ELLs). Though many studies have focused on culture and LDs through language barriers, broader cultural influences exist that influence the learning of students of color with LDs [10, 31]. For example, teachers expressed a lack of cultural understanding and competence to provide culturally relevant instruction to their culturally diverse students [4, 32].

For students with LDs, there is an increasing number of studies investigating the disproportionalities in LD overidentification. One such group of students are students with racial-ethnic minorities and those who are learning English. For example, African-American students with LDs reported negative consequences of their special education placement [12, 33]. Though they mentioned benefits of special education placement such as interactions with responsive teachers and more appropriate instructional pacing, the social consequences of having a LD label outweighed such benefits. They reported additional stigmatization by peers (in addition to their race-based harassment) [34], making limited academic progress due to a slow-paced curriculum, and barriers preventing them from returning to general education placements [33].

Much of the literature surrounding culture, race, and ethnicity disproportionalities involve students who do not primarily speak English. In the intersection between language and LD, the disproportionate labeling can be attributable to the flawed methods of LD identification (i.e., IQ and achievement) as cognitive ability measurements do not distinguish whether their lack of ability is due to their linguistic or learning ability [35]. As NCLD data [25] has shown that only 33% of students of color (i.e., Black) spend more than 80% of their day in general education classroom, compared to 55% of Caucasian students, the disproportionate placement of students of color into special education can be attributed to systemic racism inherent in the education system, considering the subjective nature of the LD identification procedures as well as the inadequate instruction to foster responsive learning opportunities for all students, including students of color.

In addition to students of color experiencing a disproportionate amount of LD identification perhaps due to the lack of responsive instruction or subjective nature of LD identification, language barriers exist for students who may have language barriers, commonly from students from culturally and linguistically diverse backgrounds. The subjectivity in being able to tell whether students have a LD or whether the lack of ability is due to their language restrictions leads to subjective labeling of LD for students and whether the purpose of LD identification is valid. Evidence has shown that students who are both ELLs and identified as having a LD are placed at an increased risk for school failure than students in either group (ELLs or LDs), due to their barrier in participating in general education classes [36]. Therefore, the disproportionality of having students who may have language barriers rather than a learning barrier can pose more academic risk than providing special education support. With this in mind, it is unclear whether there is a benefit in a LD identification, particularly due to the subjective nature of LD identification and an understanding of whether appropriate instruction can remedy this language or learning gap.

7. Inequality of sex and LDs

Much of the research surrounding disproportionality and sex differences found an over-identification of LDs among boys. Previous research exploring sex differences among students with LD found girls being 1.5 to 6 times less likely to be identified as having a LD compared to boys [10, 37]. The differences in LD identification between boys and girls is attributed to the referral bias, a step prior to LD identification. From this bias, this brings up another issue with the LD identification process and the subjective nature biased against students not from the dominant culture (i.e., Caucasian, middle-class). There appears to have a tendency where boys are referred to special education services for LD more than girls, leading to inequity for all students, over-identification for boys and under-identification for girls. This over-identification of LD identification among boys was due to the problematic behaviors (e.g., impulsivity, hyperactivity, disruptiveness) in class. Similarly, a reason for under-identification of LDs among girls was due to a lower sign of 'objective' behaviors as a reason for referral to special services. Another possibility, from a social perspective, is the different social expectations expected by boys and girls, such that society sets higher standards of achievement for boys than girls [10, 37]. The subjectivity in referral for special education services due in part to the lack of gold standard for LD referral and identification, leads to inaccurate identification of LDs in students, and creates increased social psychological risks and lowered academic expectations for both boys and girls.

8. Inequalities of class and LDs

Another source of inequality is the occurrence of LDs among students due to social class. Students with LDs were found to have similar behaviors and academic outcomes compared to students from a lower socioeconomic class [10, 38]. Students from such social backgrounds attributed achievement gaps to prenatal factors, malnutrition, parenting style differences, and deprivation of sensory and stimulating environments [10]. Historical and contemporary evidence suggests that the achievement gap used to identify LDs among students can be explained in part due to students' lower social class and being economically disadvantaged compared to their peers [10]. In this sense, the LD label, then, is used to explain lower achievement as a result of incompetent parents and low social position, all social factors that are systemic and out of the control in being able to support the students.

Students who develop in lower socioeconomic environments are exposed to reduced linguistic input in the home environment and can be behind in their language development when they enter school, which subsequently can interfere with their reading and numeracy skills [39]. Evidence has shown that early interventions targeting reading, writing, and numeracy skills remedied the achievement gap typically found in students from a lower socioeconomic class [1, 40]. Therefore, from this social perspective, the achievement gap experienced by students who are from lower socioeconomic class that are considered to have a LD can be understood as societal inequities due to lack of opportunities and resources in developing their reading, numeracy, and writing skills. If the mechanisms of students with LD are in fact having achievement gaps due to a lack of opportunities and resources in their lower socioeconomic home environment, then this calls into question the need for teachers to provide adequate and responsive support for their diverse students who may lack the resources in their home environment.

9. Intersectional identities in LD identification

In United States, there is a history of racism and persisting racial stratification that leads students of color to have less educated parents, lower levels of family income, and decreased access towards resources in the dominant culture (i.e., Caucasian culture) [41]. In this manner, students of color experience increased risks due to their lower class, including cardiovascular disease, arthritis, diabetes, and mental illness, all of which disproportionately diagnose them as having LD, though the achievement gap may not be due to a lack of learning ability but societal influences [10, 41]. Similar achievement gaps and disproportionality was found from Canadian data [42]. There is some burgeoning literature that have begin to find intersectional relationships, such as between culture and class disadvantage, being a key contributor to heightened risk in being misidentified as having a LD.

With an understanding of the inequities faced by students who are ethnically-racially diverse, of lower socioeconomic class, and both boys (over-identification) and girls (under-identification), there are several studies that have begun to look at the intersections of several of the aforementioned identities. However, studies examining intersections of students with LDs and their identities appear to be primarily focused on cultural and linguistic diverse (CLD) students commonly tied with their lower social class [10, 26]. Evidence continues to show that students coming from a lower social class and are an ethnic-racial minority are more likely to be identified as having a LD compared to Caucasian students from middle-to-higher social class [9, 43]. For example, students who are learning English can have decreased achievement scores, not due to difficulties in their learning but their linguistic barriers preventing them from accurately responding to assessment [26]. Both academic and social-psychological outcomes vary according to students' intersectional identities (i.e., ethnic-racial, linguistic, socioeconomic, sex, disability) [44].

As discussed above, each group of students experience risks associated with inequitable LD referral and identification, due to the achievement gaps used as a method of diagnosis in the three cognitive models. However, culture, language, social class, and sex were all identities and groups shown to experience inappropriate LD referral and identification. This can be understood as a reflection of the inequitable access to effective and responsive educational practices along with complex and societal inequities (i.e., achievement gap, LD identification) and biased perceptions from the teacher (i.e., LD referral) [10, 40]. Particularly as students of color are more prevalent in the lower social class [45], they are at a higher risk for being identified as having a LD, whereas such students may simply require appropriate and responsive instruction by the teacher. This risk would be even more heightened for boys (or students who exhibit more problematic behaviors in classrooms) due to their excessive referrals for LD identification [10, 37].

Though students who are learning English are a heterogeneous population in terms of sociocultural background, the lack of precision in LD identification to discriminate between neurobiological deficits and societal barriers leads to learning difficulties or systemic barriers and inequities that result in decreased achievement scores [10, 13, 26]. In addition to misidentification of LDs based on inaccurate achievement scores as a result of language and systemic barriers (e.g., socioeconomic disadvantaged environments), another layer of inequity is the biased referral towards both male and female students. The subjective referral for special education services based on problematic behaviors predominantly exhibited by male students poses an additional layer of inequity. Though LD referral and identification may be beneficial for some students to be qualified for additional support, the over-identification of male students and under-identification of female students for special education services call attention to social inequities that prevent students from appropriate learning opportunities. At the intersection of sex, one questions whether biased referrals similarly persist when taking into account diverse gender identities as biased LD referrals were based in problematic behaviors.

This leads to questions surrounding the purpose of LD identification and its intended nature. Should schools want to support students from diverse cultural, ethnic-racial, and social class backgrounds, rather than understanding the identification process of LDs in students that bar students from accessing additional educational support, a culturally responsive RTI model can be a model for teachers to provide effective and responsive instruction that supports all diverse students.

10. Moving forward

As our contemporary society is increasingly responsive to our diverse students' needs and identities, it is critical to understand how the educational system is supporting diverse students. Though LD identification allows for access to special education services, evidence shows risks associated with LD identification, such as lowered academic expectations, peer stigmatization due to special education placement (in addition to pre-existing stigmatization as a result of ethnic-racial minority identities), and lowered self-esteem among other social–emotional outcomes [10, 43, 46]. Based on the many inequities experienced by the disproportionate number of students labeled with LDs due to their intersectional identities of class, culture, race/ethnicity, and sex, research has indicated several points to move forward to better support such marginalized students.

Particularly for students of color who were diagnosed with LDs, they mentioned the importance of teacher support, availability of school counselors, additional programs, and the importance of connection between school and family to support their educational outcomes [28].

Student perspectives reported that they benefitted from flexible pedagogical and adaptive instructional choices that were responsive to their needs [28]. However, students reported that responsive instruction depended primarily on teachers' abilities to prepare and effectively communicate their curriculum that is responsive to their students' needs [28]. In this sense, this can be understood as evidence of LDs as the lack of appropriate instruction responsible by the school and teachers, as opposed to the labelling of students as having low achievement. In this sense, a culturally relevant RTI may be appropriate in having teachers provide responsive instruction that is mindful of their students' diverse needs, including their intersectional identities.

Another component of responsive instruction that aligns with a culturally responsive RTI would be individualized supports [28]. Students reported individualized supports as beneficial for students to work at their own pace without having to keep up with the rest of the class. However, this same logic does not apply to putting students with LD into special education placement due to the lowered expectations and stigmatization placed onto students with LDs by being taken out of general education classrooms [28]. As such, this reiterates the onus placed onto the teacher to be able to create individualized support opportunities for students to work at their own pace, rather than taking them out of general education classrooms, which can lead to lowered academic expectations and increased social psychological risks.

Aligned with a culturally responsive RTI, students reported key adults that were supportive in their educational journey. School counselors were mentioned as instrumental in supporting students with their needs and also acted as a medium to advocate for additional support for students as well as providing emotional and behavioral support as students of color, in particular, were afraid to upset or hurt their family to speak about their academic struggles [28]. This is indicative that helping students manage conflicts with their peers and personal problems with their family. In other words, the additional support students with LDs required can be understood as simply additional supports that all students require due to diverse, cultural needs. For example, evidence has shown that students from low socioeconomic class and from minority cultures require additional support to respond to both their academic and socioemotional needs [10, 43, 46]. As such, school counselors is not only a support system that is beneficial for students with LDs, but responds to the needs of culturally and linguistically diverse students. Additionally, school counselors need to be mindful to not be disproportionate to boys due to the more apparent behaviors as this can under-identify the needs of girls from a lower socioeconomic status and culturally and linguistically diverse backgrounds.

Lastly, as the social model of disability focuses on understanding the societal factors that influence the students' abilities to perform adequately along with their peers [6, 8], students brought up the importance of understanding school and family connections and how schools should be receptive to parental input and encourage collaboration and engagement between school and family [28]. Such communication, such as through online platforms, can facilitate parental contact with schools and promote family support, fostering a sense of family belonging for the student in their school environment. The important point is to foster this two-way street for home-school communication to maximize student support. This underlies general principles of culturally responsive RTI, such that a systemic view of support, bringing in family and multiple stakeholders, will be present to respond to the needs of students with diverse cultural and linguistic needs [19, 20]. Given that a tenet of the Individuals with Disabilities Education Improvement Act (IDEIA) is to formalize family support to foster dialog and collaboration in supporting students' needs. An important focus here is that such home-school collaborations can ensure accountability in maintaining high expectations placed upon all students, and not only students who have been identified with the LD label. IDEIA and a culturally responsive RTI are frameworks that are not only focused on students with LD and, therefore, questions the need for the subjective notion of LD identification, and focus on a broader sense of providing adequate instruction that is responsive to culturally and linguistically diverse students [19, 20], rather than base LD identification on cognitive measures that can be subjectively biased [10, 37].

Providing universal support that is culturally responsive to all students, regardless of LD identification, is effective to remedy the achievement gaps that are present as a result of social inequities. The over-representation of culturally diverse students, including ethnic-racial minorities from lower social class as well as boys, in special education placements brings up an issue in the educational system and the inequitable dilemma: low achievement, negative stigmatization, school drop-outs, academic gaps are all outcomes pertaining to such diverse students particularly those being identified as having a LD [40, 47].

11. Conclusions

An examination of literature surrounding LD referral and identification revealed existing inequities in the educational system for students of intersecting identities, including students considered to be cultural and linguistic minorities, low socioeconomic class, and boys. Though the purpose of assigning LDs to students is to provide a process in which students with LDs can have access to special education services, much of the literature has reported negative consequences for students identified with LDs: low academic expectations, peer stigmatization (due to their special education placement, along with other marginalized identities), low self-esteem, school drop-out. As such, rather than focusing on LD referral and identification that may increase their academic and psychosocial risks, focusing on a culturally responsive RTI model can be a promising method in which all students, regardless of LD identification, can have both academic (e.g., increased academic engagement, achievement) and social benefits (e.g., positive classroom climate, increased belongingness to classroom) [48–50]. Future research is needed to increase the number of studies exploring intersectional students' experiences with the LD label. As diversity and inclusion is an increasingly important topic in the current society, it is critical for equity researchers to understand and problem solve the inequities that exist to prevent students from non-dominant cultures to prosper alongside their peers.

Conflict of interest

The authors declare no conflict of interest.

Author details

Enoch Leung
McGill University, Montréal, Canada

*Address all correspondence to: enoch.leung@mail.mcgill.ca

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Chapter 6

Depression, Suicidal Tendencies, Hopelessness, and Stress among Patients with Learning Disabilities

Fahad Hassan Shah, Song Ja Kim, Laiba Zakir, Aqsa Ehsan, Sohail Riaz, Muhammad Sulaiman and Saad Salman

Abstract

Self-harm and suicide are most commonly observed in adolescents specially females in Asian countries and in western. The psychosocial predictors, along with hopelessness and non-suicidal injury (NSSI), have not been studied properly before. Therefore, there is a need to address these issues. The objective of the study was to ascertain the psychosocial and clinical features predicting suicide and NSSI in adolescents with major depression. Increased number of suicidality and impaired family function at entry is autonomously connected with a suicidal attempt. NSSI are connected at base line and apply additive effect on likelihood, one keeping on through treatment period. Poor family functions, as well as family problems and social problems, were the causative agents for adolescent's high suicidality and NSSI. A history of NSSI treatment is a clinical marker for suicidality. The previous suicidal attempts should be evaluated in depressed juvenile patients as indicators of future suicidal intent and behavior. Both suicidal and NSSI adolescents during the therapy and after treatment endure to be depressed when they are engaged in study. Major causes of suicide among our study participants were lost friend(s), drug abuse, living alone, disturbed parental marriage, sexual abuse, and other domestic problems.

Keywords: suicide, non-suicidal self-harm, adolescents, predictors

1. Introduction

Suicide is one of the foremost health concerns of numerous countries and it is responsible for the deaths of 800,000 around the globe annually [1]. Suicidal behavior disproportionately affects adolescents and one-third of all adolescent deaths in the USA were attributed to suicide. The research was done to determine the effect of venlafaxine [2]. Asian countries account for 60% of the global suicide rate, directly affecting 60 million people annually [3]; here, 60 million people are affected not only by loss of their loved ones but also because of hopelessness, sexual abuse, family disturbances drug abuse, living alone or not living with the family, disturbed parental marriage, sexual abuse, and other domestic problems. Self-harm is an attempt of harming self, with or without suicidal intent [4]. This behavior has been identified in recent researches as a predictive tool for suicide in 40% of cases [5] and is taken as a means of signaling emotional and psychological needs for family members. Non-suicidal NSSI (NSSI) among adolescents, on the other hand, is self-inflicted harm to one's self that lacks proof for suicidal intent. The risk of an adolescent's suicide is 60 times greater when he/she has attempted suicide in the past [6]. Furthermore, fearlessness and a general lack of concern about the consequences of risky behavior can also contribute to the potential for NSSI and suicide in adolescents [7].

The risk factors for adolescent suicidality have previously been identified through factorial analysis of neglect and abuse of a child, family's conception, and social consolidation. These factors have been recognized as influences that might serve as predictors of suicidal behavior and a basis for preventive measures [8]. Adolescent depression leads to a significant proportion of mortality and disability, contributing to an increased risk for suicidal behaviors if remain untreated. Moreover, as established by Weishaar and Beck, "According to Beck the hopelessness is 1.3 times more important in causing suicidal ideation as compared to depression" [9]. There is a correlation between suicidal attempts and psychiatric disorders such as depression, anxiety, substance use disorders (drug misuse and abuse), conduct, and eating disorders. According to our knowledge, we are the first to track down these known predictors of suicidality, NSSI, and hopelessness, combined. The study was carried out in adolescents (n = 121), taking venlafaxine, for 28 weeks. We subsequently assessed that how these factors were associated with suicidal attempts at baseline (admission time), throughout the treatment and follow-ups. The role of venlafaxine is to inhibit the uptake of norepinephrine and serotonin and lacks muscarinic-cholinergic or alpha-adrenergic effect. It can be administered twice or thrice daily. It has equal effect in patients older than 60 and the patients younger than 60 and in those having psychomotor retardation or agitation. It is used to treat major depressive disorders, anxiety disorders, and specifically generalized anxiety disorder.

2. Materials and methods

We carefully selected 15 clinical trials after careful consideration. We did a meta-analysis of a pool of 1211 participants with the Diagnostic and Statistical Manual of Mental Disorders-IV and the major depressive conditions were diagnosed that is integrated with the study. The gender and age of every candidate were also considered in our study.

3. Psychiatry tools

Beck hopelessness was used for family assessment but the patients were assessed by the McMaster Family Assessment Device in which the family bonding understanding and behavior were assessed as well.

The McMaster Family Assessment Device-12-Item [10] and GAF Scale [11] were used to rate the functioning of a family of adolescents participants. Parents of participants completed a Brief Health Questionnaire [12]. Hopelessness scale [9] and K-SADS-PL[1] information were collected as well as Children's Depression Rating Scale [13] and for symptom severity, Hamilton Depression Rating Scale (HAMD) [14] was used to evaluate patient's health.

4. Statistical analysis

Age, gender, and depression severity were included in the univariate analysis. By using variance inflation factors (VIFs), collinearity of independent variable was

Variable		1	2	3	4	5	6	7	8	9	10	11
1.	Suicide attempt pre-baseline	1										
2.	Suicidality item from the Children's Depression Rating Scale	0.51*	1									
3.	NSSI at baseline	0.28*	0.49*	1								
4.	Non-suicidality items from the Children's Depression Rating Scale	0.04	0.23*	0.21*	1							
5.	Family functioning	0.05	0.22*	0.22*	0.07	1						
6.	Maternal General Health Questionnaire Score	0.17	0.08	0.02	0.21*	0.03	1					
7.	Paternal General Health Questionnaire Score	−0.12	0.18	0.12	0.17	0.06	0.01	1				
8.	Hopelessness	0.13	0.23*	0.16	0.31*	0.12	−0.01	0.05	1			
9.	Anxiety disorder	0.12	0.20*	0.01	0.17*	0.00	0.02	0.08	0.00	1		
10.	Gender	−0.11	−0.04	0.05	0.18	0.10	−0.01	0.02	−0.12	0.14	1	
11.	Age	0.04	0.05	0.13	0.10	0.11*	−0.13	−0.12	0.21*	0.07	0.01	1

[a] *P-value used for the association of continuous-continuous measures; for dichotomous-continuous point-biserial correlation was used; dichotomous-dichotomous-tetrachoric correlations were used.*
* *$p<0.05$.*

Table 1.
Relevant predictor variables' correlation coefficients in depressed subjects.[a]

checked and it was found that above 10 high or multi-collinearity was indicated. Calculation of pair-wise correlations between predictor variables to specify sources of multi-collinearity. By using categorical-categorical pairs and Pearson biserial and point correlations, tetrachoric calculations were made. In **Table 1**, [a]*P*-value was used for the association of continuous-continuous measures; for dichotomous-continuous, point-biserial correlation was used; dichotomous-dichotomous-tetrachronic correlations were used and were calculated for continuous-categorical pairs. Two-tailed test was exploited for analysis of entire data through SPSS 20 statistical software.

5. Results

By studying, it was found that all the participants at baseline had to face the depressing conditions. The data that are applicable are available for everyone but 11 attempt suicides at baseline and NSSI, and 48 on NSSI and 61 attempt suicides during the following period. **Table 2** sums up the baseline demographics and clinical data in the history of suicide in the past and those with the following data for both NSSI and suicidal attempts. There were no major variations between those with follow-up data and those who have not. There was a considerable association month before baseline between suicidality and NSSI (NSSI present: suicidal attempt in 14/68 (male/female) [36%]; NSSI absent: suicidal attempt in 13/107 (male/female) [13%]; odds ratio = 2.7, x^2 = 4.6, df = 1, p = 0.016).

A pre-baseline suicidal attempt was performed by almost 28 children (17%), whereas one attempt was committed by almost 56 children (34%) during the follow-up period. Much lower were the suicidal attempts and baseline NSSI than the subsequent month attempts. It was seen as follows: 7.8%; 5-week post- and pre-assessment, 7%; 10-week preceding assessment, 8% in 24-week assessment. Predictor variables over the follow-up period of NSSI and suicide risk are shown in **Table 2**. By checking, it was found that an increased risk of suicidal attempt is associated with severe depression, suicidality and hopelessness, the existence of a suicidal attempt or NSSI in the month earlier to baseline, and family compromised operation, but not associates with care providers, friendship problems, or parental mental health.

Several logistic regressions specify that only ill family operation (odds ratio = 2.27, $p < 0.0005$) and increased suicidal attempt at entry (odds ratio = 1.59, p = 0.026) were the basic predictors of subsequent suicidal attempts.

Table 2 shows significantly higher symptoms of depression were seen at follow-up period of 28 weeks (p = 0.001) that was connected to self-harm, where the manifestation of one type of self-injury was related to other type (odds ratio = 2.5, p = 0.007).

Sixty-one adolescents (51%) had a minimum one attempt of NSSI during the month prior to baseline. During the 28-week follow-up, 60 (37%) had at least one activity of NSSI. The rate of NSSI was lower through all the studying months compared to the month prior to baseline (a month earlier than the 6-week judgment,

Characteristic	Baseline data	Follow-up data
	N = 12	N = 13
	Mean ± SD	Mean ± SD
Age (years)	13.2 ± 1.2	14.3 ± 1.2
Duration of depression (weeks)	57.7 ± 8.3	71.1 ± 7.9
Children's Depression Rating Scale, total score	49.9 ± 8.7	50.0 ± 8.4
Children's Depression Rating Scale, T score	65.8 ± 5.4	75.9 ± 6.2
Number of comorbid disorders	1.2 ± 0.2	1.3 ± 0.5
	N	*N*
Male	42 ± 2.6	48 ± 2.5
Suicidal attempt in the past month	32 ± 1.7	27 ± 1.4
Non-suicidal self-injury in the past month	65 ± 3.5	34 ± 2.9
	Median (IQR)	Median (IQR)
Children's Depression Rating Scale, suicidality item score	3 [1–5]	3 [1–5]

[a]*IQR = interquartile range [18].*
[*]*p < 0.05 [18].*

Table 2.
Clinical features and demographic of depressed adolescents committing suicide and NSSI.

28%; month prior to the 12-week evaluation; 19%; month prior to the 28-week assessment, 18%). **Table 3** mentions that NSSI in the cycle earlier at baseline there is an increase in depression level, anxiety, hopelessness, and the suicidal attempt, and during follow-up, females were extensively linked with a higher risk of minimal one NSSI case. In the chain effect, the treatment, group, and suicidal attempt were not in the previous month with NSSI.

Data on self-harm are shown in **Table 3**. Analysis indicated that the appropriate predictor for a suicidal attempt was pre-baseline NSSI (univariate RR = 2.95). The greater subgroup without NSSI, the cutoff of the best predictor for a suicidal attempt was a family function, all this will result without the pre-baseline, analyzed by the McMaster Family Assessment Device, the cutoff values that have a suicidal attempt are 25/26, 15/45 (31%) with scoring>25 and 3/56 (6%) with scores<26.

Variable	Risk of suicide attempt		
	Odds ratio	**95% CI**	**p**
Suicidality items from Children's Depression Rating Scale	1.34	0.92–2.25	0.11
Baseline NSSI	4.23	1.30–7.43	0.005
Non-suicidality items from the Children's Depression Rating Scale	0.83	0.52–1.46	0.8
Hopelessness	1.88	0.59–3.90	0.2
Family functioning	2.23	1.43–3.24	0.003
Age	0.94	0.58–1.23	0.7
Female	1.38	0.54–2.66	0.6

[a]Likelihood ratio χ^2 = 38, df = 7, p < 0.00005. Pseudo R^2 = 0.20. Maximum variance inflation factor = 1.25. Hosmer-Lemeshow χ^2 = 2, df = 8, p = 0.99. The family functioning measures are z-transformed scores. Each item in the table represents the odds ratio as well as the p-value for the difference between the level of depression and the incident of NSSI at baseline.

Table 3.
Attempt of suicide multivariate predictor's risk analysis among depressed adolescents.[a]

Variable	Risk of non-suicidal NSSI		
	OR	**95% CI**	**p**
Suicidality item from the Children's Depression Rating Scale-Revised	0.80	0.55–1.49	0.65
Pre-baseline non-suicidal NSSI	30.2	5.87–60.1	<0.0004
Non-suicidality items from the Children's Depression Rating Scale	0.55	0.37–1.23	0.056
Hopelessness	3.54	1.49–8.71	0.007
Family functioning	1.05	0.42–1.68	0.5
Anxiety disorder	5.41	1.38–10.65	0.014
Age	0.59	0.49–0.75	0.004
Female	8.80	1.64–16.0	0.012

[a]Likelihood ratio x^2 = 65, df = 9, p < 0.00005. Pseudo R^2 = 0.32. Maximum variance inflation factor = 1.30. Hosmer-Lemeshow χ^2 = 5, df = 8, p = 0.8. The family functioning measures are z-transformed scores. Each item in the table represents the odds ratio as well as the p-value for the difference between the level of depression and the incident of NSSI at baseline.

Table 4.
NSSI multivariate risk predictors in depressed subjects.[a]

The improvements were seen with model fit among the young adolescents (x^2 = 6.6, df = 1, p < 0.01). Suicidal attempts were markedly linked with family function and NSSI, but not baseline suicidality. Similar outcomes were seen the month before baseline (yes/no), with the presence of a suicidal attempt was utilized in the model rather than suicidality item: For family function, NSSI and pre-baseline suicide attempt (odds ratio = 2.4, p = 0.068) were not related to a suicide attempt.

The values predicted from the data analysis were subjected toward pairwise relationships are summarized in **Table 1**. All pair-wise correlation coefficients were less than 0.5 except the pre-baseline effort of suicide and suicidality. The maximum variance inflation factor was low at 1.25.

Table 4 demonstrates the follow-up period where NSSI in the previous month was the strongest known independent predictor of consequent NSSI. Other noteworthy predictors that were independent were hopelessness, younger age, sexual abuse, and female gender.

6. Discussion

In our previous studies [5, 15], we had analyzed suicidal tendencies and NSSIs among adolescents as well as adults with or without comorbidities. But, in this research, we have focused entirely on adolescents with no other comorbidity. Our major findings were that the participants showed a higher risk of both NSSI (39% compared with 8%) and suicidality (36% compared with 8%). Self-harm was directly associated with poor social functioning in the depressed adolescents, despite of comparable scores of depression similar to other studies [16, 17]. For several reasons, adolescents were seen to be inclined toward NSSI and one study showed that its prevalence varies between 12 and 23% for adolescents and 7.5–8% for pre-adolescents.

So far as we know, our research was the first to present that hopelessness, suicidal ideation, and NSSI are interrelated and are the predictors of forthcoming suicide attempts. Our findings also demonstrate the importance of earlier assessment of hopelessness at the time of admission. Non-responsiveness of the patients toward therapy was also associated with hopelessness, suicidal ideation, family conflicts, depression, and functional impairment. Our results determined that during treatment, depressed adolescents with pre-baseline NSSI (risk = 51%) had a greater risk of attempt than those with no NSSI (risk = 7%). This study also confirmed that poor family functioning was connected to NSSI, which is in divergence to ADAPT (Adolescent Depression Antidepressants and Psychotherapy Trial) [18, 19]. Either due to continued depression or unresponsiveness to the treatment, the risk of NSSI was greater when the scores on HAM-D were high. Later suicidal attempts were associated with problems in friendships, arguments with any of the family members, estrangement from a family member or a friend, and other such emotional traumas. None of the participants actually died, according to May and Klonsky's 2016 meta–analysis, specifically, depression, alcohol use disorders, hopelessness, gender, race, marital status, and education all were similar for attempters and ideators (d = −0.05 to 0.31). Anxiety disorders, PTSD, drug use disorders, and sexual abuse history were moderately elevated in attempters compared to ideators (d = 0.48–0.52). So the hopelessness scale is only used to measure the severity but cannot predict the suicidal attempts among depressive patients.

Those adolescents having attempted suicide and NSSI history have a greater extent of isolation or solitude, annoyance, risk-taking, carelessness, desperation, alcohol, and drug addiction as compared to solitary suicide attempts. Comparatively, the youngsters who attempted suicide and are also suffering from

NSSI are likely to evaluate themselves more negatively and self-judgmental, lacking self-confidence and self-assurance, and make decisions without thinking.

Children suffering from mental illness and distress are not very much different from the teenagers having NSSI and who attempted suicides [20, 21]. Patten and colleagues found that youngsters having NSSI or with a history of attempted suicide and NSSI only have every type of childhood exploitations, actual physical harm, emotional brutality, and negligence indicating that childhood abuse and negligence may be a major risk for NSSI [22, 23]. However, responsibility and support of parents alter in youngsters with NSSI and attempted suicide history from those suffering from NSSI only. It is reported that comparatively youngsters who attempted suicide having NSSI have less support from their parents than the patients of NSSI alone, but the groups were not different in reported peer support. It is suggested through research that teenagers with a history of both NSSI and suicidal attempts show more severe psychological symptoms. They are involved in much threatening and risky attitude than teenagers with NSSI only. It is thus highlighting the significance in clinical practice for the analysis of both NSSI and suicide among the intervention groups.

Youngsters who attempted suicide are also involved in physical violence, drug, and alcohol consumption, and they are reported with limited social circle and family relationships [24]. However, it is proposed from research and studies that suicidal attempts may result from higher levels of physiological conditions than NSSI. There are mixed findings as a result of research in youngsters but future research should make efforts to explain that suicidal thoughts functioning held with no suicidal intention or acts.

According to the findings of Wilkinson and his coworkers during treatment and monitoring a person's health, suicidal attempts were independently forecasted by poor family operations and NSSI history, while NSSI history, anxiety attacks, feeling of despair, younger age, and female gender predicted the engagement in NSSI independently. Previous NSSI history/record is the major predictor of NSSI and suicidality during the period of monitoring and treatment.

The probability of suicidal attempts seemed to be lesser in the later stages of our study as compared to the beginning. A month before the baseline, almost about weeks ago, the risk of suicide was very high than the baseline (8%). The interesting part is that due to therapy the risk of suicide declines over time after 12 weeks (7%) followed by 28 weeks of analysis (7%). Variables predicted from patients' suicidal behavior and NSSI during evaluation are listed in **Table 2**. During the period of monitoring and treatment, there is a great risk of suicidal attempts coupled with severe depression, suicidal ideation and acts, lack of hope and self-esteem, extant of NSSI, or previously attempted suicide history and compromised family operation, but not with care providers, friendship problems, or parental mental health. Numerous logistic regressions indicated that successive suicides result from an elevated suicidal attempt at entry (odds ratio = 1.59, $p = 0.026$) and ill family operation (odds ratio = 2.27, $p < 0.0005$).

Sixty-one adolescents (51%) had a minimum one attempt of NSSI during the month prior to baseline. During the 28-week follow-up, 60 (37%) had at least one activity of NSSI. The rate of NSSI was lower through all the studying months compared to the month prior to baseline (month earlier than the 6-week judgment, 28%; month prior to the 12-week evaluation, 19%; month prior to the 28-week assessment, 18%). **Table 3** mentions that NSSI a month before the baseline, higher level of suicidal ideation and thoughts, elevation in depression and sadness, increased anxious behavior and pessimism during follow-up females are drastically linked with a minimum one NSSI case. A month prior before the baseline, during the monitoring period treatment, suicidal attempts and group are not with NSSI. Data on self-harm are shown in **Table 3**. It is demonstrated through analysis that suicidal attempts are predicted by pre-baseline NSSI. As assessed by the McMaster Family Assessment Device, the family function was the best possible predictor cutoff for a suicidal attempt among the larger subgroup with no pre-baseline NSSI., with a cutoff of 25/26; 15/45 (31%) with scores >25 and 3/56 (6%) with scores less than 26 had a suicidal attempt.

Model fit significantly improved (x^2 = 6.6, df = 1, p < 0.01). NSSI and Family function were the root causes of suicidal attempts, whereas the future suicide attempt was not linked to baseline suicidality. In the case of youngsters who had attempted suicide a month before the baseline suicidal attempt, the results were similar. It has been concluded that by using various models of NSSI and family function again the pre-baseline suicidal attempt was not linked to future completed suicide (OR = 2.4, p = 0.066). In **Table 1**, pair-wise relationship of predictor variables is summarized. Variance inflation factor was low at 1.25. All the pair-wise relationship coefficients were < 0.5 except the suicidal ideations and suicidal attempts and previous suicidal attempt history. To further confirm the present findings and the relationship of NSSI, hopelessness, and complete suicide, a thorough cohort study or clinical trial is needed. Although the recent findings indicate clearly the relationship, the relationship mechanism underlying this phenomenon could be merely speculated.

7. Conclusion

The conclusion of the study is suicide and NSSI that are both significant risks for depressed adolescents. In the future, it would reveal to us that a higher tendency of a person to commit suicide, family conflict and rude behavior, and current self-abuse would increase the chance of suicidal attempts. The future NSSI is strongly predicted by the presence of the current NSSI. The encouraging outcomes belong to the trials of treatment of NSSI designated for the improvement of treatment process and treatment trials and new methods of treatments are required. The Hopelessness Scale can help clinicians determine those at the highest risk of completing a suicide attempt in the future and we believe that attention to this scale will save many lives. Depressive adolescents are at high risk to attempt suicide and NSSI. Different scales are designed to measure the risks, which help in the treatment and lowering the increasing risks. Most of the youngsters suffering from depression and having suicidal thoughts generally do not attempt suicide. Joiner's interpersonal psychological theory proposed that people who have wish to die have the ability to act on their wish attempt suicide. It is also stated by him that the people who repeatedly undergo self-injury and self-abuse have higher forbearance of pain and they are not afraid of death. Therefore, those having higher suicidal thoughts can attempt suicide.

Author details

Fahad Hassan Shah[1], Song Ja Kim[1]*, Laiba Zakir[2], Aqsa Ehsan[2], Sohail Riaz[3], Muhammad Sulaiman[3] and Saad Salman[3]*

1 Department of Biological Sciences, College of Natural Sciences, Kongju National University, Gongju, Republic of Korea

2 Ibadat International University, Islamabad, Pakistan

3 Faculty of Pharmacy, Capital University of Science and Technology, Islamabad, Pakistan

*Address all correspondence to: ksj85@kongju.ac.kr and saad.salman@cust.edu.pk

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Chapter 7

Counseling Parents of Special Children: Insight from Resilient Parents

Radhika Mohan

Abstract

Resilience is the ability to "bounce back" from adversity. Resilience research shifts our focus from the stress response to coping response. 'Human agency' takes center stage, which can be understood as making choices and taking actions intentionally. Defining resilience, as the ability of individuals to navigate their way to psychological, social, cultural, and physical resources in a culturally meaningful way to sustain their wellbeing, will be more meaningful in the Indian context. Factors leading to parental resilience are explored in the context of Indian society, with specific reference to Mumbai city, where the research has been done. This chapter summarizes the factors that both hinder and favor resilience and discusses the role of counselors in this process.

Keywords: resilience, special children, counseling, cognitive reappraisal, emotional support, socioeconomic status, social support, parenting, India

1. Introduction

> *"I was pregnant with a lot of dreams like other mums. He was cute to look at … all was okay, but still something was not up to the mark. He was slower than other kids of his age, I presumed. With eager anticipation, I took him to play school. Concerns from school followed by the diagnosis came like a jolt; I broke down. Why my son? Everyone around me enthusiastically spoke about their child's achievements. I know I always wanted to be one of them … Why me?*
>
> *I slowly realized that I am not in a horrible, disgusting situation as I imagined. My child is different, I need to slow down my pace and expectations. I took a deep breath, met people, read new parenting books. I had the choice of mourning or enjoying my special child! I made my choice … Now I will do anything, whatever it takes me, I will do my best … We shall overcome."*
>
> *Parent's Voice*

It is a giant leap from 'why me' to 'we shall overcome.'

Having a child with special needs can be a chronic strain for parents as the child care can cause relatively enduring problems in their day to day lives. These chronic strains differ from life events in that these occurrences are constant and prolonged over time. Caring for a special child is a doubly difficult situation, involving physical, financial and emotional stress. The stigma associated with disabilities also increases the family's sense of isolation. Given the poor availability of support services (therapists, schools, rehabilitation, occupation), the parents carry the entire burden of responsibility unlike in developed countries where many social services are provided.

From a developing country context of poverty, inequality and multiple stressors, the ability to survive and flourish requires resilience. The concept of 'competence' describes the intrinsic need for human beings to adapt to the environment which leads to satisfaction or self-efficacy. The concept of human agency in the construct of resilience is important here. According to Hitlin and Elder [1] human agency is defined as intentionally making choices and taking action. Research by Luthar [2] who analyzed resilience research across five decades concludes that "resilience rests, fundamentally, on relationships". The availability of support systems ensures smooth adaptation even under severe conditions of stress and trauma.

This chapter illustrates the processes involved in this journey. The journey where human agency and support systems contribute to effective coping and resilience. It looks into the factors influencing the level of stress experienced by the families of children with specific disabilities and variables that aid coping. Professional counselors can help parents alleviate the stress of handling special children. They can also learn from parents who have successfully handled their special children.

2. Impact of a special child on parents and family

The lives of parents take a drastic turn once the diagnosis is done. Their dreams and hopes are shattered and are filled with negative emotions. Parents of special needs children wrestle with multiple problems and unknown demands. The challenges faced are different as compared to experiences of parents of typically developing children. The emotional shock, self-doubt, blame, guilt and anxiety regarding the future, along with a lack of awareness about the child's disability and lack of parenting skills, are challenges faced by parents. Financial burden and lack of professional support make the situation even worse. Some of the shadow stressors can include marital conflicts, fatigue and loss of leisure time. Thus, the impact on a family with a special child is severe. Parents of special children also reported more physical symptoms than parents of normal children [3]. High parenting stress can worsen child behavior problems overtime, which in turn worsens parent's stress in pre-school children with intellectual disabilities according to previous research [4].

Every family is unique with its own patterns and experiences and is the primary and important social institution for every child. Family is "interacting communicative networks in which every member influences the nature of the family system and is in turn influenced by the system" [5]. Adversity can either strengthen family relationships or rupture the family bonding. Certain parents and families adapt well and stay resilient in the face of challenges [2]. However, not all of them manage to adapt. Adaptability according to Olson's Model [6] is defined as a family's ability to change its rules, roles, and power structure in response to situational and developmental stress. The systems theory in general stresses on circular causality – an idea that events are related through a series of interacting loops. An unhealthy pattern that emerges in these families can be 'fusion and triangulation' [7], which comes in the way of the family's mental health.

The emotional symptoms of a family member are expressions of the emotional symptoms of the family. Parental narrations share experiences similar to Bowen's findings. The diagnosis often is highly stressful and traumatic when parents experience a myriad of negative emotions. It is observed that parents deal with problems associated with a special child, like how they deal with earlier stressful/traumatic experiences or how they have seen their parents dealing with such situations. Similar to "emotional fusion," [7], parents often get caught up in the emotional connection with the child, react emotionally, without being able to think through or talk about choices they can enforce in stressful situations. Families going through anxiety show less flexibility in adapting to stress. They may take a longer time in accepting the diagnosis and reaching out to support systems. In highly stressful situations, parents seem to pass on these negative emotions onto their children in the family or to the special child. Research [8] confirms that more fusion was found in college students with disabilities compared to those without disabilities. Fusion and triangulation with family of origin were observed in children, who could not cope up with college.

Family adaptation is based on the interplay of experienced stress, available coping resources, and ecological contexts in which the individual family operates [9]. Parents are the pillars of the family structure and have a major influence on their children. This identifies the importance of working with families of special children. Having a special child is often a turning point for parents, which require a change in perception and a paradigm shift in expectations. Interviews with parents of special needs children share life stories that convey themes which have an obvious trauma (diagnosis of the child) followed by the parent moving ahead and solving/coping with these life situations or stagnating and at times regressing from the point he/she started off. It is important to recognize the unique group of parents who coped effectively in spite of multiple stressors and use this learning to guide and support those parents who need assistance and effective coping strategies.

3. Factors that prevent parents' coping

A typical scenario in a joint family (as shared by a parent).

> *Akhil's (name changed) mother suspected that her son (5years) is highly distracted and slower than her friend's kid of the same age. His teacher was concerned that his worksheets are incomplete and he hates coloring. She informed mother about his lack of concentration in work. His father, however, felt he is playful and lazy. The father confirmed that as Akhil can concentrate while watching cartoons, his concentration cannot be an issue. Being in a joint family, Akhil's grandmother confirmed that all her sons disliked school work.*

The above case elaborates lack of awareness as one of the factors that come up in parental narrations that impacts the child and eventually the family's well-being. Parents tend to ignore developmental delays and attribute them to heredity, laziness or playfulness, which affects their understanding of the special child. Some parents attribute the reason for a child's condition to metaphysical causation (one's karma) and thus refuse to opt for remedial services.

Parent's Voices

> *"If God has decided that he has to be born to us, he will find a way out too. I don't have to bother; God knows what needs to be done. He will take care."*

> *"It's our destiny! My friends told me that marriage between first cousins can affect the mental health of the next generation. Our family did not listen. Nobody can change our fate now. This child is already born."*

The above mindset delays parents opting for support services, resulting in blocking the child's progress. There is limited awareness about the causes of such conditions among the traditional, rural and lower socio-economic sections in the Indian society. Lack of awareness about the state's policies regarding the people with special needs adds to their burden.

Parent's Voice

> *Mrs. and Mr. S shared "our son is bright as both of us are qualified and well placed. We both hail from highly educated families in the city. Our genes cannot become fragile and we cannot have a brainless child, he is just playful. He is just in the first standard; a little push can make him try harder to remember all alphabets. We don't want to accept the diagnosis".*

These parents sent their son to multiple tutors for extra coaching and refused to understand or accept their son's condition. The child was diagnosed with Fragile X syndrome.

Such a diagnosis often triggers stressors due to lack of acceptance, which contribute to imbalance in the family equilibrium. Many parents visualize the situation as a tragedy and are overwhelmed by their powerlessness to prevent it. The future seems depressing, as their child may not be able to achieve those age-appropriate developmental tasks. Grief about their child's lack of achievements and fear of stigmatization contributes to lack of acceptance. Parents feel that if they accept this diagnosis, they have to face the consequences that they fear. They believe that their persistence and teacher support will help them overcome whatever is mentioned in the medical reports. Some believe miracles to happen. Unfortunately, this attitude prevents the child from getting the adequate care required.

Parent's Voice

> *"We believed God will take care, my wife was busy performing rituals told by the priest and I was busy with my work. I can find reasons, but I realize now that we didn't do our share. Support was around, we did not notice. Like the God who parted the Red Sea … we believed miracles to happen, we were not practical, we can't say we did not get any support … rather we did not opt for it."*

A parent shared his misfortune that he did not seek help at the right time. Now his daughter is 20 and is still dependent for managing her basic routines.

Some parents highlighted the role of the media for non-acceptance. The media often reflects the society's attitude, which either shows sympathy or stigmatizes special children, reactions which are not liked by many parents.

This research reflects that academic qualification and financial status do not influence the acceptance level. Lack of acceptance seems to be a factor across socioeconomic classes, while the reasons for lack of acceptance vary across class. Parents from a high socioeconomic status expect more from the child, while parents from a lower socioeconomic status worry about the child's dependency and care requirements. Both these reasons prevent them from accepting reality. Anxiety about the future seems to be a concern across socioeconomic groups.

4. Other factors that contribute to stress

Parent's Voice

> *"I have to travel every day by train (public transport), two hours both ways to reach the hospital where therapy is free, two days for speech therapy, three days for*

> *physiotherapy and one day for meeting the doctor. All these happen at different parts of the city. We can't afford the center near our residence. Now I was told he needs to go to some special teacher for academics. Not sure how we will manage. I have two other normal children whose education is also important. Since I have to take our child everywhere, I have left my job. This adds burden on my husband. We hardly get time to talk to each other. He always comes home tired. I too am drained by the end of the day. Life is miserable."*

Children with challenging behavioral disturbances or complex physical needs add enormous stress to the family. Dependency of the child with respect to managing routine activities contributes to stressful parental experiences. Schools also require the parents to assist the child in school with their routine if the child is dependent. Children with severe behavior problems pose difficulties for parents in care giving, training them with self-help skills and monitoring their routine exercises at home which are mandatory for their progress (as suggested by therapists). Most parents are agonized at their child's physical health, treatment options and hospitalization.

In developing countries like India, public health resources are severely overburdened and parents are forced to access private healthcare. Parents from the lower socioeconomic status are not aware of the facilities available for special children. They have difficulty accessing special schools and fail to take assistance from professionals/therapists. Parents of lower- and middle-income households feel that they cannot afford private healthcare due to financial limitations. Special services like physiotherapy, occupational therapy, and speech therapy, which need to be accessed regularly for special children, become a luxury for them. Those who are ready to walk that extra mile and access public health care facilities report that they travel long hours to avail public health services and wait for a long time to get an appointment. So, child care becomes a crisis for many parents. When both parents are bread winners, lack of time also becomes an obstacle. Sometimes, families are economically strained, where the mother, the primary care giver, may not be able to return to work, which increases the burden of the working partner. Parents report that to manage the extra expenses in supporting the child, they work double shifts or take up additional part-time work. Poor access to services, lower social support coupled with the strain of poverty lead to lower levels of self-efficacy among parents from a lower socioeconomic status with regard to child care. Parents also report that financial strains, lack of energy and other resources create a lot of problems for family relationships.

Lack of support systems for parents can exacerbate stress. Support can be from professionals, schools, family and friends. Schools provide structure and a setting for the child to grow and develop skills. Schools also provide a context where there are other parents in a similar situation, providing an opportunity to meet and relate with other parents. Support from school authorities and staff members can alleviate stress, whereas a non-cooperative school environment creates stress. Parents report dearth of schools, therapists and special services. As discussed earlier, professional support is essential for parents to care for a special child. Professionals like doctors, paramedical professionals, counselors and special education teachers can help parents understand the child's condition and provide them hope about the child's future. Good therapists can be an important source of support, while encounters with unsympathetic health professionals can be very stressful.

Support from the partner, other immediate family members and children in the family can trim down stress. When partners do not actively contribute to child care and household chores, it can overburden the family, which results in special children being denied adequate care. Some parents single-handedly manage child care and expenses, which lead to health problems and emotional breakdowns for the caregiver. Lack of support from the special child's sibling is seen as one reason for family conflict. In some families, siblings feel they are neglected, which can lead to repressed aggression or open fights at home. Parents report getting lost in these fights, which add to their emotional burden.

Emotional support to caretaking parents is mandatory for child care. Marital discord is also reported due to differences in opinion about what is best for the child. Switching roles as a primary caretaker can alleviate issues, but just one parent taking responsibility can lead to blaming and agony. Lack of time for nurturing the marriage is also reported as a trigger for marital problems.

Parents need space and time to accept and cope with the situation due to a myriad of negative emotions experienced at the time of diagnosis. Many parents are forced to take up jobs less demanding or have to opt out of a full-time dream job to take care of the child. They report feeling socially isolated from friends, extended family or social groups they wish to belong due to lack of personal time. Pessimism, anger and shame can be the emotional turnover parents face due to the child's dependency, behavior and health problems [10].

5. Resilient parenting and factors that support coping

Despite problems, parents of special children show a lot of resilience. Parents who have coped effectively have narrated their experiences. The following section studies the patterns of successful coping. Parents have narrated their emotions and their inner struggles. These life stories all have an obvious trauma followed by the parents coping with this life situation (in different ways) and their interpretation of it [10].

Professionals working with special children and families may follow various models. This study does not discuss how efficient these models are, but a brief look at the models may benefit further discussions. The medical/biomedical model enumerates that these conditions exist within individuals and they are responsible for themselves. Environmental and functional models suggest that parents carry the stigma of having a special child and have to deal with societal prejudices and discrimination. The sociopolitical model aims at reducing discrimination and does not accept diagnosis aiming at full equality.

A model close to the current work is the peer counselor model, which assumes that people with direct experience with disabilities can be the best helpers, people who can assist and support parents whose children have been recently diagnosed. Counselors who work with the child and family need to understand what problems they face, social and financial. They have to assess the current level of functioning and environmental factors that either hinder or enhance functionality. Theoretical models can incorporate learning from those parents who have handled similar situations successfully.

It was seen that other than diagnosis, one's handling of the situation and support systems determine whether the situation is stressful or not. An effort is made here to understand the elements contributing to effective coping as evolved from parental experiences and professional support.

The most prominent theme in the narration is parental acceptance and awareness. Acceptance of the diagnosis and the child's condition helps in effective management of the child. Accepting the child's diagnosis emerged as the base for adaptation and resilience. The professional's role in conveying the diagnosis is extremely important. The way the diagnosis is conveyed has an impact on the parents' beliefs and expectations. It is important to clearly state the diagnosis and its impact on the child with clarity; it is important to be clear about the nature of the condition and its implications. Realistic acceptance of the child's condition is equally important for effective child management.

Parents conclusively share how 'hope' helped them cope with problems. They reflect on their experiences and the role of the school, the doctor and other professionals, who instilled this hope. According to Snyder [11], 'hope' is a learned thinking pattern, a set of beliefs and thoughts, having very discrete ways of thinking. Having faith in achieving what one requires is important for coping and resilience. All parents who accepted the condition hoped to see progress in their child.

The ability to appraise the situation positively (Cognitive adaptation) paves the way for acceptance. It is an effective coping strategy seen in parents, who shared that they find meaning in their experiences with special children, which has made them more effective. Cognitive reappraisal of the situation helped parents in understanding the situation as more manageable, helped them to be optimistic and easily accept the diagnosis, thereby maintaining an optimistic outlook.

Many parents shared that they are the chosen parents, as they have the skill to handle special children. The tendency to reappraise the situation is sensed in terms of the parents' ability to see their inner strength and perceive the fighting spirit in them. They could perceive the situation from a different perspective, which sounds similar to the concept of cognitive illusions proposed by Taylor [12]. The Cognitive Adaptation Model proposed by Taylor [12] is based on the work done with the coping efforts of cancer patients. Taylor's model proposes that 'threats' induce adaptation by searching for meaning in the experiences, trying to gain mastery over the event and eventually life in general and by restoring self-esteem through positive evaluations. Taylor calls it 'cognitive illusions.' Adjustment is based on the ability to modify these illusions. The parents in these narrations could make a similar adaptation.

Many parents talked about esteem-enhancing cognitions. The importance of a positive outlook is shared by a parent – *"when children are small, we get to think how we will manage, but the faith that we will manage takes us ahead"* [10]. Parents share how the birth of the child changed the family dynamics positively. Spirituality aided adaptation in some narrations. Some parents mention the 'Karma' theory (sum of person's actions in one of his successive states of existence, viewed as deciding his fate for the next birth in positive light). Some parents see the birth of a child as a blessing.

Professionals and institutions working with special children can ease this process. The principal of a special school shared in her narration the importance of language used.

Professional's Voice

> *"I realize language makes a big difference when I talk to parents. I often tell them that your child is differently abled. He/she is not their disability. He has a disability and we are here to help and streamline things for him. It is important for parents and society to become consciously aware that children are more than their disability."*

Parent's Voice

> *"I have accepted that my son is special. Initially, I was reluctant, now I take him everywhere. ... sympathy from others at times hurts, knowing to handle those comments is important. I tell them I got a lot of luxury, money after he came, he is God. I started responding positively to questions raised by others about his conditions. This keeps those negative people away" [10].*

All the narrations and interactions with professionals working with special children confirm that higher levels of acceptance are associated with parents who either rely on themselves or seek help from support systems.

Other than parental acceptance, there are certain other parental traits that help in coping with the child's condition. *Parental perseverance* is the ability to keep pursuing their chosen paths despite difficulties. They often describe themselves in such terms as *"I am not a quitter" and "I never want to give up." "I will do my best."* These parents have a clear goal, which is the child's well-being. These parents put a lot of effort to learn more about their child, choose the best schools possible, and are willing to travel long distances every day for therapy sessions. These parents show the willingness to take support from others or relocate their residence and change their routines for the child.

Parent's Voice

> *"You cannot say somebody else will help, you have to help yourself ... the amount of effort you put in, you will see that much outcome, and your effort will not go waste."*

Parents' perseverance is not just related to how they handle their children. It is also seen in how they handle themselves – like eating on time, pursuing their hobbies etc.

The positive traits of parents seem to shield them from negativity. Parents often experience strong feelings for their child immediately after receiving the news of the disabling condition as discussed earlier. These include shock, anxiety, disbelief and disappointment as reported in narrations. Mothers often share that they wept for days together and few stopped interacting with others. However, after the initial phase of negativity, narrations had either positive or negative emotions taking over. The theme that emerges from these parental voices is *Trait Positive Affect*. Trait refers to a dispositional tendency that remains stable over time. Positive Affect is defined as the "level of pleasurable engagement with the environment" [13]. Parents who are initially negative turn positive, because they are inherently dominated by positive affect. Thus some narrations have mothers expressing positive affect, which are expressed as happiness in child rearing experiences. These narrations have shared optimism while enumerating the success stories of children. They were able to celebrate even the slightest improvement and also felt good about the effort put in by the child, themselves and family.

The role of positive emotions was illustrated by Folkman and Moskowitz [14]. When negative emotions are experienced due to a stressful event, positive emotions may provide a psychological break or respite, which support coping efforts and restock resources that stress has taken away. Thus, positive affect might help parents in strengthening psychological and physical resources during stress and protect them from depression. According to Lazarus and Folkman [15], "positive emotions reload resources that have been depleted by the stress by providing a psychological break or breather which supports coping."

Most of the narrators who share experiencing positive emotions also share effective *emotional regulation*. They undergo negative emotions at times, which they are able to channelize instead of feeling burdened. They channelize their fears and anxieties by talking to the partner, family members or counselors. Parents also channelize their emotions by participating in routine exercises like yoga and engage in spiritual activities (visiting churches and temples, praying), thus distracting themselves from negative cogitation.

Not all narrations are positive. The narrations with dominant negative feelings are filled with feelings of pessimism, anger, shame, denial, guilt, grief, depression,

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and self-blame. Parents who sound depressed and unhappy are very pessimistic in their approach. They either blame themselves, the family members, or the system. Guilt and depression affect the social lives of parents. A lot of anger towards self, significant others and at times towards their child was sensed. Some parents shared health hazards faced by them. They fail to take support, thereby failing to support their child like other parents.

Parent's Voice

> *"I know my daughter is dependent on me for many things including self-care. I will be there and I want to be there … I am constantly vigilant and learn/invent options to support her. Recently, I realized it has started showing on me. Lack of exercise, disrupted sleep and no time for self … I am irritable and anxious most often and I am getting tired easily. Our marriage seems to be in doldrums too."*

Disability of a child can restrain the normal expression of emotions and thoughts of parents, as they believe that the child must be their priority. Parents share in their narrations that a negative affect results in accumulated anger resulting in outbursts, sadness and health concerns, which are often psychosomatic.

Early understanding of the diagnosis and awareness about the child's condition result in positive affect. Having adequate skills to handle the child and cognitive adaptations like finding hope and optimism facilitate positive feelings. Working with negative emotions is an important part of counseling parents. Accepting and normalizing these emotions is crucial in dealing with negative emotions. Parents are made to realize that it is not the child or the partner that is the cause of these emotions, but rather it is the condition or the disability. This helps them in handling emotions better.

Managing a special child necessitates the ability to handle countless issues. The quotes *"I can cope"* and *self-efficacy* are shared by parents, in multiple narrations. Parents who have handled previous stresses successfully, parents who are positive about handling a special child and get acquainted with other parents of special children are more confident about their current situation. Parents' narrations were similar to "mastery experiences" and "vicarious experiences from social models" as detailed by Bandura [16]. Observing other parents and listening to them enhance the belief that they can also help their own children effectively.

Parent's Voices

> *"I lost my parents during my 10th grade. It became my responsibility to bring up my younger siblings. I managed well; both my brothers are educated and settled. I too managed a good degree in commerce and am employed in a bank. I can handle stress well. God had thought of it and has given me my child. I only can bring him up and in the process I can help others like him as well."*

> *"I was lost when I heard about the diagnosis from the doctor during routine checkups. He doubted the chance of me having a child with delayed milestones and lower IQ. My husband felt we should abort this child, I was reluctant. I met parents who had children with similar difficulties, I spoke to professionals. I realized that if they can manage, I too can."*

Assertiveness seems to be a major factor in parents while taking decisions for themselves and their child. Their ability to say *'no'* and the ability to *"stand for the child,"* while handling comments and criticism from family and society is very crucial. *"Being assertive also helps me handle negative emotions,"* says a parent. Assertion is important when it comes to spending for the child and choosing the right school and professionals to work with one's child. Often, parents need to speak up for the child too. Parents share instances, where they may have to deal assertively with immediate family members to raise money for the child. Parents say they have to be assertive with family members, who refuse to give space to the special child in the family. Passive parents often become negative and develop guilt and anger.

Decision-making skills are important according to the narrations shared. The ability to assess the available options and the ability to envisage consequences of different actions along with knowing and protecting the rights of the child are shared as essential.

Parent's Voices

> *"My son also would have done NIOS and I knew he can if I push him ... but he was not interested. I knew he needs to learn self-help skills and activities for daily living than a SSC certificate. If I prioritize exams, he would not be doing what he enjoys, nor would he be independent as he is now. He enjoys cooking and is now part of the finest hotels in the city".*

> *"It was a difficult decision to relocate to Mumbai, especially leaving my husband who just had an attack, but I knew it's important for my daughter. My in-laws are there to take care of my husband, I decided. My family did not completely agree to my decision. I knew I have to manage both kids and their education and support expenses for my special child. I took it up and joined as a helper in special school and eventually completed a special education course. Now I am part of my daughter's school as a special educator. That decision to relocate to Mumbai helped our family to handle the crisis."*

Positive evaluations of situations, perseverance, assertive skills, decision-making skills and self-efficacy beliefs are all crucial for effective coping in parents. All these personal variables stem from cognitive reappraisals of parents, which lead to parents accepting the child's condition.

Parents showing the above-mentioned traits are able to come to terms faster with the child's condition compared to those parents who lack the above traits. These parents are motivated to seek information and approach professionals who could guide them to handle and nurture their child. Some of them prepare themselves by taking personal counseling.

An important factor that leads to positive adaptation in these parents is *social support*. Supports come from different levels and are seen as crucial for adaptation. Support systems for family can function at various levels. Support from the partner, children and other family members can alleviate stress and boost emotional support.

Parent's Voices

> *"As parents, we work in shifts. My son is mentally challenged and also not very mobile. It's important that we both work, so that we can provide the best for our son. We can't afford a caretaker. My husband will be with the son after I leave for work at 8 am in the morning. My daughter who is 8 years old will reach home from school and take over the responsibility of my son. My husband will feed him and put him to sleep and leave for his night shift at 3 pm. She will take care of him till I come home from work. My daughter is our support. She is very patient with her elder brother. She is the one who taught him to sing and read alphabets. We as a family support each other."*

> *"My husband without any complaints works double shifts so that I could leave my work and take care of children. There are days he comes home very tired but has a smile in his face. That smile gives me the energy to carry my child and walk to his special school and later to therapy. Now my son can walk with support. Thanks to my family and the support from my partner."*

> *"As a family, we share all responsibilities. All the chores of the family are shared by me, my in-laws, husband and my children. This helps us to give that extra time to my daughter who needs special care. My mother-in-law sees to it that I get adequate rest and I eat on time. There are days she gives me a break with my husband and manages my kids. My family is my biggest support. I am cheerful and so is my child."*

6. Professionals as an important support

Professionals working with special children can support parents for all the factors discussed above. Interactions with professionals highlight that it is important to assess the needs of the family, available resources and support systems and make a tailor-made plan for each family. This will aid in identifying additional support and services crucial to improve the family's capacity to meet the developmental needs of the child and maintain family equilibrium. Research demonstrates that clients, along with what they bring to the session, are responsible for the success of counseling. So, understanding parents and their situations become important. Reflections from parent-counselor interactions as well as personal experiences of parents serve as a resource for developing, at times, unconventional styles of coping, based on 'practice-based evidence' as suggested by Egan and Reese [17].

Special schools with trained and sensitive professionals can ease the emotional strain of parents. Some schools take help from parents to speak about their experiences. These parents are trained to support other parents, who feel dejected with their child's diagnosis/disability.

Parent's Voice

> *"My child's school introduced me to a positive child, who is smiling despite his immobility and dependency on people around. He is dependent even to meet his basic needs. I was made to hear through his mother and how she is cheerful herself and could bring smile in all children in the special school. Here I learned to give space to every child and accept them as they are. Now I am not only able to accept my son with his diagnosis, but also give space to my daughter who is a normal child. My son taught me parenting and that helped me to nurture my daughter better. Parents usually decide what is good for the child, get good marks, do this do that … my daughter is beyond all these. She is never worried for exams/marks, yet does so well in school. As a family, we are very cheerful. Thanks to the school and 'that' parent."*

There are professional helpers to assist parents, who want to come to grips with problems in living with a special child. Every child is unique and so the requirements of parents are also unique. Parents need help in understanding the child's needs and managing them effectively, which can be achieved through counseling, family education and skilled training. Previous research also confirms that early intervention and psychosocial assistance are crucial protective factors [18]. Counseling parents soon after the diagnosis is made can work positively on the family's belief systems. The ability to clarify and give meaning to a crisis is crucial for coping and family resilience. Counseling can strengthen family bonding and improve adaptability and flexibility in members, which will equip them to manage change. Family therapy can also aim at effective communication between family members and conflict resolution.

Often, parents require practical, informational, and educational support as soon as the diagnosis is given. Parents benefit from factual information about the causes of disability and ways of accessing resources to manage their child. Information support and services to locate professional services, including what can be expected from these services, are mandatory information parents need access to. Every state administration needs to have educational training platforms, which can be made available for all parents coming with concerns. With current technology, online programs, which are self-paced, can be made available to disseminate this information. Information regarding special schools in the locality, respite care services for parents who need a breather, and daycare programs for grown-up children can be made available. Services for children with disabilities are strongly influenced by government legislation. Professionals who work with special children need to keep themselves updated with the current government norms.

Proficiency in handling special children comes with skilled training, which introduces behavior management strategies. Parents and professionals need to work in unison.

Parent's Voice

> *"I learned from my therapist that whatever I do with my son like helping him to manage routine or feeding, I need to do it with love and care. Also not to think of it as a task that takes 40 minutes, one hour and it is over. It should not be a monotonous therapy. My son needs repetition and I need to do it without feeling the tension that I have to do this … Always I see to it that I am happy doing that. My child takes more than an hour to eat. As guided by my therapist, I eat first before feeding him. so I am not hungry while feeding".*

Professional support is mandatory to deal with emotions. Parent programs can help parents in dealing with stress, grief, guilt, fears and anxiety. Coping skills can be easily discussed once the emotional pain is handled. Changes in the emotional state affect the quality of parenting. Parents getting professional training, like cognitive-behavioral therapy and behavior management skills, help them cope with negative thoughts and non-productive behavior. Importance of parental programs has always been recommended in previous research [19]. Stress management interventions are found to effectively reduce the reported stress [20, 21]. Interventions of longer durations and addressing parental concerns and parenting skills have a greater impact. It can be confirmed that working with parents is a fundamental part of intervention for special children compared to letting parents working with the child alone.

Group counseling can be an excellent platform that enables parents to realize that they are not alone. Topics addressing the needs of both the child and parents are beneficial. These meetings can give parents the opportunity to develop a personal support network. Trained moderators are required to help parents handle their emotional well-being. Parents need space to vent out their anger and frustration. Group work, with a skilled professional, can address and alleviate emotional pain.

Some special schools have initiated parent support groups. As the child passes through various stages, parents need a platform to share and learn from other parents. Parents report that these support groups are seen as a place to share their fears and find alternative solutions to their current concerns. It is a platform for parents to share feelings and ideas, where they can do physical exercises, yoga and pursue their hobbies with their children. It is a place where everyone can come together to pray to handle negativity. Some of these parent groups have started programs to make their children financially independent. Pickle making, painting, printing, making hand-made artifacts are some of the extension activities done by these support groups. Some cities in India have eat-out joints started by special children with the support of dedicated parents and Non-Government Organizations working for a social cause.

Professional assistance is required to address the special educational needs of the child. Special programs are required to address these needs, through the involvement of parents and professionals.

Parent's Voice

> *"For others my daughter is dependent, but for me she is in the process of being independent. She started eating on her own! She has learned to button her shirt, she can signal me now if she wants to use the toilet! When she eats alone, I don't see how much she spilled, I see how much she could eat without getting tired. She started enjoying music, can sway her head with the rhythm, started smiling more often and responds when called … my daughter is showing great improvement. I won't be talking to you this way if I had not met my daughter's special teacher. She is teaching her to be independent so patiently and also helping me identify her progress. This professional is amazing!"*

Special kids, who cannot handle sexual feelings, may require a psycho-educational approach to help them handle these feelings. Other emotional concerns like depression may require cognitive or behavioral interventions. Role play and psychodrama are used for kids who need to own up or take responsibility for their actions and eventually be more independent.

Parent's Voice

> *"She is differently abled; her comprehension about worldly matters is poor. Her behavior bothers me, at times. She is hyper, stubborn … she is 15 now. I recently realized that she is attracted to the opposite sex, something which happened in the school bus (parents shared the incident). I was upset, too emotional to handle but the therapist handled it well. She spoke to her like a 15-year-old; she educated her … , explained to her without accusing and accepting her completely. Therapy to handle developmental changes is important. I am lucky to have the best one in the city to work with my daughter. I feel relieved."*

Professional's Voice

> *"When I joined as a special educator in a regular school, I was asked to work with this girl with cerebral palsy. She was 7yrs old and got admission in this school with the class of 40 children – The so called 'normal' students. All her class mates were less than 5yrs old. With the support of class teacher, I made her pair up with one student in class each day. This friend assisted her to carry her bag, supported her with worksheet, played with her in class while others went to ground. This friend ate with her in class and sat next to her the whole day. Not only my special girl felt happy and confident, the whole class was proud and confident in assisting her. Currently she has cleared her 1oth grade in flying colors. Her class mates were together in this journey. This class is known to be the most sensitive student group according to teachers. These students not only cared for their classmate but also were sensitive to all those needed support".*

This beautiful example highlights the role of professionals in not only supporting children with disability but also sensitizing the community. The point to be noted here is the trust placed on inclusion. Inclusion need to address infrastructural needs, curriculum development, suitable evaluation system and teacher training. Special educators have a major role to play in providing instruction tailored to meet the needs of the students. Diversity is a fact and inclusion is an art to support special children. Right for education is for all and cannot be denied due to any reason. Decisions about who can be educated or rehabilitated should not depend on classification systems. The classification systems will not provide the necessary information or guidance to understand child's learning pace.

There is hope with new education policy. The primary emphasis of education policy in India is to improve the quality of education for all. The Mental health care act, 2017 [22] and The Rights of Persons with Disabilities Act, 2016 [22] ensures every person have a right to live life with dignity and should not being discriminated. The New Education Policy [23] had come with more hope to children with special needs. The policy asserts that children with disabilities will have opportunities for equal participation across the educational system. Special schools will be known as alternate schools which will be equipped with trained staff to address children's educational and emotional needs. The need for humanizing education, encouraging self confidence and motivation in children with special needs is the need of the hour. This has come as a respite for parents and educators who were voicing the concerns since two decades.

Rehabilitation counseling, a specialty in the counseling profession, is particularly focused on serving individuals with disabilities [24]. These specialized counselors are not only aware of medical terminology related to a child's condition and its impact, but are also trained in skills to help the child and parents. They play a decisive role in the rehabilitation of these children towards independent living and employment, wherever possible. They are trained to do personal counseling to assist children in making social and emotional adjustments to their environment. They assist parents with educational and training resources. The recent polices bring hope to the system and the role professionals have in execution of this policies is incredible.

7. Conclusion

Indian culture emphasizes the crucial role of family in the child's development. This is more pronounced in the case of family with special children, who require constant guidance and support. Parents can go through phases of denial, self-blame and stigma that prevent them from taking support for effective guidance of their child. Unrealistic expectations and anxiety about the future adds to the burden. Research suggests that adaptation by the family is based on the interaction between the stress experienced and the available coping resources.

It is the role of the professionals who work with these children to support parents and families to adapt and come out resilient. Families who emerge as resilient can be used as role models in the helping process. It is important for professionals to work on the family belief systems and nullify negative evaluations. The ability to clarify and give meaning to a crisis is crucial for resilience. Strengthening family bonding and identifying support systems outside the family can be another area professionals can work on.

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Author details

Radhika Mohan
Vivekanand Education Society's College of Arts, Science and Commerce (Affiliated to University of Mumbai), Mumbai, India

*Address all correspondence to: radhika.mohan@ves.ac.in

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Section 3

Clinical Features of Learning and Neurodevelopmental Disorders

Chapter 8

Learning Disorder (Dyslexia): An Overview Description of the Entity through Available Researches

Sambhu Prasad and Rajesh Sagar

Abstract

Dyslexia is a specific learning disability can be explained with number of biological and neuropsychological theories. It is characterized by difficulties with accurate and/or fluent word recognition and by poor spelling and decoding abilities. The available research in this field show that there is impairment in processing the sensory input that enters the nervous system. It also indicate that there are problem in phonological decoding. There are various educational interventions and programs to address dyslexia which includes regular teaching in small group, a learning support assistant like a specialist teacher, policy interventions etc. The basic strategies of intervention focus on phonemic skill such as the ability to identify and process word sounds.

Keywords: dyslexia, fMRI, neurobiology, management

1. Introduction

Specific learning disorder (SLD) is manifested by specific and significant impairments in learning of scholastic skills in children and adolescent. Over the years they have been given different labels like dyslexia, perceptual handicap, neurological impairment, minimal brain dysfunction, congenital word blindness, development aphasia, congenital aphasia, educational handicap. Until very recent times they were often not diagnosed due to lack and paucity of assessment tools. Learning disability is not a single disorder, but is composed of disabilities in any of the 7 specific areas:- like Receptive language (listening), Expressive language (speaking), Basic reading skills, Reading comprehension, Written expression, Mathematical calculation, Mathematical reasoning.

There is heterogeneity in term of etiological factors and manifested as difficulty in reading (dyslexia), writing (dysgraphia) or perform efficient mathematical task (dyscalculia) despite intact sense, intelligence, motivation with adequate socio-cultural opportunity [1, 2]. The term SLD does not include who have learning disability primary the result of any organic lesion in brain, subnormal intelligence, any psychiatric disorders or socio-cultural disadvantages [3]. This disorder is seen worldwide and occurs in students irrespective of their mother tongue and medium of instruction in the school which may be English or any other vernacular language.

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Dyslexia was first identified in the latter half of the nineteenth century and subsequently several subtypes have described [4]. In 1993, Castle and Coltheart point out the basic subtypes namely Phonological, Surface and Mixed varieties. The phonological subtype have deficiency in development of graphic phonemes reading ability whereas in surface subtype show difficulty with developmental lexical procedure [5]. The neurobiological aspect of dyslexia has been described as earlier as in 1891 by Dejerine suggesting angular gyrus, supramarginal gyrus in inferior parietal lobe, posterior aspect of supra temporal gyrus and ventral aspect of occipito-temporal were critical for reading [6, 7].

2. Prevalence of dyslexia

Dyslexia is perhaps the most common neurobehavioral disorder affecting children, with prevalence rates ranging from 5 to 17.5 percent [2]. An epidemiological study in British school children in the age range of 8–10 year found the prevalence of 'specific reading difficulties 'to be 3.9%, with the overall prevalence of SLD around 7.5% [8]. According to one Asian study the prevalence of dyslexia and probable dyslexia were found to be 6.3% and 12.6% respectively. The male to female ratio of dyslexia was 3.4:1 [9]. In India, there was about 250 million school going children, 12.5 million (1.25 Crore) children suffering from SLD [10]. Barring arithmetic disorder which may be more common in girls, all other learning disorder seems to be 3–4 times more common in boys. In another study conducted by Sadhu et.al, (2003) reported presence of neurological soft signs in SLD children from Indian context [11]. Agrawal et al. (1991) used Bender Gestalt test, Piaget's test and Indian modification of WISC for the detection of SLD in rural primary school children [12].

3. Diagnostic criteria

Characteristic diagnostic features include difficulty recalling, evoking, and sequencing printed letters and words; processing sophisticated grammatical constructions; and making inferences. There are certain criteria in International Classification of Diseases (ICD-10) [13] and Diagnostic and Statistical Manual of Mental Disorders (DSM-5) [14] for diagnosis of specific reading disorder (**Table 1**).

S. No.	According to ICD 10	DSM 5
1	Specific reading disorder (F81.0)	Reading Disorder (315.00)
2	Specific spelling disorder (F81.1)	Mathematics Disorder (315.1)
3	Specific disorder of arithmetic skills (F81.2)	Disorder of Written Expression (315.2)
4	Mixed disorder of scholastic skills (F81.3)	Learning Disorder Not Otherwise Specified (315.9)
5	Other developmental disorders of scholastic skills (F81.8)	
6	Developmental disorder of scholastic skills, unspecified (F81.9)	

Table 1.
Classification of specific learning disorder.

4. ICD-10, diagnostic criteria for specific reading disorder

A. Either of the following must be present

1. 'A score on reading accuracy and or comprehension that is at least 2 standard errors of prediction below the level expected on the basis of the child's chronological age and general intelligence with both reading skills and I.Q. assessed on an individually administered test standardized for the child's culture and educational system'.

2. 'A history of serious reading difficulties or test scores that met criterion (A) [1] at an earlier age plus a score that is at least 2 standard errors of prediction below the level expected on the basis of the child's chronological age and I.Q'.

B. 'The disturbance described in criterion (A) significantly interferes with academic achievement or with activities of daily living that require reading skills'.

C. 'The disorder is not the direct result of a defect in visual or hearing acuity or of a neurological disorder'.

D. 'School experiences are within the average expectable range'.

E. 'Most commonly used exclusion clause – IQ below 70 on an individually administered standardized test'.

5. DSM-5 criteria for Reading disorder (F81.0)

With word reading accuracy, reading rate or fluency, reading comprehension include:

A. 'Reading achievement, as measured by individually administered standardized tests of reading accuracy or comprehension, is substantially below that expected given the person's chronological age, measured intelligence, and age-appropriate education'.

B. 'The disturbance in Criterion A significantly interferes with academic achievement or activities of daily living that require reading skills'.

C. 'If a sensory deficit is present, the reading difficulties are in excess of those usually associated with it'.

Coding note: If a general medical (e.g. neurological) condition or sensory deficit is present, code the condition on Axis III.

6. Characteristics of reading disorder

History of language delay, or of not attending to the sounds of words (trouble playing rhyming games with words, or confusing words that sound alike), along with a family history, are important red flags for dyslexia [2]. Specific symptoms of reading disorder include difficulties in single word decoding, slow oral reading and poor comprehension of written text. The developmental dyslexia as per

Bakker classification: Linguistic (L) type, perceptual (P) type, and M type [15]. It is also classified by Doehring (1977) into Subtype I (Poor in oral reading of letters, nonsense syllables and words relative to their silent reading skills); Subtype II (Read slowly and made many mistakes) and Subtype III (Better able to read single letters than to read words or syllables during either silent or oral reading) [16]. As per Petrauska and Rourke (1979), developmental dyslexics were classified into those:a) who had language difficulties with intact visual motor skills; b) who had sequencing, visual memory and finger identification difficulties; c) who had language and concept formation difficulties and poor visual motor skills [17]. Rourke also postulated a model which is organized into primary, secondary and tertiary assets and defects [18]. The primary assets has following feature such as repetitive motoric skills, auditory perception, mastery of rote or repetitive material. Its defects include tactile and visual perception complex psychomotor skill and ability to process novel situation. In secondary assets there were selective and sustained attention for simple, repetitive verbal materials and its defects include tactile and visual stimuli and exploratory behavior. The tertiary assets involve rote verbal memory with defects in tactile and visual memory, concept formulation, problem solving, hypothesis- testing skills and understanding the semantic and pragmatic aspects of language [19]. These deficits appear to increase with age. It was also postulated that nonverbal learning disorder is related to dysfunction of white-matter tracts that serve to connect associational areas, with particular involvement of the right hemisphere [18].

7. Etiological factors of dyslexia

A. **Heritability**-It has both familial and heritable cause and found that the rate among siblings of affected persons was around 40 percent and among parents it ranges from 27 to 49.The chromosomal analysis show linkage and implicate loci on chromosomes 2,3,6,15 and 18 [20].

B. Cognitive Influences: Theories of Developmental Dyslexia

1. Cerebellar theory: The studies have shown that the cerebellum of dyslexic have mild dysfunction with number of cognitive difficulties ensue [21].

2. Magnocellular theory: The magnocellular dysfunction is not restricted to the visual pathways but is generalized to all modalities [22].

3. Phonological deficit theory: The dyslexic have a specific impairment in the representation, storage and/or retrieval of speed of sounds [23].

4. Rapid auditory processing theory: This theory says that the primary deficit lies in the perception of short or rapidly varying sounds [24].

5. Visual theory: There is a visual impairment giving rise to difficulties with the processing of letters and words on a page of text [25].

Among investigators in the field there is now a strong consensus supporting the phonological theory.

C. The neural basis of dyslexia

Galaburda et al., 2000 found that there was a microscopic malformations in the perisylvian regions (cortical ectopias and dysplasias) and the geniculate nuclei (size reduction of magnocellular neurons) suggesting abnormal neuronal migration and maturation, prompting research on the neural basis of dyslexia [26]. In skilled adult readers the functional neuroanatomy of reading is widely distributed but dominated by a left-sided network [27]. They also found that the ventral pathway in the posterior fusiform gyrus re[present an automatically assessed visual word-form area [28]; however the dorsal pathway (include angular and supra-marginal gyri) represent phonology based assembly process [29], implicated in the output of phonological and articulatory aspects. Most studies show reduced activity in the left, rather than bilateral perisylvian regions. There was a disconnection within the left perisylvian network, which has a role in phonological processes [30].

D. Neuropsychological Deficits in dyslexia

Visual processing deficit: Both visual auditory and tactile information processing deficit was documented by Laasonen and Tomma, 2000 [31]. There were impairments in executive functioning and deficit in central information processing. It was also shown that there were maturation lag of left hemisphere, also called disconnection syndrome. They also have difficulty with inter-hemispheric transfer and defect in left parietal lobe, temporal lobe, angular gyrus and cerebellum.

E. Neurological Soft Signs in dyslexia

It include abnormalities in: Graphethesia, Stereognosis, Motor task, Face hand face noise test, two point discrimination, maintenance of posture & tapping, more rotation error in BGT. It was also found that arithmetic disabled children had right sided soft signs indicating left hemispheric dysfunction.

8. Neuro-imaging of dyslexia

Given that reading disorder is essentially a language deficit, the left brain has been hypothesized to be the anatomical site of the dysfunction. There are different neuro-imaging studies done including positron emission tomography (PET scanning), event related potentials (ERPs) with auditory and visual stimuli, magnetic evoked potentials by megnetoencephalography (MEG) and magnetic resonance spectrography (MRS) alongwith functional magnetic resonance imaging (fMRI) [32]. The research studies using functional magnetic resonance imaging (fMRI) studies have suggested asymmetrical activation of left brain in children with both language and learning disorders. Functional MRI (fMRI) detects the hemodynamic response related to neural activity in the brain, based on the principal of BOLD (blood oxygen level detection). It has better spatial resolution and BOLD activity from all regions of the brain can be obtained. It can noninvasively record brain signals without risks of radiation inherent in other scanning methods, such as CT and PET scans. Hence, this study was planned with fMRI neuro-imaging technique for studying the areas of activity during different processing tasks in dyslexia.

9. FMRI and dyslexia

Neuroimaging method such as functional magnetic resonance imaging (fMRI) provide evidence of hypoactivation of the left posterior language system in dyslexia, across different languages. This hypoactivity has been localized to left posterior parietal cortex [33], inferior occipitotemporal cortex, and superior temporal gyrus [34].

Temple et al. 2000, found that the fMRI data revealed largest activation was in the left prefrontal region, between the middle and superior frontal gyri in Brodmann area 46/10/9. Analysis of the dyslexic readers revealed no left frontal response to the rapid, relative to the slow, stimuli. This brain imaging study shows both a disrupted neural response to rapid auditory stimuli and its location in dyslexic adults [35]. By using fMRI, Brown et al., 2001 have shown that there were hypointense gray matter in most of the left temporalcortex by voxel-based morphometry or anisotropy in white-matter fibers [36]. Helenius, showed that prelexical processing in left inferior occipitotemporal regions was sometimes absent in people with dyslexia [37]. Using fMRI, Shaywitz et al.,2002 found that the brain activation in dyslexic opposite during reading task where frontal part was more active in comparison with back regions [34].

Johanna Pekkola 2006 et al., found that dyslexic readers' use more of motor-articulatory and visual strategies during phonetic processing of audiovisual speech, possibly to compensate for their difficulties in auditory speech perception [38]. Martin Kronbichler et al., 2008 found that there was less gray matter volume for dyslexic readers in the left and right fusiform gyrus, the bilateral anterior cerebellum and in the right supramarginal gyrus. There was decrease volume mass in gray matter in right and left fusiform gyrus which highlight the importance of this brain regions in developmental dyslexia [39]. Quaglino V et al. 2008 during their fMRI study i a phonological deficit in developmental dyslexia [40]. Vera Blau et al. 2009 showed that dyslexic readers has under activation of superior temporal cortex for the integration of letters and speech sounds. They also showed that there was reduction of audio-visual integration the fundamental deficit in auditory processing of speech sounds, which in turn predicts performance on phonological tasks and account for developmental dyslexia, in which phonological processing deficits are linked to reading failure through a deficit in neural integration of letters and speech sounds and IQ [41]. Fabio Richlan et al., 2010 found that there was dysfunction of the region in the developmental cases who failed to exhibit responsiveness of left OT regions to the length of words and pseudo- words [42]. Rimrodt SL et al., 2009 found that the dyslexic group show more activation in the linguistic processing areas such as left middle and superior temporal gyri as well as in the attention and response selection areas such as bilateral insula, right cingulate gyrus, right superior frontal gyrus, and right parietal lobe [43]. Li Liu et al., 2012 showed that the dyslexic has less activation for both tasks in right visual (BA18, 19) and left occipito-temporal cortex (BA 37), suggesting a deficit in visuo-orthographic processing. It also has abnormalities in frontal cortex and in posterior visuo-orthographic regions may reflect a deficit in the connection between brain regions [44]. In the recent neurobiological study of dyslexia from India dyslexic where compared with healthy matched control and BOLD acquisition using fMRI was done with three different paradigms (semantic, picture and auditory), the study show that it was an important contribution in beginning to understand how higher level language processing impacts reading comprehension, especially in disabled readers. Healthy controls show greater activation within left occipito-temporal region (visual word form area). The Dyslexic group demonstrated right hemispheric dominance for language and exhibit increased articulation and planning as compared to control, in performing the semantic tasks. The BOLD cluster activation and signal intensity were greater in dyslexic patients as compared to control [45]. The further description of BOLD activation during the above mention tasks are given in detail in the tabular form and brain imaging using fMRI (**Tables 2–4** and **Figures 1–3**).

No clusters	Z-score	mni coordinate	Talairach coordinates	Hemi-sphere	Area of activation	Brodmann area
Patient vs. control during rhyming task (p<0.001)						
29	3.21	44 -46 -28	40 -42 -24	Right	Cerebellum-Culmen	
39	3.17	24 -2 -36	22 -1 -28	Right	Uncus	BA 36
14	3.08	20 -30 30	17 -32 29	Right	Cingulate Gyrus	
65	3.01	54 -18 34	49 -22 34	Right	Postcentral Gyrus	BA 2
45	3.01	-4 -46 22	-5 -47 20	Left	Posterior Cingulate	BA 30
Controls vs. patients during rhyming task with respect to meaningless stimulus (P<0.001)						
11	3.81	58 -48 20	52 -48 19	Right	Supramarginal gyrus	BA 40

During intergroup comparison of dyslexic group with respect to control for auditory phonological rhyming task BOLD activation was observed in the right post-central gyrus, right cerebellum and uncus and the left posterior cingulate gyrus. Thus the decoding of language occurs in left superior temporal gyrus that was not observed in dyslexic group.
During Intergroup comparison of controls with respect to dyslexic group during auditory phonological task, rhyming with respect to meaningless baseline BOLD activation was observed more in right superior temporal gyrus where the right hemisphere is dominant for visuo-spatial auditory processing. No such activation was observed in dyslexic group with similar condition. This finding concord with the previous study in which the middle and posterior part of superior temporal sulcus was activated by silent speech-reading, and also by audio-visual speech. This region usually constitutes the principal focus of activation in fMRI studies of speech-reading.

Table 2.
BOLD Activation in Intergroup Comparison during Rhyming Task.

No clusters	Z-score	mni coordinates	Talairach coordinates	Hemisphere	Area of activation	Brodmann area
Controls						
10	3.49	32 -52 68	28 -56 61	Right	Superior Parietal Lobule	BA 7
29	3.29	-52 -70 28	-50 -69 22	Left	Middle Temporal Gyrus	BA 39
Patients						
102	3.15	8 -34 50	6 -38 46	Right	Precuneus	BA 7
28	3.88	-32 38 -14	-30 35 -6	Left	Middle Frontal Gyrus	BA 47
51	3.87	58 0 -34	53 1 -25	Right	Middle Temporal Gyrus	BA 21
58	3.81	-64 -40 34	-61 -42 30	Left	Supramarginal Gyrus	BA 40
238	3.74	-18 -36 4	-18 -36 4	Left	Thalamus	
62	3.66	2 -34 72	0 -40 65	Left	Paracentral Lobule	BA 5
48	3.61	6 -44 20	4 -45 18	Right	Posterior Cingulate	BA 30
14	3.42	-20 66 10	-19 59 19	Left	Superior Frontal Gyrus	BA 10
39	3.39	18 -18 62	15 -24 58	Right	Medial Frontal Gyrus	BA 6
11	3.36	34 -26 66	30 -32 61	Right	Postcentral Gyrus	BA 3

No clusters	Z-score	mni coordinates	Talairach coordinates	Hemisphere	Area of activation	Brodmann area
13	3.33	-46 -20 2	-44 -20 3	Left	Insula	BA 13
16	3.29	-50 -74 28	-48 -73 22	Left	Middle Temporal Gyrus	BA 39
10	3.25	54 -32 40	48 -35 38	Right	Inferior Parietal Lobule	BA 40
Patients **vs.** Controls						
30	3.82	-32 34 -12	-30 31 -4	Left	Inferior Frontal Gyrus	BA 47
Controls **vs.** Patients						
No Activation						

During picture task, in the control group BOLD activation was observed more in left middle temporal gyrus which are involved in visual encoding and memory processing as well as in the right superior parietal lobule (visual processing area). However in dyslexic group BOLD activation was observed more in right precuneus, right posterior cingulate gyrus (visuospatial processing), right medial frontal gyrus (involved in planning and co ordination of movement), right paracentral lobule (voluntary motor function and motor planning) and bilateral middle temporal gyri (right hemispheric dominance). BOLD activation was also observed in left supramarginal gyrus (association area) and left thalamus (sensory motor coordination). Thus the dyslexic group used more memory component of brain.

Table 3.
BOLD Activation during Picture Naming Task in Controls, Dyslexic and the Intergroup Comparison (P<0.001, Cluster Threshold=10).

No clusters	Z-score	mni coordinates	Talairach coordinates	Hemisphere	Area of activation	Brodmann area
Controls (p<0.001)						
363	4.18	-16 -90 -14	-16 -84 -17	Left	Cerebellum - Declive	
99	3.62	22 -88 -10	19 -83 -12	Right	Lingual Gyrus	BA 18
86	3.52	12 -98 0	10 -93 -4	Right	Lingual Gyrus	BA 17
90	3.42	-20 -102 -6	-20 -96 -11	Left	Lingual Gyrus	BA 17
Patients (p<0.001)						
357	4.10	-12 -92 -6	-12 -87 -10	Left	Lingual Gyrus	BA 18
1160	4.36	44 -54 24	39 -54 21	Right	Superior Temporal Gyrus	BA 22
94	4.22	-20 -40 26	-20 -41 23	Left	Cingulate Gyrus	BA 31
218	3.61	-14 -56 36	-15 -57 31	Left	Precuneus	BA 31
141	3.83	-44 20 -30	-41 20 -22	Left	Superior Temporal Gyrus	BA 38
137	3.78	20 -86 4	17 -82 0	Right	Lingual Gyrus	BA 17
57	3.68	2 16 -16	1 15 -9	Right	Anterior Cingulate	BA 25
48	3.66	-30 -74 -16	-29 -69 -17	Left	Cerebellum Declive	
38	3.42	34 -66 -20	31 -62 -19	Right	Cerebellum Declive	

No clusters	Z-score	mni coordinates	Talairach coordinates	Hemisphere	Area of activation	Brodmann area
Patients Vs. Controls (p<0.005)						
25	3.61	-20 -40 26	-20 -41 23	Left	Cingulate Gyrus	BA 31
346	3.18	18 -52 28	15 -53 25	Right	Cingulate Gyrus	BA 31
63	3.14	46 -54 26	41 -55 23	Right	Superior Temporal Gyrus	BA 39
16	3.03	32 -46 6	28 -45 6	Right	Temporal Lobe	Hippocampus
Controls Vs. Patients (p<0.005)						
13	2.73	42 -44 -22	38 -41 -19	Right	Fusiform Gyrus	BA 20

It show bilateral lingual gyrus (left side greater than right) activation. Bilateral superior temporal gyrus (right hemispheric dominance) involved in auditory processing and left precuneus (visuo-spatial imagery, episodic memory retrieval and self-processing operations). Bilateral cingulated gyrus was also activated that plays role in visual spatial processing. Bilateral cerebellum was activated for motor speech articulation as the subject had to verbalize the response. However in control group only bilateral lingual gyri were involved. The finding suggested that reading disable group showed significantly more activation than typical reader in areas associated with linguistic processing (left middle/superior temporal gyri), and attention and response selection (bilateral insula, right cingulate gyrus, right superior frontal gyrus, and right parietal lobe). However during intergroup comparison BOLD activation was observed in control group with respect to dyslexic in right fusiform gyrus (visual word form area). In dyslexic group with respect to control, BOLD activation was observed in bilateral cingulate gyrus involved in visuo-spatial processing (right cerebral dominance). Right superior temporal gyrus (word processing) and right hippocampal (memory encoding and retrieval) were activated. Thus the dyslexic group used different pathway and greater areas of activation as compared to that of control group.

Table 4.
BOLD Activation during Complex Sentence Reading Task (Semantic Task 3) in Controls, Dyslexic and the Intergroup Comparison.

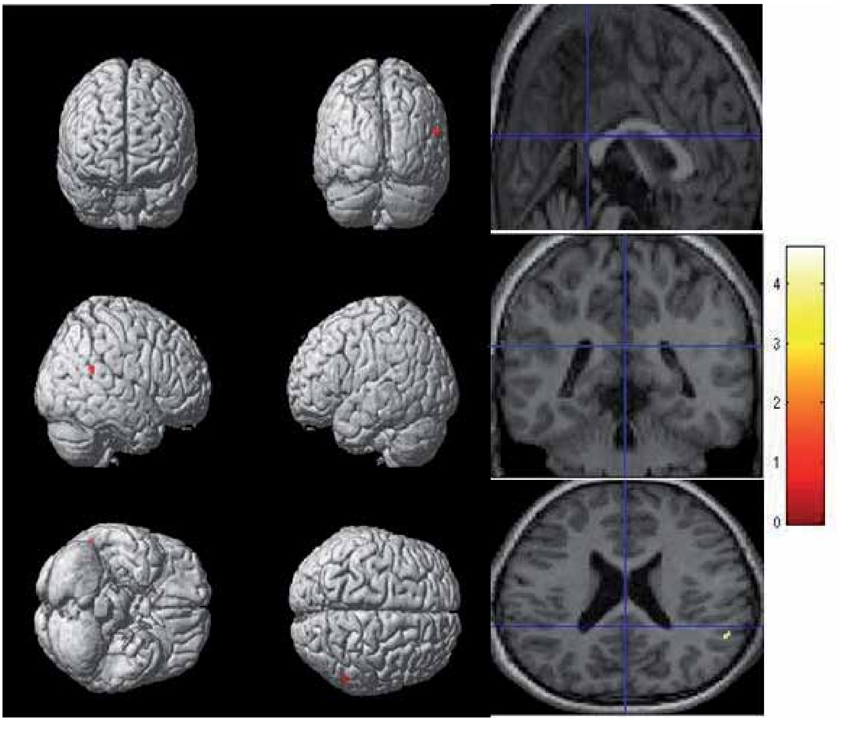

Figure 1.
BOLD activation in intergroup comparison Patient vs. Control during rhyming task (p < 0.001).

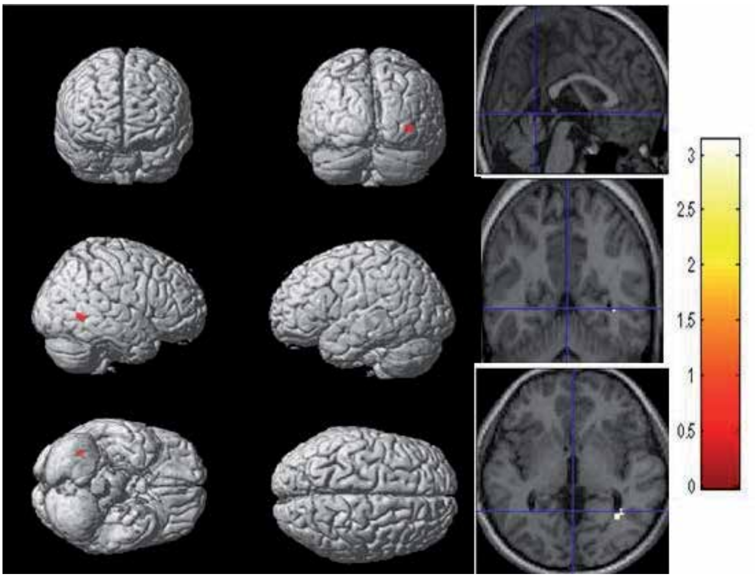

Figure 2.
BOLD activation in intergroup comparison between Patients vs. Controls during picture naming task ($p < 0.001$, cluster threshold = 10).

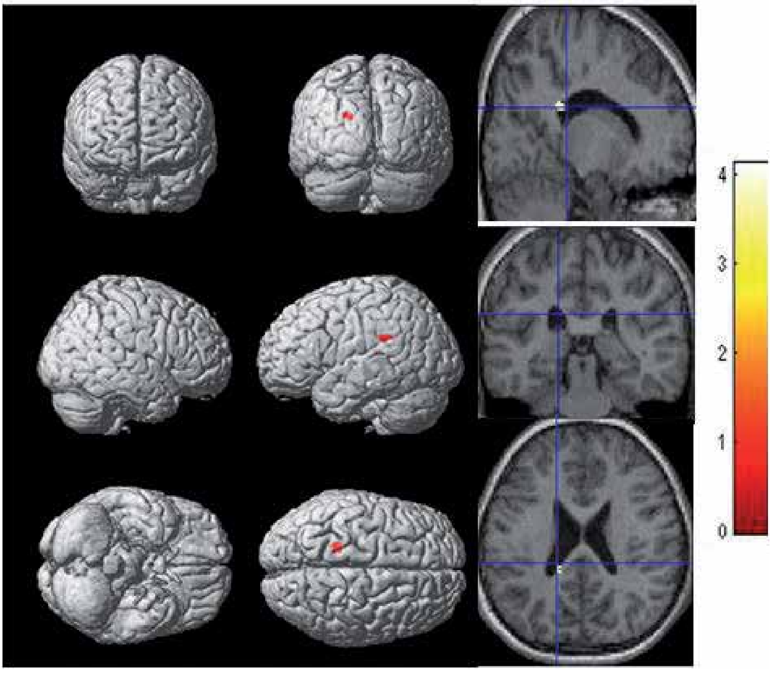

Figure 3.
BOLD activation in intergroup comparison between Patients vs. control during complex sentence reading task ($p < 0.005$, cluster threshold = 10).

10. Management strategies

There are various educational intervention and programs are available to address dyslexia which include regular teaching in small group, a learning support assistant like a specialist teacher, policy interventions etc. The basic strategies of intervention focus on phonemic skill which include the ability to identify and process word sounds. It include recognize and identify sounds in spoken words such as recognize that even words such as 'RAT' are actually made up of 3 sounds: 'R', 'A', and 'T'. It also include combining letter to create words, and over time, use the words to create more complex sentences, practice reading words accurately to help them read more quickly, monitor their own understanding while they read. The Orton-Gillingham program include special skill which teaches the patient how to match letters with sound and also to recognized letter sound in the words. In the multisensory instruction process the patients were instructed how to use all the senses (touch, sight, hearing, smell, and movement) – to learn new skills. For example, they might run their finger over letters made out of sandpaper to learn how to spell. There are some laws in in school which priorities these children called Individualized Education Plans (IEP). This IEP outlines special services the child needs to make school easier. These might include extra time to finish tests, audio books or text-to-speech—a technology that reads words out loud from a computer or book [46].

11. Besides these there are structural remediation techniques

1. Alphabetic orthography (Henry MK, 1998) [47]

It has multisensory design in which instruction has visual, auditory, and kinesthetic or tactile elements. It is generally believed that such forms of instruction are more effective for such patients. Birsh (2005) [48] and Connor (2007) [49] highlighted the importance of "explicit instruction for remediation as well as the need for intensity that is completely different from regular classroom instruction". The dyslexic needs structured and sequential interactive activities, close monitoring, connecting the known with the new and sufficient time for practice of new skills which would be in use to build automaticity and fluency. They found that the ideal size of the instruction group would be 1:! And 1:3.

2. Academic remediations [50, 51]

It includes appropriate remedial instruction in a structured literacy approach

- Phonology: developing skill in form of rhyming, counting words, clapping syllables in spike words.
- Sound-Symbols Association: In include developing skill to map the phonemes to symbols which could be taught into two direction such as visual to auditory (reading) and auditory to visual (spelling).
- Syllabus Instruction: The concept behind is that a syllabus is a unit or a written language with one vowel sound. So, the instructions must include the 6 basic syllable types in English which include closed, vowel-consonant-e, open, consonant-le, r-controlled, and vowel pair.
- Morphology: In morpheme (the smallest unit of meaning in any language) the base of the words, roots, prefixes and suffixes are considered.
- Syntax: The set of principle which help in sequencing and functioning the words in sentences with concepts of grammar, sentences variation and mechanics of language.

Besides these in include semantics, systematic, cumulative and explicit instruction which in teaching with through interaction with students.

3. **Class room recommendation** (Dyslexia Style guide from the British Dyslexia Association Archived 2013) [52]

The oral testing, untimed tests, audiobooks, eliminate or reduce spelling tests, accept dictated homework. It emphasis on such activities in which students are more active such as sports stories, biographies famous persons, inventors, musicians etc. Recommendation were using appropriate layout, large front size, line space (1.5) and a clear font (sans-serif fonts).

Now there is the concepts that each country has adopted and developed a writing system of choice which are convenient to their people. They have their own statutes relating to the provision of education, and special educational needs. There are various Non-Government Organization (NGOs) and agencies provide many independent and voluntary support in this regards.

12. Conclusion

SLD is a disabling academic problem in children with neurobiological origin. The entity of reading disorder is heterogeneous with respect to its a etiology as understood by the number of biological and neuropsychological theories postulated for the explanation and also with respect to the extent and type and manifestation either because of the different types of disabilities. Many reasons have been cited for its causation starting from genetic defects, perinatal insults, and metabolic abnormality to deficits in the information processing of the central nervous system. According several studies conducted in the past the entity of reading disorder is widely unrecognized and the affected children lacked earlier detection and appropriate intervention.

Author details

Sambhu Prasad[1*] and Rajesh Sagar[2]

1 Department of Psychiatry, All India Institute of Medical Sciences, Patna, India

2 Department of Psychiatry, All India Institute of Medical Sciences, New Delhi, India

*Address all correspondence to: sambhu3011@gmail.com

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Chapter 9

Phonological Deficit Traits in Verbal Language of Dyslexics

Aya Adel and Marwa Mahmoud Saleh

Abstract

Developmental dyslexia is a common learning disorder which is defined as a specific deficit in reading acquisition that cannot be accounted for by low IQ, lack of typical educational opportunities, or an obvious sensory or neurological damage. Dyslexic children commonly present with delayed language development first, which selectively affects phonological processing more than other aspects of language. The problem at the level of phonological representations causes a range of typical symptoms which include problems of verbal short-term memory, non-word repetitions, phonological learning of new verbal information, word retrieval, and rapid naming. This chapter will address the picture of early oral language difficulties especially phonological deficits in dyslexia, and how reading problems are related to them.

Keywords: dyslexia, phonology, oral language

1. Introduction

Failing to acquire an age-appropriate reading level could be due to many reasons; as low intelligence score, lack of proper education or proper home environment, lack of motivation, or presence of sensory deficit. These factors lead to the development of a 'poor reader', but even in the absence of any of the previous causes, learning to read could be laborious, baffling, frustrating, and highly unsuccessful. This is due to a specific reading difficulty, termed dyslexia, which was classified by the Diagnostic and Statistical Manual of Mental Disorders (DSM–5) as a form of neurodevelopmental disorder. Many definitions were presented to describe developmental dyslexia. A simple definition was given by Snowling et al. [1], who described dyslexia as a difficulty in learning to decode (read aloud) and to spell. The International Dyslexia Association characterized dyslexia by difficulties in accurate and/or fluent word recognition together with poor decoding and spelling abilities.

2. Body

2.1 Dyslexia as a language disorder

Dyslexia is coherently language-based. Why? If we cannot speak, we cannot read. Oral language has to come first, then written language could be converted by reading to an oral form. As Shaywitz and Shaywitz [2] put it, the printed characters have no meaning on their own, they have to refer to speech sounds. Unless this phonetic code happens, the written symbols are just a bunch of lines, circles, and dots. Historically, when this perplexing disorder was identified it was termed 'word blindness'. Adolf Kussmaul used this term [3] to describe stroke patients who selectively lost their ability to read. Later in the 19th century, Pringle Morgan introduced the term 'congenital word blindness', to describe the condition of a boy who found it impossible to learn to read in spite of typical level of intelligence [4]. This concept continued into the mid-twentieth century, with dyslexia still being identified as a hereditary deficit affecting the visual processing of words, and leaving oral and non-verbal intelligence intact [5]. As visual identification of written symbols is only the first step in the story of reading, with the second step related to converting them to oral symbols; the focus shifted to consider dyslexia as a language disorder. Language of dyslexics was later characterized by failure to acquire proper phonological skills [6]. This led to the emergence of the widely accredited phonological theory of dyslexia.

2.2 The phonological theory of dyslexia

This phonological theory of developmental dyslexia postulates that dyslexia emerges due to poor ability of the child to perceive the word as divided into individual phonemes. These phonemes are the ones that need to be matched with their visual counterparts, which are the letters, during reading. This auditory ability of proper perception of phonemes in the same order is known as 'phonemic awareness'. A broader term is 'phonological awareness', as phonemes integrate together to form syllables, each having a characteristic onset and rhyme, then words, and finally sentences. The phonemic awareness can preferably be assessed by getting children to repeat pseudo-words. These are sequences of sounds with no meaning, which the child has to memorize and repeat. Successful development of phonological awareness is considered a strong predictor of later linguistic and reading competence [7].

There is, however, more to phonological deficits in dyslexia than the phonological awareness skill. On a wider phonological scale, dyslexia is also widely thought to be underlaid by a deficit in phonological processing ability [8]. Phonological processing includes phonological awareness, phonological working memory, and phonological retrieval. This only goes to explain that despite intense treatment, some aspects of dyslexia persist into adulthood, as poor spelling [9].

2.3 Phonological sequencing errors in dyslexia

The nature of phonological defects occurring with dyslexia could be evident when the phonological processes in their oral language are analyzed. Peter et al. [10] studied the phonological processes in oral language of adult dyslexics compared to an age-matched control group, with the aim of exploring whether sequential errors were more prevalent than substitution errors. The phonological errors were more evident in nonword repetitions, which is a short-term memory task. They were classified as either errors of phoneme sequence (assimilation, migration, metathesis, deletion, and insertion) or errors of phoneme identity (substitution), with a focus on the type of assimilation used. Assimilatory processes could be either anticipatory or perseverative assimilation. Anticipatory assimilation is the commonly expected form of assimilation and constitutes about 75% of assimilation errors in typical development [11]. It is a regressive form of assimilation where a speech sound becomes similar to another speech sound in the word, anticipated to be spoken after it. The presence of anticipatory assimilation indicates an active motor plan, as the motor plan for the entire word is thought to be set at the onset of the word [12]. The prevalence of perseverative assimilation, on the other hand, implies an underspecified motor plan and a weak representation of the sequence of sounds in short-term memory.

The whole phonological errors were significantly higher in the dyslexia group compared to a control group, with a special prevalence of sequencing errors in the dyslexia group compared to substitution errors, pointing to a core deficit in processing sequential information. The assimilation was the commonest form of sequencing errors, being more perseverative than anticipatory. There was, in addition, a high percentage of deletions and insertions in the language of the dyslexic group. The same phenomena are interestingly noted in spelling defects in the written language of dyslexics. The dyslexic group was also slower in rapid syllable repetition (diadochokinesis) compared to the control group; a fact also documented by Malek et al. [13].

There is a system of serial order processing or sequentiality related to verbal short-term memory. A defect in this system in dyslexia was pin-pointed by Martinez-Perez [14, 15]. Failure in proper development of phonological awareness may be the cause of the defect in phonological short-term memory, which psychologists term difficulty in creating fine, individualized, well-segmented phonological representations. This short-term memory defect in serial ordering of information in dyslexia is recently gaining attention and psychologists are investigating the presence of selective impairment in it, beyond the verbal domain. This also affects transition of serial information from short- to long-term memory [16, 17].

Adults and children with dyslexia also have sequencing errors in repeating real words, compared to typical adults and children. The words are retrieved from long-term memory rather than from short-term memory, then passed through the phonological component assembly, buffer, motor planning and programming, and motor execution stages. It is theorized that adults with dyslexia have an inaccurately stored phonemic representation of multisyllabic real words in their long-term memory, or encounter difficulty in retrieving this stored information (at the level of motor planning and programming). Evidence for motor planning and programming deficits has been proved by many studies [18, 19]. Research has shown that dyslexics make more errors on phonologically complex stimuli than other typical controls [18].

Common occurrence of unexpected phonological errors in the language of the child in the pre-literacy stage is likely to fall under the diagnostic umbrella of specific language impairment (SLI). At that time developmental dyslexia cannot be yet identified. It is reported that both conditions could be comorbid [20]. Developmental dyslexia could also coexist with attention deficit hyperactivity disorder (ADHD) [21] and childhood apraxia of speech (CAS) [10].

2.4 Morphological defects in dyslexia

Considering that the reading problem in dyslexics is mainly related to a phonological processing disorder, that is reflected on the decoding procedure in reading; is a very simple way to look at it. This is only the beginning of the story of this puzzling dilemma, as reading is not just 'decoding.' The mode of reading is different between beginners and experienced readers. Beginners depend on 'decoding'; they serially correspond each grapheme to the corresponding phoneme then blend the phonemes in the correct order to form the intended word. Here comes the importance of the correct serial order or sequentiality. Experienced readers, on the other hand, read through 'direct access'; they read automatically as most words have been decoded before multiple times and have been integrated in their long-term memory. This allows them to read fast and with ease, focusing on the meaning of what they are reading. Reading, after all, aims at comprehension.

Visual identification of morphemes of the word also takes place during the process of reading development. Studies on typical adult readers indicate that morphological processing is involved in reading [22]. In a word like 'dreamer', the target morpheme 'dream' and the bound morpheme 'er' should be identified with speed and accuracy. There is a sensitivity to morphological structure during visual word recognition. Morphological knowledge contributes to a broad range of literacy skills—reading acquisition, writing acquisition, word recognition, reading accuracy and reading comprehension. Studies of morphology and reading have revealed that dyslexic children and adults score lower than chronologically age-matched controls on morphological tasks, are less sensitive to the internal structure of words, and have difficulty breaking words up into morphological segments. The morphological relationship between stem and pattern with its inflected forms has not been mastered by them [23].

2.5 Early language development and dyslexia

Individuals with dyslexia may also show language problems that extend to vocabulary and grammatical development. In fact, research has shown that the existence of deficits in oral language beyond the phonological component may place children at a higher risk for dyslexia. Authors of the present review, however, believe that all associated language problems probably stem from phonology; the basic units of sounds that are arranged to form syllables, and morphemes. The basic units of language are perceived disarrayed, and the child suffers in forming larger units as morphemes and words.

A study by Scarborough [24] followed the progress of children at high risk of dyslexia because of having one dyslexic parent, at ages of 2–7 years, before they went to school. When the children were 7 and their reading skills could be assessed, it was possible to compare retrospectively the pre-school data of children who became dyslexic with children who did not develop reading difficulties. An important difference between the groups was in their early language skills. Although the dyslexic children used as large a range of vocabulary as their non-dyslexic counterparts at 2.5 years, they made more speech errors and their use of syntax was more limited. At 3 years, the dyslexic children had more difficulty with object naming and at 5, their difficulties in phonological awareness started to become apparent. Their emerging literacy skills were also poorer; they were less familiar with the letters of the alphabet and less competent at matching pictures with print. Scarborough's data are compatible with the phonological deficit theory, but also suggest that the phonological problems, at least of familial dyslexics, may be less specific than is usually supposed, since language skills outside the phonological domain were also affected.

Nation and Snowling [25] denoted that the severity of a child's phonological processing deficit and the integrity of their other language processes predict how well they will learn to read. Another study was done for exploring the early language precursors of dyslexia in a longitudinal study from 4 to 8 years, of children at genetic risk by virtue of having a first degree affected relative [26]. It indicated that the children with significant reading impairment at 8 years, showed a pattern of oral speech and language delay in their pre-school period and poorly developed phonological awareness shortly after school entry. Interestingly, at an earlier stage of literacy development at the age of 6 years, both groups of high-risk children showed difficulty when compared to controls on tasks requiring the use of letter-sound relationships, namely in nonword reading and in phonetic spelling processes. This difficulty was noticed equally in those who did not go on to develop reading problems as well as to those who did. Likewise, Moll et al. [27] and Catts et al. [28]

also showed that children with a family history of dyslexia were more likely to develop dyslexia themselves if they had preschool problems in vocabulary and/or syntax in addition to difficulties in phonology.

As was previously mentioned, phonemes are interwoven to form syllables and words. The problem of dyslexia that starts at the beginning with defective phonological awareness leads to impaired development of vocabulary. This is also reflected on reading. So, the pathway from a phonological disorder in order to reach dyslexia, has to accumulate other factors. These factors as summarized by Snowling and Melby-Levrag [29] were related to vocabulary size and language development, phonological awareness, and letter naming. Viersen [30] studied both word accuracy and word fluency and described two pathways to proper reading. The first, as noted by Caravolas et al. [31], has to do with the preliteracy skills in close association with phonological awareness, phonological skills, and word decoding. The second pathway is through continuous use of language, which fosters the linguistic competence and the reading comprehension, as implied by Storch and Whitehurst [32]. He concluded that word accuracy and fluency were related to three factors: letter knowledge, phonological awareness, and rapid automatized naming (RAN).

2.6 Dyslexia and the brain

Functional MRIs (fMRIs) have shown that processes related to understanding written language are related to many areas in the left hemisphere in the frontal, parietal, temporal, and occipital lobes. The areas that play the most significant role in reading reside in the left parietotemporal and the left occipitotemporal lobes. In readers without dyslexia, the temporal lobe is active in relation to phonological awareness and sound discrimination. The occipital lobe is active to recognize familiar words, while the frontal lobe is active to pronounce words. In readers with dyslexia, there is more activity in the frontal lobe as the child struggles to produce the word, and less activity in the parietal and occipital lobes. The parietal lobe is involved in word analysis and decoding, while the occipital lobe functions to automatically recognize the word for fluent reading [33].

Imaging studies have shown clearly that the phonological impairments in dyslexics are associated with significant abnormalities not only in cerebral connectivity, but also in cortical structure, particularly involving the left hemisphere language network. Researchers have found there is reduced gray matter volume in the left temporo-parietal cortex, middle frontal gyrus, superior occipital gyrus, and reduced regional white matter in bilateral parieto-occipital regions compared with controls matched for age and controls matched for reading-level [34]. The cerebellum was also implicated as some dyslexics struggle with tasks across many domains that are influenced by cerebellar functions, e.g., rapid pointing, and control of eye movements [35]. Recently, the role of the cerebellum in language and reading was established. It is involved in processing nonmotor sequential information including linguistic information [36]. The cerebellum also plays a significant role in infants during speech perception [37], in children and adults during tasks involving syntactic rules [38], and in children during reading tasks [39].

2.7 Persistence of dyslexia into adulthood

Many studies assessed the serial order learning in children and adults with typical and disordered reading ability and showed that immediate recall of serial order was found to be associated with early oral language learning [40]. The capacity for verbal and nonverbal serial order learning was associated with reading ability and phonological awareness [41]. Several studies showed that serial-order learning,

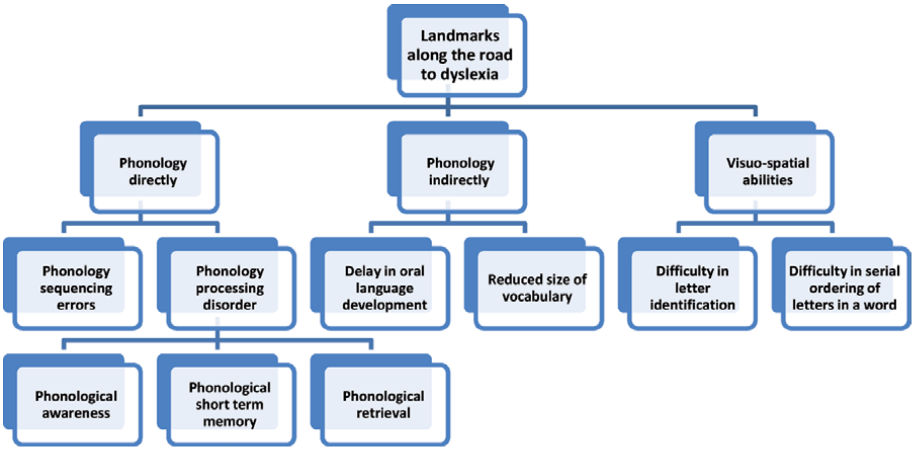

Figure 1.
Landmarks along the road to dyslexia: This figure summarizes the defects that could underlie developmental dyslexia.

both in the verbal and nonverbal modality, was deficient in adults with dyslexia [16, 17, 42]. Similarly, in a study investigating how type of presentation (i.e., simultaneous versus serial) affected recall of visual symbols in a sequence, Romani et al. [43] reported that the adults with dyslexia did not differ from the typical controls in the simultaneous condition but performed significantly worse in the sequential condition.

Transferring sequential information into long-term memory may be an underlying deficit in dyslexia. This deficit persists into adulthood in different modalities, and is evident at the level of the graphemes and the corresponding phonemes in words, leading to the disordered processing of written language characteristic of dyslexia. Although the main feature of spelling errors in dyslexia declines with age and schooling, words with irregular and unpredictable structure, which typical readers have mastered, continue to challenge individuals with dyslexia [44].

According to data revised in this chapter, **Figure 1** summarizes factors that could entangle together to produce obstacles along the way of typical development towards literacy. Although visuospatial perception defects were identified in dyslexia and were formerly thought to be the only cause, phonological defects stem out either directly or indirectly to cast a shade on the majority of factors leading to developmental dyslexia.

3. Conclusion

Several factors interact till reading comprehension is achieved. Letter knowledge is related to visual perception, which cannot be bypassed as a contributing factor. Phonological awareness is at the seat of the problem, as spoken language comes first. Exercises in phonological awareness have been actively integrated in pre-school activities. The focus on lifting up phonological awareness skills should be considered if there is family history of dyslexia. Avoiding language delay should be an important parental target, not only for verbal communication, but also for proper age-appropriate acquisition of reading skills.

Author details

Aya Adel and Marwa Mahmoud Saleh*
Department of Otolaryngology, Ain Shams University, Cairo, Egypt

*Address all correspondence to: marwa.saleh7@gmail.com

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Chapter 10

Neuropsychological Perspective on Dyslexia

María-José González-Valenzuela and Isaías Martín-Ruiz

Abstract

The aim of this chapter is to offer a neuropsychological approach to dyslexia. Firstly, the definition of dyslexia is addressed, as a specific learning disability that is neuropsychological in origin. Secondly, the clinical manifestations of dyslexia are discussed: academic, cognitive-linguistic, and socio-emotional. Thirdly, the main clinical explanations are explored, based on genetic theories (familial and twin heritability) and neurological theories, mainly neuroanatomical (brain asymmetry, corpus callosum morphology, cerebellar morphology, and variations in grey/white matter) and neurophysiological hypotheses (magnocellular system, connectivity between brain areas, and functional activity of brain areas). Finally, the main bases of an adequate neuropsychological intervention are detailed, such as training in visual perception, auditory perception, phonological processing, and orthographic processing.

Keywords: Definition, clinical manifestations, neuropsychological theories, neuropsychology intervention

1. Introduction

Dyslexia has been studied from various fields such as medicine and psychology, and a number of different explanatory and descriptive approaches can be found in this regard. Scientific and clinical research has provided various definitions of dyslexia, describing deficits and their origin, giving rise to an array of differing approaches that have even offered conflicting explanations, blurring definitions, causes, and interventions [1–4].

In recent decades, the study of literacy and its disorders has sparked interest in understanding the underlying cognitive and psychological mechanisms, as well as the biological bases [2, 5]. Neuropsychology has focused on providing a comprehensive explanation for the genetic and neurological foundations of reading and writing mechanisms, and putting forward different theories about brain structures and cortical functioning involved in reading and writing disorders, which characterise dyslexia.

Dyslexia affects between 5 and 17.5% of the population in compulsory education, depending on criteria, definitions, and classifications [2, 4]. Prevalence also depends on the transparency and granularity of spelling systems, more frequent in opaque languages. In transparent languages such as Spanish, it can range from 3 to 7% of the population.

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The aim of this chapter is to provide a neuropsychological approach to dyslexia that makes several relevant contributions in relation to this disorder. Firstly, the conceptualisation of dyslexia is addressed, reviewing the different definitions provided by major scientific and professional organisations. Secondly, the clinical manifestations of dyslexia at the academic or school level, in cognitive, linguistic and socio-emotional terms, are discussed, focusing particularly on the description of deficits that can occur according to the different subtypes of dyslexia. Thirdly, the main clinical explanations of dyslexia are examined, according to genetic, neuroanatomical, and neurophysiological hypotheses, with the aim of synthesising and integrating the different neuropsychological theories. Finally, we review early intervention in cases of dyslexia, proposing certain tasks to target the processing deficits that occur in this pathology.

2. Definition

In recent decades, the definition of Dyslexia has gradually changed, specifying certain aspects that have been controversial over the years. During this time, not only inclusion criteria but also exclusion criteria have been considered when defining this pathology. Some relevant definitions of this disorder are provided below, such as those proposed by the World Federation of Neurology (WFN), the International Dyslexia Association (IDA), the International Classification of Diseases (ICD-11) of the World Health Organisation (WHO), and the American Psychiatric Association's (APA) Diagnostic and Statistical Manual of Mental Disorders (DSM-5).

The **World Federation of Neurology** states that dyslexia is a disorder manifested by difficulty in learning to read and write despite conventional instruction, normal intelligence, and adequate learning opportunities [6]. According to this definition, dyslexia depends on fundamental cognitive disabilities, which are constitutional and structural in origin. Dyslexia, therefore, is a disorder that appears in childhood and is characterised by failing to achieve language skills in reading, writing, and spelling in accordance with the child's intellectual abilities.

For its part, **International Dyslexia Association** defines dyslexia as a specific learning disability that is neurobiological in origin, characterised by difficulties in the accuracy and/or fluidity of word recognition, and problems in spelling and decoding skills [7]. These difficulties typically result from deficiencies in the phonological components of language that are often unexpected in relation to other cognitive skills and reading instruction within the classroom. The consequences or side effects are reflected in problems of understanding and poor experience with printed language that impede vocabulary development.

From a more descriptive and nosological perspective, the Diagnostic and Statistical Manual of Mental Disorders 5 [8] and the International Classification of Disease 11 [9] point to dyslexia as a Specific Learning Disorder, within the Neurological Development Disorder axis with onset in childhood, along with other disabilities such as Intellectual Disability, Autism Spectrum Disorder, or Attention Deficit Hyperactivity Disorder, among others.

ICD-11 considers dyslexia a developmental learning disorder (code 6A03) in the classification of Developmental Disorders in axis 06 (**Table 1**), considering different exclusion criteria in its definition. Dyslexia is defined as a specific developmental disorder of school skills characterised by a specific and significant deterioration in the development of reading skills [9]. This deficit may be accompanied by difficulties in reading comprehension, spelling, and is often associated with emotional and behavioural disturbances during school age. ICD-11 establishes

Developmental learning disorder is characterised by significant and persistent difficulties in learning academic skills, which may include reading, writing, or arithmetic. The individual's performance in the affected academic skill(s) is markedly below what would be expected for chronological age and general level of intellectual functioning, and results in significant impairment in the individual's academic or occupational functioning. Developmental learning disorder first manifests when academic skills are taught during the early school years. Developmental learning disorder is not due to a disorder of intellectual development, sensory impairment (vision or hearing), neurological or motor disorder, lack of availability of education, lack of proficiency in the language of academic instruction, or psychosocial adversity.

Table 1.
Definition of learning development disorder according to ICD-11 [9].

differential diagnoses with intellectual disability, visual acuity problems, and inadequate teaching. The definition states that Dyslexia is produced by some kind of neurobiological dysfunction and is usually preceded by a history of speech or language disorders.

The DSM-5 [8] notes that dyslexia is a type of neurodevelopmental disorder and, in particular, a type of Specific Learning Disorder (code 315.00.F81.0) (**Table 2**).

A. Difficulty learning and using academic skills, evidenced by the presence of at least one of the following symptoms that have persisted for at least 6 months, despite interventions targeting these difficulties: 1. *Difficulty reading (e.g., inaccurate, slow* and only with much effort, in other words, reads individual words aloud incorrectly or hesitantly, often guesses words, difficulty expressing words well). 2. Difficulty *understanding the meaning* of what is read (e.g., can read a text accurately, but does not understand the sentence, relationships, inferences, or deeper meaning of what has been read). 3. *Spelling difficulties* (e.g., might add, omit, or replace vowels or consonants). 4. Difficulties with *written expression* (e.g. makes multiple grammatical or punctuation errors in a sentence; poor paragraph organisation; written expression of ideas is unclear). 5. Difficulties in mastering *numeric sense, numeric data, or calculation* (e.g. misunderstands numbers, their magnitude, and their relationships; uses their fingers to add single-digit numbers instead of remembering mathematical operations as their peers do; becomes lost when performing arithmetic calculation and might swap procedures around). 6. Difficulties with mathematical reasoning (e.g., has great difficulty in applying mathematical concepts, facts or operations to solve quantitative problems).
B. Academic skills are substantially affected, quantifiably below expectations according to the individual's chronological age, and *significantly interfere* with academic or occupational performance, or with activities of daily living, as confirmed by standardised, individually administered measurements (tests) and a comprehensive clinical evaluation. In individuals aged 17 and older, the documented history of learning disabilities can be replaced by standardised assessment.
C. Learning disabilities *begin at school age* but might not fully manifest until the demands of the affected academic skills exceed the individual's limited abilities (e.g., in set examinations, reading or writing complex and long reports for an non-deferrable deadline, very large amounts of school work).
D. Learning disabilities *are not best explained* by intellectual disabilities, uncorrected visual or hearing disorders, other mental or neurological disorders, psychosocial adversity, lack of proficiency in the language of academic instruction, or inadequate educational guidelines.

Table 2.
Nosological description of specific learning disorders, according to DSM-5 [8].

Specific learning disorders cause deficiencies in personal, social, academic, or occupational performance, such as school dropout, mental health problems, and high levels of psychological distress, or high unemployment. Based on exclusion criteria, it is not explained by intellectual disability, global developmental disorder, visual, auditory, or motor disorders, other mental or neurological disorders (stroke, brain trauma), psychosocial adversity (economic difficulties, absenteeism), inappropriate academic instruction, or lack of opportunities to learn. Dyslexia is a type of specific learning disorder characterised by specific deficits in the ability to perceive or process information efficiently and accurately that impede the learning of reading (accuracy and speed) and writing (accuracy), resulting in problems of reading comprehension and written expression, and which persist for at least six months despite intervention. It may be associated with a known medical or genetic condition or environmental factor. The DSM-5 notes that it is not clear whether cognitive processing difficulties are a cause, correlate, or consequence.

The DSM-5 definition of Learning Disorder (**Table 2**) presents new developments with respect to previous editions. One of them is the term "specific" disorder, to emphasise the importance of attributing the diagnosis to a specific area or aptitude, either in the sublexical processes of literacy (accuracy or fluency in reading and/or writing), supralexical processes (reading comprehension and/or writing composition), or mathematics (mathematical calculation and reasoning). Furthermore, for the first time, the concept of dyslexia has been included as a term used to refer to the learning disorders of reading and writing accuracy and fluency, which may present other additional difficulties, such as deficits in reading comprehension or mathematical reasoning.

In short, the definitions indicated above point to dyslexia as a specific learning disorder that presents deficits in learning accuracy, reading fluency and orthographic fluency, mainly in the sub-lexical processes of reading and writing (**Table 3**). There is also consensus regarding its neurobiological origin and ruling out the socio-educational environment or socio-educational deprivation as a cause. They point out that individuals with dyslexia present cognitive problems and agree that this disorder begins in childhood, when children first begin to learn the written code. They also point to other disorders that require a differential diagnosis, such as intellectual disability, general developmental disorders, brain injuries, and others.

	WFN (1968)	IDA (2002)	WHO (2018)	APA (2013)
Reading accuracy and fluency	✓	✓	✓	✓
Spelling	✓	✓		✓
Neurobiological origin	✓	✓	✓	✓
Cognitive components	✓	✓		✓
Other secondary deficits		✓	✓	✓
Onset during childhood	✓		✓	✓
Differential diagnosis (intellectual or sensory disability, general developmental disorders, psychosocial adversity)		✓	✓	

Table 3.
Main coincidences between the different definitions of dyslexia.

3. Major clinical manifestations of dyslexia

Dyslexia presents a pattern of specific characteristics at the academic, cognitive-linguistic, and finally, socio-affective levels [1–4].

3.1 Academic manifestations

The academic manifestations of dyslexia are presented in the accuracy and speed of reading words and/or pseudo-words, as well as spelling and spelling correction [2]. The most common reading and writing errors that may occur depend on the type of dyslexia [2–4].

There are two types: phonological dyslexia (difficulties with the phonological route) and visual or dyseidetic dyslexia (difficulties with the visual route) (**Table 4**). On the one hand**, phonological dyslexia** affect the grapheme-phoneme conversion mechanism, and in particular, it causes errors in the decoding of reading/writing and reading speed. The most frequent academic manifestations are: slow and sounded-out reading; lexicalisations (turning pseudo-words into words); errors in reading long, unfamiliar, or pseudo-words; derivative errors (maintains the root, but modifies the suffix); inappropriate separations and joins in writing; and visual errors, such as rhotacism, where words that are orthographically and visually similar are interchanged. On the other hand, **visual dyslexia** is characterised by subjects' inability to do global reading/writing and making errors primarily in reading and writing accuracy. Its most common academic manifestations are: errors in reading short, frequent and familiar words; errors in understanding homophones; errors in the task of lexical decision-making with pseudo-homophones; phonological errors (errors due to phonetic similarity); and frequent errors in conventional spellings and exception words.

3.2 Cognitive-linguistic manifestations

The main manifestations of dyslexia are found in the cognitive and linguistic areas, in particular in visual processing, auditory processing and speech discrimination, auditory and phonological memory, knowledge of letters, prosody, phonological knowledge, rapid automatic naming, and executive functions [10–12].

One of the most widely debated issues surrounding the study of dyslexia is its relationship to intelligence [1, 2]. Today, the general consensus is that subjects

	Phonological or dysphonetic dyslexia	**Visual or dyseidetic dyslexia**
Errors depending on the type of words	• Long, infrequent, or pseudo-words	• Short, frequent and familiar
Common errors in reading	• Lexicalisations • Slow reading speed • Sounding out	• Understanding homophones • Pseudo-homophones lexical decision-making
Common errors in writing	• Incorrect separations and joins in words	• Conventional spellings and exception words

Table 4.
Main characteristics of phonological and visual dyslexia.

with dyslexia do not present relevant deficits in intelligence, i.e., they display a standardised intellectual capacity; however, dyslexic subjects can have high intelligence quotients, resulting in the phenomenon of double exceptionality [13, 14], or medium-low intelligence quotients. Furthermore, it appears that subjects with dyslexia do not present differences between their total intellectual quotient (IQ) and manipulative IQ (perceptual reasoning), but may have differences or discrepancies between verbal IQ (verbal comprehension) and manipulative IQ (perceptual reasoning), with low working memory indices. Children with dyslexia often have deficits in crystallised intelligence, but not in fluid intelligence, that is, they may manifest problems in practical intelligence [1].

One of the cognitive manifestations that dyslexics may present is a deficit in **visual perceptual processing** (**Table 5**). Problems in visual perception are often manifested in terms of difficulties distinguishing stimuli presented sequentially over short intervals of time, so the subject may have problems in differentiating between the stimuli presented, as the different stimuli interfere with each other and are not processed separately [15, 16]. Visual perceptual deficits may also occur due to difficulties in processing quick time sequences in time order judgement tasks. Therefore, the subject does not properly process the order in which stimuli are presented and is less sensitive to the order in which visual stimuli are presented sequentially [17]. Other deficits that dyslexia subjects typically experience are that they have longer execution times in visual perceptual processing tasks, because they are slower and require more time to acquire information during vision fixation, performing more saccade and shorter movements [18, 19]. Another feature is that they need larger time gaps between stimuli to perceive two different low spatial frequency, low contrast, or low brightness sequential stimuli as separate stimuli [20]. Another characteristic deficit is difficulty in processing position in the left-to-right spacing of words, and in the beginning part of the word and in letters that look similar (for example, m-n; F-E). Ultimately, the deficits presented by subjects with dyslexia in visual processing do not originate in problems of attention in general, but rather in perceptual processes.

Other deficits are manifested in relation to **auditory perceptual processing and speech discrimination** (**Table 5**). Subjects with dyslexia have alterations in auditory temporal processing related to verbal sounds or non-verbal elements, resulting in a lack of integration of auditory sensory information [21]. They also have difficulties in automatically discriminating between phonemes presented sequentially, causing interference between the two. Dyslexics have difficulty discriminating certain frequencies and amplitudes of sounds within a single tone presented sequentially and separated at short intervals of time. For example, they have difficulties with auditory stimuli that are phonetically and acoustically similar (da-ba), but do not present deficits when it comes to very different phonemes (ba-sa). Dyslexic subjects do not perceive in the acoustic signal the basic characteristics of phonemes (sound, place, and point of articulation) that are necessary to discriminate phonetic sounds, which could result in a deficit when it comes to identifying phonemes and syllables [22]. Finally, it should be emphasised that these difficulties would be related to deficits in phonological memory and phonological knowledge.

Subjects with dyslexia also have deficits in **auditory and phonological memory** (**Table 5**). Dyslexics have difficulties storing phonological items and retrieving or repeating them immediately [23–25]. Difficulties in phonological memory can justify difficulties in phonological knowledge for awareness and in the grapheme-phoneme association, which requires retention and retrieval of phonological information. These deficits occur mostly in languages with greater morphological complexity.

Another cognitive variable where dyslexics may present problems is **knowledge of letters** [26, 27] (**Table 5**). Subjects with dyslexia have difficulties learning the

	Manifestations:
Visual perceptual processing	• Difficulties in differentiating stimuli presented over short intervals of time • Difficulties in processing fast time sequences • Slow visual processing • They need longer intervals between stimuli depending on presentation conditions • Left–right processing deficits
Auditory perceptual processing and speech discrimination	• Deficits in sequential perception of phonemes or non-verbal sounds • Low discrimination of frequencies and amplitudes with the same tone in fast time sequences • They do not perceive sound, place, and point of articulation
Auditory and phonological memory	• Deficits in storage and retrieval of verbal information • Related to difficulties in phonological knowledge and grapheme-phoneme conversion
Knowledge of letters	• Problems learning the name and/ or sound of the letter • Deficits in distinguishing capital letters or similar letters • Difficulties in creating representations between phonemes and possible graphemes
Prosody	• Difficulties perceiving tonic syllable or accent • Difficulties in the prosody of pseudo-words • Difficulties repeating sequences of syllables
Phonological knowledge	• Difficulties perceiving and manipulating speech segments • Difficulties in identification, counting, omission, addition and substitution of syllables and phonemes • In early stages and in less consistent languages
Rapid Automatised Naming	• Slow in naming alphanumeric and non-alphanumeric items • Verbal or visual deficits
Executive function	• Deficits in use and control of cognitive skills such as attention and memory • Poor flexibility of thought • Deficits in productivity and verbal fluency

Table 5.
Cognitive and psychological manifestations of dyslexia.

alphabetical code, in particular, learning the names of letters, case sensitivity, or between similar letters (m-n, F-E) or symmetrical letters (p/q). They also exhibit problems in identifying the sound of letters, i.e. creating phoneme representations so that the phoneme can be matched to the grapheme (t——/t/). And finally, in creating consistent representations between phonemes and graphemes when there are several possible associations between them.

Prosody is another psychological variable where dyslexics can manifest serious problems [28–31] (**Table 5**). In particular, they present difficulties in perceiving the tonic syllable, according to the accent or stress of the word (differentiating the intonation MA-ma vs. maMA), difficulties in the prosody of pseudo-words (repetition of POga, RuPA), or in the reading of syllables (repetition of syllable sequences: Mamama/mamama).

Phonological knowledge for awareness is another of the most frequent deficits found in dyslexia [1, 2, 24, 32] (**Table 5**). Dyslexics present difficulties perceiving and/or consciously manipulating linguistic units (syllables and/or phonemes) in different tasks such as identification, counting, omission, addition, and substitution. These deficits are usually present mostly at younger ages and in less consistent languages.

Rapid Automatised Naming (RAN) is another variable where dyslexics often present deficits, as it is related to sublexical reading and writing processes (**Table 5**). These difficulties manifest themselves when the subjects are asked to quickly name a sequence of highly frequent elements, which can be colours or objects (non-alphanumeric) or letters and numbers (alphanumeric). Dyslexic children are often slower to name non-alphanumeric items (colours and drawings) and alphanumeric items (letters and numbers), with greater deficits observed in the latter. Subjects must access a phonological label from a graphic symbol [33]. This ability could therefore refer to both phonological and non-phonological skills [34], as they need access to information of a visual nature (detection and discrimination of visual traits) and also phonological (integration of visual information with stored phonological patterns and retrieval of phonological labels). These deficits may be due to phonological or verbal memory difficulties or may also be related to visual processing deficits [32, 35–37].

Dyslexics also present serious deficits in **executive functions** [38–41] (**Table 5**) that would justify their difficulties in reading and writing. The most relevant deficits are in working memory, planning, organising and switching attention. There are also deficits in the inhibition of distractors and in the sequencing of elements, deficits in the flexibility of thought, as well as difficulties in productivity and verbal fluency.

3.3 Socio-emotional manifestations

Subjects with dyslexia also have other socio-emotional clinical manifestations, such as anxiety and depression problems, maladaptive attributional styles, low self-concept and self-esteem, as well as low motivation (**Table 6**).

Subjects with dyslexia are more likely to present **anxiety**, which is more frequent among boys than in girls, and in situations of greater stress such as tests. They also manifest more internalising emotions associated with **depressive symptoms**, although their relationship with dyslexia is not precise [42–44].

Maladaptive attributional styles are also common in subjects with dyslexia [45, 46]. In particular, dyslexics often present maladaptive patterns, attributing their successes to luck, the quality of help and attention given by their teachers (external locus and uncontrollable), and to a lesser extent to their own effort (unstable internal locus). Their achievements are not attributed to their interest

	Manifestations:
Anxiety and depression	• Greater anxiety found among boys and in test situations • Internalising emotions and depression
Maladaptive attributional styles	• Attribution of success to unstable external causes (luck, teachers) • Attribution of failure to stable internal causes (ability)
Self-concept and self-esteem	• Negative self-esteem patterns • Inconclusive studies
Motivation	• Poor reading motivation • Low persistence in tasks

Table 6.
Socio-emotional manifestations of dyslexia.

in the activities or their capabilities (stable internal locus). Instead, based on the experience of repeated failure, they perform causal attributions of their failures to their own capacity (stable internal locus) compared to normal subjects, who attribute their successes to internal causes and failures to non-stable external or internal causes (such as effort).

Subjects with dyslexia often have problems of **self-concept and self-esteem**. Dyslexics present dependence, insecurity, lack of confidence, and feelings of helplessness more frequently than normal subjects [47, 48]. However, it is unclear whether self-concept is negative in all cases, with very few studies conducted on adults. In addition, the self-perception of subjects with dyslexia seems similar to that of control groups.

Another common problem is the **low motivation** of students with dyslexia. Children with dyslexia are not oriented towards motivation for achievement and performance, and show low perseverance in achieving their goals [47].

4. Clinical explanations of dyslexia

The various definitions have shown that Dyslexia is a developmental disorder that is biological in origin [2.10]. These definitions include interaction between genetic, epigenetic (e.g. embryonic development, proteins or enzymes) and environmental (e.g. premature or low birth weight, prenatal exposure to nicotine) factors that affect the brain's ability to perceive or process verbal or non-verbal information, efficiently and accurately. Neurological and genetic alterations in dyslexic subjects are the basis for cognitive processing problems, although there are no known universal markers for the individual diagnosis of a patient with Dyslexia.

At present, there are different neuropsychological explanatory theories of dyslexia, such as genetic explanations (familial and twin heritability, and genetic iteration) and neurological explanations (neuroanatomical and neurophysiological).

4.1 Genetic explanations

Numerous studies relate genetic predisposition and the development of dyslexia [49, 50]. Etiological research has carried out two types of studies around genetics, namely studies of family heritability and studies with twins; and studies of molecular genetic alterations.

4.1.1 Family and twin heritability

One of the findings indicating that dyslexia may have a genetic explanation is that it is more common in boys than in girls [49, 51]. Similarly, family inheritance studies have found that dyslexic children often have parents who have also had reading disabilities, so there is a greater likelihood of developing reading problems when family members have a history of dyslexia. Some studies indicate heritability levels of between 18 and 65%, with up to eight times the probability of developing dyslexia when one of the parents is dyslexic [49, 52], and even greater if both the father and mother are dyslexic [53]. In contrast, this probability drops to 5% when the parents have no history of dyslexia [54]. This research supports genetic predisposition; however, these data are not sufficient, as in addition to genes, families share a cultural and socio-educational environment as well as parenting patterns that can also influence [2].

Studies conducted with twins also propose a genetic explanation for dyslexia. Brothers who share the same genetic load (monozygotic) have been found to show greater concordance of reading deficits than twins with different genetic (dizygotic) loads, so the probability that one monozygotic twin presents dyslexia when the other presents it is between 70 and 100%, a figure that it is reduced to 32% when they are dizygotic [55]. Variation in prediction also appears according to the domain subtype we are dealing with, being higher in phonological competency or spelling [55].

4.1.2 Molecular genetic alterations

Genetic alterations in dyslexia have been investigated using molecular genetic techniques, trying to isolate the genes responsible for reading and writing problems [49, 56]. However, studies have not concluded that there is a single chromosome responsible for dyslexia, but instead there are several possible chromosomes that could explain it, depending on the type and characteristics (**Table** 7).

Chromosome 1 is involved in visual processing deficits, and more specifically in processing speed, which would justify literacy problems [49, 57].

Chromosome 21 (short arm) is related to the functioning of cognitive processes that depend on the hippocampus, affecting the way words are processed [52].

Likewise, research has also shown that *chromosomes 13 and 7* (short arm) are involved in the circuits that interconnect the cortex, thalamus, and the striatum [58, 59]. This circuit would be responsible for linguistic processing, and its mutation would give rise to a phonological deficit related to verbal working memory [60].

Chromosome 15 and specifically Gene DYX1C1, located at locus DTYX1 (long arm), was among the first to be isolated [61], identified through high concurrency among members of a Finnish family [62]. This gene would be related to the different tissues, including the brain, involved in the radial migration of neurons and linked to the development of the cortex. It is located in the nucleus of certain neurons and glial cells of the cerebral cortex, so it is postulated that the gene acts indirectly and would maintain cell functionality [63]. Its role seems to be related to reading isolated words and spelling [61].

Chromosome 6, and in particular genes DCDC2 and KIAA0319, located in region DYX2, is related to the development of the temporal cerebral cortex and the cingulate gyrus. Its function is unknown, but it appears to be involved in neuronal migration [64, 65], and may be involved in mediating the interaction between glial cells and neurons. This chromosome would influence phonological and orthographic reading processes, although other studies do not find such an association [66].

Chromosome	Gene	Structure	Deficits
1	—	—	• Visual processing
21	—	Hippocampus	• Cognitive processing
13 and 7	—	Cortex circuit, thalamus and striatum	• Phonological processing (verbal working memory)
15	DYX1C1	Cerebral cortex	• Isolated words and spelling
6	DCDC2 KIAA0319	Temporal cerebral cortex and the cingulate gyrus	• Phonological and visual processes
3	ROBO1	Cerebral cortex and thalamus	• Discrimination of sounds of speech and phonological processing

Table 7.
Genetic alterations of dyslexia.

Chromosome 3, and specifically gene ROBO1, located in region DYX5, appears to be related to the development of the cerebral cortex, the growth of the thalamus, and the origin of dyslexia [67]. It is involved in the growth of axons and neuronal migration, as well as the growth of the corpus callosum. Specifically, the ROBO1 gene is linked to disorders in speech and the phonological processing of sounds [68].

4.2 Neurological explanations

Neurological theories have grown substantially in recent decades in the field of dyslexia study. This boom is motivated by an interest in brain function and, above all, by advances in neuroimaging techniques [69, 70].

Neurology has taken an interest in the description of brain areas and structures, as well as the functioning and organisation of brain activity according to different reading patterns and their deficits. To this end, technological progress has been key, with the emergence of techniques that allow for neurological studies to be conducted while these processes are taking place.

Neuroimaging techniques are the most widely used in neurological research into dyslexia. These include MRI (Magnetic Resonance Imaging), PET (Positron Emission Tomography), and fMRI (Functional Magnetic Resonance Imaging). *MRI* performs high-precision imaging of the brain, providing information about the brain structure, and being able to identify and locate areas with high precision. *PET* improves on the previous technique by imaging the brain through metabolic activity and changes in blood flow, so contrast is required. The image shows the areas that are active during a cognitive process, so it offers a high degree of precision regarding the brain structures involved. However, it does not provide temporal data, that is, regarding the sequence of a process. fMRI outperforms the above, providing spatial and temporal information on brain structures involved in a cognitive process. In addition, it does not require the use of contrasts and is less invasive than the previous technique.

Below we discuss two types of complementary neurological explanations: neuroanatomical and neurophysiological hypotheses.

4.2.1 Neuroanatomical hypotheses

Neuroanatomical theories refer to abnormalities in the different brain structures involved in reading and writing. Some of the most relevant studies from this perspective are listed below.

4.2.1.1 Cerebral asymmetry

Studies on cerebral asymmetry have been very relevant in the explanation of dyslexia [71, 72]. Two types of explanatory hypotheses have been developed about cerebral asymmetry and dyslexia (**Table 8**).

The first hypothesis assumes that dyslexics have a pattern of cerebral symmetry between the two hemispheres. Some studies indicate that this non-asymmetry is shown in dyslexic children in the temporal plane responsible for receptive language, since the upper part of the temporal region of the left hemisphere is not more developed than that of the right hemisphere [73]. This occurs in types of dyslexia associated with deficits in phonological processing and reading comprehension. Other studies find that non-asymmetry is shown in the parietal and frontal areas, and in particular in the left inferior frontal gyrus [74]. Dyslexics with these deficits present difficulties in speech perception processes, auditory and phonological processing implicit in word reading.

Hypothesis	Description of structures	Deficits
Cerebral hemispheric symmetry	Superior temporal region	• Phonological processing and reading comprehension
	Parietal and frontal regions	• Speech perception, phonological and auditory processing
Different cerebral hemispheric asymmetry	Parietal-occipital region	• Verbal difficulties
	Parietal–temporal region	
	Hippocampus, Lenticular Nucleus and Amygdala	• Visual difficulties

Table 8.
Neuroanatomical hypotheses about cerebral asymmetry.

The second hypothesis assumes that dyslexics have an inverted cerebral asymmetry pattern, that is, different from the pattern presented by those with normal reading development [75, 76]. Some studies find that, in dyslexics, asymmetry is higher in *the parietal-occipital region* and lower in the parietal–temporal region [77]. This pattern is related to verbal difficulties and, in particular, to phonological processing displayed by dyslexics. Other studies find a different asymmetry in *the hippocampus, parahippocampal gyrus, lenticular nucleus (putamen and Globus pallidus) and amygdala* [78, 79] with greater asymmetry between the right and left hemisphere.

Jiménez, Hernández and Conforti [80] investigated the relationship between cerebral asymmetry and dyslexia. Three experimental groups participated in the research: the first group consisted of dyslexic subjects; the second group consisted of subjects with a reading performance similar to the previous group, but with a lower chronological age; and the third group consisted of subjects of the same chronological age as the subjects with dyslexia. The results indicate that there are significant differences in the pattern of verbal and spatial cerebral asymmetry between children with dyslexia and the two control groups. More specifically, there are no differences in the lateralisation of linguistic functions, since in all cases it occurs in the left hemisphere, with bilateralisation being more pronounced in the case of children with dyslexia and those who showed equal reading performance at a younger age. However, significant differences are found in the lateralisation of spatial functions, which occurs in the right hemisphere in the case of control groups, but not in subjects with dyslexia, where it occurs in the left hemisphere. Regarding the hemispheric confluence of linguistic and spatial functions, it was found that the group of subjects with LD as well as the matched group in terms of reading performance presented a convergence of both functions in the left hemisphere, showing significant differences with the matched group in terms of chronological age [80]. This convergence of linguistic and spatial functions in the left hemisphere in subjects with LD stands in contrast to the hemispheric specialisation found in subjects without difficulties and makes higher-order psychological processes less effective, since they require a great deal of synchrony and execution of all available resources and in the case of LD they are concentrated exclusively in a single hemisphere. Thus, the authors conclude that dyslexic subjects do not develop this hemispheric specialisation, concentrating both spatial and linguistic functions in the left hemisphere [80]. Dyslexic subjects show a symmetrical pattern due to a convergence of verbal and spatial functions in the left hemisphere, which sets them apart from subjects with normal reading development. A similar pattern is found when investigating lower-age, normalised subjects matched in reading performance to dyslexic subjects, i.e. in the process of learning literacy, as reading functions are not yet fully specialised [80].

Hypothesis	Description of structures	Deficits
Corpus callosum	Larger posterior portion, and similar anterior-middle portion	• Poor lateralisation of functions
	Smaller anterior portion	• More brain tissue in the temporal–parietal region
	Thin, rounded shape	
	No differences	

Table 9.
Neuroanatomical hypotheses on the morphology of the corpus callosum.

4.2.1.2 Morphology of the corpus callosum

Some studies have observed differences in **the corpus callosum** of dyslexics, presenting a larger posterior portion of the corpus callosum [74], while the anterior and middle part is similar to those with normal reading development. These anatomical variations could be associated with a non-lateralisation of functions (**Table 9**).

Other research indicates that dyslexic subjects have *a smaller anterior portion of the corpus callosum* than subjects in the control groups [81].

Other alterations in dyslexic subjects would be *the more rounded and thinner shape* and sometimes a larger middle third of the corpus callosum. This finding is consistent with the fact that most symmetric brains have more brain tissue in the temporal–parietal region connected to the corpus callosum. The difference in the size of the corpus callosum may reflect hormonal influence during the critical development period of inter-hemispheric connections [82].

Finally, other research suggests that *there are no morphological differences* between controls and dyslexic subjects in the corpus callosum [83].

4.2.1.3 Morphology of the cerebellum

One of the structures that present a different morphology in subjects with dyslexia is the cerebellum, involved in psychomotricity, development of motor skills, and their automation (**Table 10**).

Some studies indicate that while subjects with normal reading development have cerebellar asymmetry, with a larger right anterior lobe size, dyslexic subjects have *cerebellar symmetry* [84]. Its role in language processing, speech perception, and reading has also been discovered [85]. Children with cerebellar symmetry make more errors than those with cerebellar asymmetry in writing, associated with motor difficulties, and reading accuracy difficulties, associated with automation and articulation problems that would justify the phonological knowledge and memory problems that dyslexics present.

Other research indicates that there are *slight cerebellar abnormalities*, since the cerebellum is smaller in subjects with dyslexia. This leads to deficits in postural

Hypothesis	Description of structures	Deficits
Cerebellar symmetry	RH = LH	• Motor difficulties, in language skills, in speech perception, in reading and writing
Cerebellar abnormality	Slightly smaller size	• Difficulties in postural stability, tone, articulation problems, and phonological problems

Table 10.
Neuroanatomical hypotheses on the morphology of the cerebellum.

tone and stability, as well as articulation problems. These difficulties would lead to speech difficulties and problems in the auditory and phonemic processing of words [86], and as a consequence difficulties in the awareness of rhyme and the phonemic structure of language and phonological deficit [86].

4.2.1.4 Variations of grey and/or white matter

Another neuroanatomical explanation shown in neurological studies refers to variations in grey and/or white matter in certain brain regions presented by dyslexics [87]. Using the VMB (Voxel-based morphometry) technique developed by Ashburne and Fristonn [88], the density of grey and/or white matter in various regions of the brain and cerebellum (**Table 11**) has been shown to be different in dyslexics and those with normal reading development.

Some research indicates that there is a variation in the volume of grey matter in the brain. On the one hand, studies indicate that there is a lower volume of grey matter in the brain of subjects with dyslexia, compared to subjects with normal reading development, in particular in two regions.

The temporal–parietal region, and in particular, in the superior temporal supramarginal gyrus of both hemispheres, has a lower density of grey matter in dyslexic subjects. This alteration would be related to deficits in speech perception (production and auditory discrimination of phonemes) and phonological processing, as well as deficits in integrating the auditory processing of linguistic stimuli [87].

Lower levels of grey matter have also been found in bilateral occipital-temporal regions, related to visual processing deficits or letterforms in dyslexic children [89, 90].

Other research indicates that dyslexic subjects present a lower level of grey matter in the right cerebellum and right lentiform nucleus [91, 92], which is related to phonological and lexical difficulties. Subjects with lower volumes of grey matter display a poorer performance in pseudo-word reading and phonological tasks (phoneme omission) than those with a higher volume.

In contrast, other studies have shown variation in white matter in the cerebral hemispheres of dyslexics, finding a lower volume of bilateral white matter in frontal lobes [93] and temporal–parietal lobes [92], which is associated with phonological and/or visual processing deficits.

Neurocognitive research has indicated that grey and white matter variations would lead to changes in brain function, as they generate lower left hemisphere activity and compensatory overactivation in the right hemisphere. In addition, subjects with dyslexia have a reduced gyrification index, and a lower volume of grey matter in the left temporal lobe and ectopia, suggesting a gestational defect in origin or abnormal prenatal brain development [94, 95]. Other authors note that variations in grey and white matter are due to the absence of cerebral asymmetry [70].

Hypothesis	Description of structures	Deficits
Grey matter.	Parietal–temporal brain regions	• Auditory and phonological processing
	Occipital-temporal brain regions	• Visual processing and letterforms
	Right cerebellum and right lentiform nucleus	• Pseudo-words and phonological tasks
White matter	Frontal and temporal–parietal regions (bilateral)	• Visual and phonological processing

Table 11.
Neuroanatomical hypotheses about variations in grey/white matter.

Hypothesis	Description of structures	Deficits
Magnocellular system	Alteration of the lateral geniculate nucleus of the thalamus	• Difficulties in processing short stimuli • Difficulty in motion sensitivity • Difficulties in low contrast and low frequency stimulation
Connectivity	Angular gyrus disconnection LH	• Phonological processing.
	No synchronisation between	• Phoneme recognition
	Broca's Area and Wernicke's Area	• Word recognition
	No transcallosal inhibition	• Deficits in processing speed of letters and words
Functional activity	Dorsal route (left parietal–temporal (angular gyrus, supramarginal, and superior temporal gyrus)	• Deficits in phonological processing
	Dorsal route (middle left occipital-temporal (fusiform and lingual gyrus)	• Deficits in visual processing
	Inferior left frontal area	• Compensation of visual deficits

Table 12.
Neurophysiological hypotheses of dyslexia.

4.2.2 Neurophysiological hypotheses of dyslexia

Neurophysiological hypotheses describe the organisation and activity of the areas of the brain as a whole. Neurophysiological explanations of dyslexia are divided into those related to the magnocellular system, to the connectivity of brain areas, and to the functional activity of brain areas (**Table 12**).

4.2.2.1 Magnocellular system

Magnocellular deficit theory [78, 79] postulates that there are physiological and anatomical deficiencies in the magnocellular system of dyslexics, mainly in the size and organisation of the cells of the lateral geniculate nucleus (LGN) of the thalamus. This structure would be responsible for rapid processing of visual information (spatial perception, selection, planning and hand-eye coordination). It plays an important role in orthographic processing and could be the cause of dyseidetic or visual dyslexia [79].

The LGN would be connected to the parietal lobe and would be critical to RAN skills [96]. Some of the manifestations that dyslexics would present as a result of these deficits would be difficulties in processing short stimuli, movement difficulties, difficulties in low-contrast stimulation and low spatial frequency [18, 97]. However, there would be no difficulties when stimuli are presented at low speed or with high contrast. These difficulties would justify errors in the visual coding of letters, programming of saccadic movements during reading, and selective attention during visual search [98].

Stein [79] notes that the LGN would not only be key to visual processes, but would also extend to perceptual deficits – auditory, sensory, tactile, and motor, and therefore also phonological. Cuetos [99] also points out that it would explain auditory perceptual deficits, since both have the same origin, and subjects with dyslexia have problems in the processing of visual or auditory stimuli presented in a fast and changing manner.

4.2.2.2 Connectivity of brain areas

The explanations for a deficit in the connectivity of brain areas are varied. One of these points out that reading problems in dyslexic subjects occur because of a functional disconnection between the angular gyrus of the left hemisphere and the occipital and temporal areas when phonological tasks are performed [82, 100].

Another theory of connectivity points to the lack of synchrony among dyslexics between Broca's Area and Wernicke's Area. Dyslexics and those with normal reading development activate the same areas during reading: on the one hand, Broca's Area, specifically the lower left frontal area (AB 6/44), responsible for articulation and the mental representation of the sound of the word; and, on the other hand, Wernicke's Area, specifically the upper left temporal gyrus (AB 21/22), which is responsible for relating the processing of phonemes and the recognition of words [101]. However, in subjects with dyslexia, these areas are not activated synchronously, so there is a disconnection between these two regions, due to a dysfunction of the insula (responsible for connecting the anterior and posterior regions responsible for language).

Theory regarding deficits in transcallosal inhibition [102] points out that in subjects with dyslexia, the corpus callosum is unable to inhibit the right hemisphere, interfering with the activity of the left hemisphere. These deficiencies in transcallosal inhibition would justify the poor transfer of information between the hemispheres. This would lead to a loss in processing speed with letters and words [103].

4.2.2.3 Functional activity of brain areas

Another line of research has been related to the functional activity of various brain areas involved in reading in people with dyslexia. Deficits in the functional activity of various neurological structures related to reading circuits have been found in those with normal reading development [75, 104]. Thus, in dyslexics, different areas of the brain activate in comparison to normal readers [105]. In general, it has been found that there is less activity in the left hemisphere and more activation in the right hemisphere, which would justify problems of hearing perception found among dyslexic subjects [106].

In particular, subjects with dyslexia have low parietal–temporal activity in the left hemisphere (supramarginal and angular gyrus in the interior part of the parietal lobe and superior temporal gyrus), which would justify phonological deficits (dorsal route) [60].

A second region with low activity is the left occipital-temporal zone (fusiform and lingual gyrus), related to visual deficits, in particular, the rapid and automatic recognition of words (ventral route) [60].

Overactivity has also been found in dyslexic adults in the inferior left frontal area, responsible for articulation and phonological analysis of words. It is suggested that this overactivity is caused by the overuse of the articulation and grapheme-phoneme conversion systems, to compensate for deficits in visual processing [107, 108].

These investigations have been carried out in languages with different spelling consistency, achieving different results depending on the transparency and granularity of languages [107, 109]. In opaque languages there is low activity in the left inferior frontal gyrus, right superior temporal gyrus and left precuneus, and high activation in the left anterior insula. In contrast, the activity pattern in transparent languages shows low activation in the left fusiform gyrus, left temporal–parietal cortex, right frontal operculum, and high activity in the left pre-central gyrus.

5. Neuropsychological intervention in dyslexia

Neuropsychological intervention in dyslexia requires a neuropsychological evaluation of the clinical variables and manifestations described so that early detection of academic, cognitive-linguistic, and socio-emotional problems can be achieved. Following evaluation, early intervention should be initiated, applying scientifically validated and proven neuropsychological techniques and programmes.

It has been shown that when intervention is carried out at an early age, the neuropsychological results are surprising, as they improve psychological, cognitive, and academic skills, and avoid associated problems such as frustration, internalising problems, and reading rejection. Early intervention is based on evidence of brain modification due to cerebral plasticity since, following early quality intervention, subjects with dyslexia show greater brain activity in regions with neurological deficits [75].

Adequate intervention in dyslexic children has also been shown to lead to improvements in literacy processes, which are manifested following the brain changes generated by the intervention [105, 110]. Following neuropsychological intervention, fluency (precision and speed) was improved, and neurophysiological and neuroanatomical changes were observed. In particular, greater activation was observed in several cortical areas, mainly in the occipital-temporal area, along with an increase in the volume of grey matter in several brain areas (hippocampus, left fusiform gyrus, and right cerebellum).

Yet, studies that design and validate treatments for the improvement of dyslexia are scarce. In recent years, however, efforts have been made to test the effectiveness of intervention programmes based on different theoretical models. This allows intervention programmes to be tailored according to whether this pathology is considered the result of a specific cognitive deficit (e.g. phonological knowledge or processing speed) or the result of a primary general deficit that would explain the cognitive deficit (e.g. auditory and/or visual perceptual processing). The most successful intervention programmes are those responsible for improving accuracy (learning the rules of grapheme-phoneme conversion, phonological awareness, naming speed) and speed (automation of grapheme-phoneme conversion rules and the formation of orthographic representations by repeating words and texts).

Finally, in view of the neurological explanations found, tasks are proposed below for the design of effective interventions, to improve the cognitive processes affected in dyslexia. Neuropsychological intervention focuses on performing tasks that would have to be targeted and adjusted to the characteristics of each case, in order to activate or compensate the areas of the brain that present a malfunction or alteration. In addition, it is generally recommended in all cases to practice repeated reading with and/or without a model (teacher, partner, CD, computer) and provide feedback by recording responses.

Below are some activities designed to improve perceptual processing (visual and auditory), phonological processing, and orthographic processing. Visual and auditory perceptual processing tasks are aimed at improving deficits in the detection and discrimination of graphic and verbal signals.

Tasks for improving visual perceptual processing include [1, 111–113]:

- Pair matching series of signs (letter, syllable, word, pseudo-word)
- Finding a sign (letter, syllable, word, pseudo-word) in an array
- Same-Different: deciding whether pairs of signs are the same or different

- Finding the different sign in an array

Tasks for improving auditory perceptual processing include [1, 12, 112, 114]:

- Identifying the tone of a sound from a series of given tones that vary in sound
- Playing a series of tones of emitted sounds
- Identifying emitted phonemes that vary in articulation point or mode
- Reproducing series of phonemes
- Identifying the location of a syllable/phoneme emitted from a sequence of syllables/phonemes
- Identifying a syllable/phoneme between the emission of two that differ in terms of the mode of articulation
- Matching two syllables/phonemes, which differ in articulation mode, with the drawing that contains them
- Deciding whether or not two auditory sequences formed by a syllable/phoneme differ in rhythm
- Identifying the drawing that begins with a certain syllable/phoneme from two spoken syllables/phonemes

Another area of intervention would be phonological processing, aimed at optimising deficits in the elaboration and interpretation of phonological information, such as phonological knowledge and the improvement of phoneme-grapheme correspondence. Activities to improve this area include [1, 12, 111–113]:

- Counting words in a spoken phrase
- Identification of syllables and/or phonemes in spoken words
- Finding rhyming words with a model
- Counting syllables and/or phonemes
- Sorting words by their syllables and/or phonemes, located in different positions
- Omitting syllables and/or phonemes in a spoken word
- Combining sequences of spoken syllables or phonemes to form words
- Adding syllables and/or phonemes to a spoken word
- Replacing a syllable or phoneme and pronounce the resulting word
- Reversing the order of spoken syllables or phonemes

Finally, intervention in orthographic processing deficits would also be necessary, improving visual word identification [1, 12, 111–113, 115]. Activities would include:

- Differentiating homophone words (understanding homophones)
- Choosing a word from a pair of homophone words according to the stated meaning
- Choosing the word written correctly between a word and a pseudo-homophone
- Completing words by adding vowels or consonants
- Matching a word with its drawing, giving a set of words (flash-card)
- Matching word and pseudo-homophone
- Selecting words represented in drawings from an array of words and pseudo-words
- Word search
- Identifying the model word from a sequence of words
- Forming words with given syllables

6. Conclusion

This chapter has addressed dyslexia from a neuropsychological perspective, specifically tackling the definition, main clinical manifestations, genetic, neuroanatomical and neurophysiological explanations, and finally neuropsychological intervention options.

Firstly, the main definitions of dyslexia [7–9] were analysed, highlighting some key considerations. In general, it is defined as a neurodevelopmental disorder that is biological in origin and which begins in childhood, with deficits in accuracy and/or fluidity in word recognition, pseudo-word recognition, and spelling. These difficulties are not consistent with the child's intellectual level or the school instruction received. They may or may not be accompanied by supralexical deficits, such as reading comprehension and written expression, and cognitive-linguistic manifestations and/or socio-emotional problems. The relevance of differential diagnosis with other deficits, such as intellectual disability, ADHD or sensory-motor problems, has also been indicated. Some definitions identify the psychological and cognitive origin of dyslexia, mainly in phonological components [7].

Secondly, the main clinical manifestations in three areas have been described. Academic deficits occur in terms of problems with the accuracy and speed of reading words and/or pseudo-words, and spelling. The problems are different depending on whether the dyslexia is phonological or visual. Phonological dyslexia is characterised by deficits in the reading of long, infrequent words or pseudo-words, with errors in lexicalisation (converting pseudo-words into words), slow reading speed, and sounding out of words. Writing deficits are gaps and improper joins of words. In contrast, visual dyslexia presents deficits in reading short, frequent, and familiar words, with misunderstandings of homophones and in lexical decision-making with pseudo-homophones. Writing deficits occur in conventional spellings and exception words [2–4, 10–12]. The different academic manifestations mean that adequate neuropsychological assessment is necessary in order to establish appropriate intervention based on the phonological and/or visual deficits presented by the subjects. The manifestations of dyslexia in the linguistic cognitive areas have also been reviewed. It has been pointed out that the role of intelligence in dyslexia is not relevant, as subjects usually present an average IQ, with discrepancies between verbal and manipulative IQ, and low working memory indices. Subjects with dyslexia may also present deficits in visual processing with difficulties in discriminating between stimuli presented sequentially and temporarily, with slow response times and the need to increase intervals in order to perceive two stimuli independently [15–19]. Similarly, subjects with dyslexia may present deficits in auditory perceptual processing and speech perception, problems in the sequential perception of phonemes, low discrimination of frequencies and amplitudes in rapid temporal sequences, and deficits in perceived sound, place and point of articulation in phonemes [21, 22]. Dyslexics may also present deficits in auditory and phonological memory, with problems in the storage and retrieval of verbal information, which sustain deficits in phonological knowledge and problems in grapheme-phoneme conversion [23–25]. Other manifestations of dyslexia occur in knowledge of letters (the name and sound of the letter, and establishing the relationship between grapheme and sound), prosody (deficits in the perception of the tonic syllable of the word, pseudo-words and in sequences of syllables), phonological knowledge (deficits in perceiving and manipulating speech segments), RAN (slow naming of alphanumeric and non-alphanumeric elements) and executive function (use and control of cognitive and metacognitive abilities). Undoubtedly, the diversity of cognitive and linguistic manifestations makes it necessary to establish different typologies and characteristics in each of the areas identified, since they can translate into different approaches of evaluation and intervention. Subjects with dyslexia may also present clinical manifestations of a socio-emotional nature, with symptoms of depression or anxiety [42–44], maladaptive attributional styles [45, 46], problems of self-concept or self-esteem [47, 48], and low motivation [47]. These secondary or concomitant problems of dyslexia cause great psychological distress in the subject and in their immediate family environment, and are often the reason neuropsychological assistance is requested.

Thirdly, the different clinical theories of dyslexia have been reviewed, according to various genetic, neuroanatomical and neurophysiological factors. Genetic explanations have highlighted the relevance of family heredity, as dyslexia is more frequent when parents have also presented delays in their reading development, and given the concordance of reading deficits in monozygotic twins [55]. These findings have encouraged molecular research to focus on discovering potential candidate genes related to dyslexia deficits, with different genes responsible for different cognitive deficits (chromosome 21), phonological processes (chromosomes 3, 7, 13, and 15), or visual processes (chromosome 1). These findings promote research on the biological foundations of dyslexia and genetic programming of tissue development and structures responsible for reading and writing functions. However, the lack of conclusive results means that further research is required to investigate the specific typologies and deficits of dyslexia in order to find concrete genetic bases. We should also highlight the various neurological explanations put forward in recent decades, thanks to the development of neuroimaging techniques and interest in the functioning of the brain. Neuroanatomical hypotheses have developed theories based on deficits in different brain structures among dyslexic subjects, such as cerebral asymmetry [71–80], corpus callosum [81–83], cerebellum [84–86], and volume of grey and white matter [87–95]. Undoubtedly, these brain structures present a different anatomical pattern to subjects with normal reading development patterns that serve as a basis for explaining the academic deficits presented by different dyslexic subjects. The different neuropsychological investigations must be unified to provide a neuroanatomical explanation of the different subtypes of dyslexia and the neuroanatomical bases that support them. Neurophysiological hypotheses, on the other hand, have sought to explain the functioning and organisation of the different areas of the brain that develop in the reading and writing of subjects with dyslexia, referring to the functioning of the magnocellular system and, in particular, the lateral geniculate nucleus of the thalamus, associated with auditory sensory perceptual processing deficits, motion sensitivity, and difficulties in discriminating low contrast and frequency stimulation [96–99]. Theories have also been presented that point to deficits in connectivity between different areas [100–103], between cerebral hemispheres (phonological deficits), asynchrony between Broca's Area and Wernicke's Area (recognition of phonemes and words), and deficits in transcallosal inhibition (low processing speed of letters and words). Finally, theories on the functional activity of neurological reading structures in dyslexic children in two circuits, dorsal and ventral, have also been discussed [104–109]. In conclusion, neuropsychological theories have identified the functioning of different brain structures during reading among subjects with normal reading development patterns, children who are learning to read, and in subjects with dyslexia. However, the findings of the different investigations need to be integrated in order to establish the role of the different structures of the Central Nervous System involved in subjects with dyslexia at different moments of learning, the subtypes of dyslexia, and in different languages, in order to establish an integrated and universal theory.

Finally, the chapter has addressed the importance of early neuropsychological intervention, as well as the need to establish scientifically tested and validated intervention methodologies. Early intervention in dyslexia has proven to be particularly effective when programmes target deficits in reading and/or writing, as they are more relevant to the specific needs of subjects, rather than focusing on general cognitive deficits, which are more non-specific and difficult to modify, making them therefore less sensitive to neuropsychological intervention. Finally, a number of neuropsychological tasks have been presented, aimed at improving visual and auditory perceptual processing, phonological processing, and orthographic processing [1, 12, 111–115]. Early evidence-based interventions are required so that the benefits of neuropsychological treatments and the validity of programmes can be quantified according to the deficits of each subtype of dyslexia.

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Author details

María-José González-Valenzuela and Isaías Martín-Ruiz*
Faculty of Psychology and Speech Therapy, Developmental and Educational Psychology Department, University of Málaga, Málaga, Spain

*Address all correspondence to: ismar@uma.es

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Chapter 11

Oral Language Skills and Literacy Skills of Malay Children with Dyslexia

Rogayah A. Razak, Loke Xing Lin and Mohd Azmarul A. Aziz

Abstract

Dyslexia can involve among others, difficulties in spoken language. However, there is limited local data on oral language (narrative skills) and literacy skills in children with dyslexia. The relationship between language and literacy is well documented although they involve complicated and non-straightforward processes. There is also evidence suggesting a link between language difficulties with subsequent literacy difficulties. Thus, this study aims to identify and describe the language and literacy skills of Malay children with dyslexia, and to discuss the possible relationships between them. Subjects were six children with dyslexia in the Klang Valley, Malaysia aged 8:0 to 9:11 (mean age, 8:10) who were compared to an age-matched control group ($n = 10$). The battery of tests administrated was phonological awareness test, language task, narrative, and literacy tasks. Our findings showed that children with dyslexia had generally weaker language and literacy skills than the control group. There were significant differences ($p < .05$) in grammar understanding, sentence repetition, and reading and spelling at both word and paragraph levels. Pearson correlation between language and literacy was shown to be positive and strong, $r = .887$, $p < .05$. The qualitative discussion of the data is presented. Findings from this study would provide useful information to teachers and speech-language therapists in their teaching or planning of appropriate clinical evaluation and management of children with dyslexia.

Keywords: oral language skills, literacy skills, narrative, Malay children, dyslexia

1. Introduction

Dyslexia affects about 10–15% of primary school children in Malaysia which is similar to the prevalence rate of 10–15% of the population in the world [1, 2]. According to statistics from the Department of Special Education, Ministry of Education Malaysia, there are approximately about 500,000 children in Malaysia who are suffering from dyslexia. On average, it is reported that there is one dyslexia case being identified in every 20 students [3]. In addition, the local newspapers reported that nearly 10% of students in primary and secondary schools are affected with dyslexia [4, 5].

Dyslexia is a neurobiological impairment that primarily affects reading ability which is commonly known as a reading disorder, that is likely to be present at birth but generally identified at the preschool level [1]. Children with dyslexia have difficulties in reading, writing, and spelling despite having intelligence on par or above-average of their typically developing peers [6]. The most widely used definition of dyslexia currently is a difficulty to identify and spell words correctly and/or fluently. The phonological deficit is the underlying factor of this difficulty [2].

Although studies on dyslexia focused more on the aspect of literacy, there is also evidence that indicated that the deficits are also in oral language particularly in the early years among children with dyslexia [7]. International Dyslexia Association (IDA) also states that oral language difficulty is one of the characteristics of dyslexia. A study showed that students with dyslexia were less eloquent, and they gave more ungrammatical and incomplete verbal answers compared to ordinary readers [8].

Thus, this chapter aims to determine the language, oral language skills, phonological awareness skills, and literacy skills of Malay children with dyslexia whose native language is Malay. An in-depth analysis will help in the identification of the capabilities and weaknesses of children with dyslexia in terms of literacy and language skills. Language difficulties can serve as a risk marker for learning difficulties and early intervention could be provided with appropriate education and rehabilitation [9]. Findings from this study can contribute to the evaluation and management of language and literacy difficulties for local Malaysian children with dyslexia.

2. Literature review

2.1 Malay language

Malaysia, a country situated in the Southeast Asia region, with a population of over 32 million, is a country with three major ethnic groups i.e., Malays, Chinese, and Indians, and a plethora of minority groups. Malaysia is a multilingual and broadly diglossic or even polyglossic country [10]. The verbal and speech repertoires of most Malaysians would include not only a native tongue or first language but also a second or further language [11]. The Malay language is the national and official language with English as the second language. Most Malaysians including Malays speak at least two languages but many particularly Chinese or Indians, speak three to five languages [12].

The Malay language or Bahasa Melayu (henceforth Malay) is a member of the Austronesian group of languages with agglutinative morphology which consists of mostly derivational and a small portion of inflection morphemes. Standard Malay is an alphabetic-syllabic writing script used in Malaysian schools. Malay has a highly transparent orthography with near-perfect and consistent grapheme-phoneme correspondences [13]. Malay has 26 alphabets like English. Malay has the following types of sounds: vowels, consonants, diphthongs (ai, au, oi). There are also diagraphs such as /gh/, /kh/. /ng/, /ny/. /sy/ with each diagraph representing the sound of an individual phoneme. Malay utilizes the morphological processes of affixation (eg. prefix *di-* in *dibuka*) compounding (eg. *rumah sakit* 'hospital', and reduplication (eg. buku-buku 'books'). Malay words are based on 4 distinct syllables i.e., V, VC, CV, and CVC. Words in Malay are formed by two or more syllables with very few monosyllabic words [14]. The most frequently occurring word structures in the Malay texts were bisyllabic with CV + CVC, CV + CV, V + CVC, and CVC + CVC word structures [15]. Most words in Malay orthography are either bisyllabic or polysyllabic.

2.2 Studies on children with dyslexia

Although dsylexia is a much-researched topic, there seemed to be no consensus yet on its diagnostic criteria. Most definitions agree, however, on a few primary inclusionary criteria in that dyslexia is marked by difficulties with word reading, decoding, and spelling as evidenced by low accuracy and/or fluency on standardized assessments [16, 17]. One source of confusion concerns perceptions about the oral language abilities of children with dyslexia. Even though dyslexia has been described as 'language-based' but the focus has primarily been on phonological deficits as a core feature of dyslexia. There are also less clarity about the extent of other aspects of language development such as vocabulary, syntax, and discourse which are affected in individuals with dyslexia [18].

A 'Language and Literacy' Program [19], is a literacy program to support the development of oral language (vocabulary, grammar and narrative) and literacy. The study on 15 first grade dual program students was aimed at understanding the extent to which grammatical skills of bilinguals at risk for language and/or reading difficulties. Their findings showed that the intervention group had good outcomes in English and Spanish as evidenced by the significant increases in the cloze and sentence repetition accuracy. The increased productivity on their narrative skills was evidenced by their mean length utterance and overall grammaticality score. They concluded that structured intervention which includes an emphasis on grammatical elements in the context of a broader intervention can lead to change in the production of morphosyntax evident in elicited constructions and narrative productivity.

Studies on dyslexia in Malaysia have mainly concentrated on the description of difficulties Malay children with dyslexia faced in reading and writing. One case study [20] looked at Annie, a 9-year-old girl diagnosed with dyslexia with problems in the area of visual perceptual skills. She had difficulties in reversals, tracking and word recognition. The Davis Orientation Counseling Method helped to overcome Annie's dyslexic symptoms. Another study [21] investigated word recognition performance of 11 low-progress early readers in Year 1. The results indicated that both syllable awareness and phoneme blending were significant predictors of word recognition which suggested that both syllable and phoneme grain-sizes are important in Malay word recognition. A multisensory programme [22] was administered on 8- and 9-years old dyslexic students in remedial classes from 12 schools in Perak and determined its effectiveness on the identification and mastery of the alphabet. The results showed there were significant differences for alphabet identification and alphabet mastery after implementation of the programme. There was a study [23] conducted on multi-senses activities in words mastery among five dyslexic children aged 8 and 9 years. The findings revealed that the multi-senses activities provided a conducive, fun learning environment for the mastery of words among the subjects.

Another group of studies looked at development of assessment tools to assess children with dyslexia in Malaysia. A Malay reading assessment battery [24] was developed and established its validity. The test contained 10 subtests which included letter naming, word reading, non-word reading, spelling, passage reading, comprehension, listening comprehension, elision, rapid letter naming and digit span. An intervention program called MyBaca [25] was introduced which uses the grapheme phoneme correspondence multisensory strategy. The program is designed as a paper-based word recognition intervention program with tutor support and future development to a computerized format is envisaged. A recent study by another group of researchers [13], described a new comprehensive early reading assessment battery for multilingual learners in Malaysia. A total of 866 year 1 primary school students from multi-ethnic and multilingual backgrounds were tested using the newly developed tool. The reading assessment battery comprised 13 subtests. High reliability and validity were obtained for the test. An exploratory factor analysis yielded three main constructs for reading: phonological-decoding, sublexical-fluency and vocabulary-memory.

Thus far, no study on children with dyslexia in Malaysia has looked at other aspects of language development such as vocabulary, syntax, and narrative which are affected in children with dyslexia. Our study is the first study to attempt to explore the association between language, oral language, and literacy skills.

3. Methodology

This study is part of a bigger project to collect data towards the development of an adapted version of the Dyslexia Screening Test namely the Bahasa Malaysia (DST-BM). 501 students who are native speakers of the Malay language were tested in a few national primary schools in Klang Valley, Malaysia. 76 children failed the screening and were diagnosed with dyslexia by the clinical psychologists. 6 children from the 76 diagnosed were selected to be in the dyslexic group. The children were on average 8; 10 years old and consisted of five male and one female student. 10 students (five males and five females) of the same chronological age and who had no history of language problems and other risk factors as reported by their teachers were selected as the control group.

3.1 Materials and procedure

The battery of tests consisted of:

1. Malay Phonological Awareness Test [26]: Subsections include rhyming, hearing letters, segmenting words into syllables, segmenting words into phonemes, blending, isolation, and deletion.

2. Malaysian Preschool Language Assessment Test (MPLAT) [27]*:* Selected subtests were chosen as criterion-based tasks. Receptive language (*Picture Vocabulary*, *Grammatical Understanding*) and Expressive Language (*Sentence Repetition* task, *Referential Meaning*, *Relational Meaning*) were administered.

3. Malay Narrative Test [28] adapted from the Expression, Reception, and Recall of Narrative Instrument (ERRNI) [29]. The scoring sheet from ERRNI was used and the picture story was taken from the 'Race between Tortoise & Hare' [30]. Participants were evaluated on their ability to tell and recall stories.

4. Measures of literacy. A battery of reading tasks was administered including word and paragraph reading, reading and listening comprehension, word spelling and paragraph dictation, and copying abilities.

   a. *Word Reading:* A word list of 25 words organized at different levels of difficulties derived from [31] and the Year Two workbooks available in the market. This measures single-word reading.

   b. *Paragraph Reading:* A 141-word excerpt was modified from the storybook "Tortoise and Hare" to assess the participants' reading ability.

   c. *Reading Comprehension:* Ten questions were adapted from [28] to measure participant's reading comprehension. In this test, the students answered comprehension questions verbally.

d. *Listening Comprehension:* Five questions were created based on the text adapted from [32] to assess participant's listening comprehension. Participants listened to an audio recording reading of a paragraph and answered questions about the paragraph verbally.

e. *Word spelling:* Participants were required to write the words dictated to them. This is a list of 25 words grouped into different levels of difficulties based on the phonological structures and word lengths of the words.

f. *Paragraph dictation:* Subjects were asked to first listen to the paragraph being read. Then the tester will read aloud the phrases, sentences and subjects will write down the phrases dictated to them one after the other. After that, they checked their dictation for any spelling errors. They are allowed to correct any mistakes done.

g. *Copying:* A three-sentence paragraph developed based on the primary level one language workbooks was provided. Participants were asked to copy the sentences on the dotted lines on the sheet.

4. Results

4.1 Intelligence quotient (IQ) test and dyslexia screening test-Malay (DST-BM) performance of subjects with dyslexia

The performance of subjects with dyslexia based on the Weschler Intelligence Scale for Children- IV (WISC-IV) [33] and Dyslexia Screening Test-Bahasa Malaysia (DST-BM) [34] are shown in **Table 1**. Two subjects were at borderline (70–79), three subjects were at low average (80–89), and one subject was at average (90–109). The full-scale intelligence index was generally affected by poor performance in the Verbal Comprehension Index and Working Memory Index. They also failed in the DST-BM, indicated by their performance at the level of high risk to very high risk.

Dyslexia Subjects	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**
Gender	Male	Female	Male	Male	Male	Male
Full Scale IQ	81	73	87	80	91	77
DST-M						
Rapid Naming	3	3	3	3	3	3
Phonemic Segmentation	0	1	0	1	0	1
Two Minute Spelling	3	2	2	3	1	3
Nonsense Passage Reading	3	3	3	3	1	2
One Minute Writing	0	0	1	1	3	3
Verbal Fluency	0	1	1	1	0	0
Semantic Fluency	3	3	3	3	1	2
Backwards Digit Span	0	2	0	2	2	0

***Dyslexia Screening Test – Bahasa Malaysia (DST-BM) [34]: 0–3 marks each index represents normal (0), risk (1), high risk (2), and very high risk (3).*

Table 1.
The full-scale intelligence index dan DST-M index marks.

4.2 Comparison of language skills between dyslexia and control groups

Table 2 shows language performance of dyslexia (n = 6) and control group (n = 10) for each subtest of the Malay Preschool Language Assessment Tool (MPLAT). Significant mean differences in language skills were observed in grammatical understanding (r = 0.54; $p < 0.05$,) and sentence repetition (r = 0.71; $p < 0.05$).

For oral language skills (narrative test), the dyslexia group had a significant weakness ($p < 0.05$) in story retelling (M = 13.3, SD = 4.08) compared to the control group (M = 18.3, SD = 4.55) (see **Table 3**).

4.3 Comparison of literacy skills between dyslexia and control groups

Table 4 shows performance in literacy skills between the groups. There was a significant mean difference across the two groups in reading and spelling, at both single word and paragraph levels. Subjects with dyslexia performed poorer on single-word reading (r = 0.83; $p < 0.05$), paragraph reading (r = 0.66; $p < 0.05$), spelling (r = 0.75; $p < 0.05$,) and dictation (r = 0.79; $p < 0.05$) compared with the control group.

4.4 Comparison of phonological awareness skills between dyslexia and control groups

There was a significant mean difference ($p < 0.05$) between the groups at phoneme level. The dyslexia group showed significantly poor performance in phoneme segmentation (r = 0.87; $p < 0.05$) and isolation (r = 0.76; $p < 0.05$) subtests compared with the control group (see **Table 5**).

Language component	MPLAT sub-test	Control (n = 10) mean (SD)	Dyslexic (n = 6) mean (SD)	p < 0.05*
Receptive	Picture Vocabulary	38.1 (0.57)	36.5 (1.87)	0.093
	Grammatical Understanding	**18.1 (1.29)**	**16.3 (1.51)**	**0.026***
Expressive	Referential Meaning	11.0 (3.74)	7.5 (3.73)	0.091
	Relational Meaning	23.7 (3.16)	23.8 (4.26)	0.944
	Sentence Repetition	**11.0 (5.16)**	**2.5 (1.97)**	**0.003***

**Significance level is at p<0.05. The results in bold show the following: 1) Grammatical Understanding score at p=0.026, and 2) Sentence Repetition at p=0.003, which is within p<0.05.*

Table 2.
Mean score difference between control and dyslexia groups in MPLAT subtests.

Narrative test	Control (n = 10) mean (SD)	Dyslexic (n = 6) mean (SD)	p < 0.05*
Initial Story Telling	19.3 (5.10)	15.8 (4.99)	0.168
Story Retelling	**18.3 (4.55)**	**13.3 (4.46)**	**0.046***

**Significance level is at p<0.05. The results in bold show Story Retelling score at p=0.046, which is within p<0.05.*

Table 3.
Mean score difference between control and dyslexia groups in oral language skills.

Component	Literacy sub-test	Control (n = 10) mean (SD)	Dyslexic (n = 6) mean (SD)	p < 0.05*
Reading	**Reading single word**	**24.2 (1.03)**	**12.8 (6.59)**	**0.001***
	Reading paragraph	**137.8 (3.52)**	**110.8 (27.65)**	**0.007***
Comprehension	Reading comprehension	5.8 (1.75)	5.3 (1.03)	0.565
	Listening comprehension	2.7 (0.82)	2.7 (0.82)	0.875
Dictation/Writing	**Single word dictation**	**21.4 (3.95)**	**7.33 (5.50)**	**0.001***
	Paragraph dictation	**32.3 (4.02)**	**18.8 (6.18)**	**0.001***
	Copying	24.0 (1.89)	21.8 (4.02)	0.118

**Significance level is at p<0.05. The results in bold show the following: 1) Reading Single Word score at p=0.001, 2) Reading Paragraph at p=0.007, 3) Single Word Dictation at p=0.001, and 4) Paragraph Dictation at p=0.001, which is within p<0.05.*

Table 4.
Mean score difference between control and dyslexia groups in literacy skills.

Level	Subtests	Control (n = 10) mean (SD)	Dyslexic (n = 6) mean (SD)	p < 0.05*
Syllable	Blending	10.0 (0.00)	10.0 (0.00)	1.000
	Deletion	9.8 (0.42)	8.8 (1.17)	0.093
	Segmentation (syllable)	9.8 (0.42)	9.0 (1.67)	0.562
Rhyme	Rhyming matching	9.0 (0.94)	8.0 (1.67)	0.263
	Letter Naming	9.8 (0.42)	7.8 (2.64)	0.093
Phoneme	**Segmentation (phoneme)**	**9.8 (0.42)**	**6.5 (1.52)**	**0.001***
	Isolation	**9.9 (0.32)**	**5.7 (4.13)**	**0.005***

**Significance level is at p<0.05. The results in bold show the following: 1) Segmentation (phoneme) score at p=0.001, and 2) Isolation at p=0.005, which is within p<0.05.*

Table 5.
Mean score difference between control and dyslexia groups in phonological awareness.

4.5 Correlation between language and oral language skills with literacy skills of subjects with dyslexia

Table 6 shows the bivariate Pearson correlation results between literacy and language skills, and literacy and oral language skills of subjects with dyslexia. There was a strong positive correlation between language and literacy skills, r (4) = 0.911, $p < 0.05$ indicating that as language skills improved, literacy skills improved. However, the relationship between literacy and oral language skills was not significant despite showing positive correlation ($r = 0.745$; $p > 0.05$) and large impact size ($r^2 = 0.555$, $p > 0.05$).

4.6 Correlation between phonological awareness with literacy skills of subjects with dyslexia

The bivariate Pearson correlation was also conducted between phonological awareness with reading and spelling skills of subjects with dyslexia. As shown in **Table 7**, the

		Literacy skills	Language skills	Oral language skills (story retelling)
Literacy skills	Pearson correlation	1	0.911	0.745
	Sig. *(2-tailed)*		**0.011***	0.089
	n	6	6	6
Language skills	Pearson correlation	0.911	1	0.693
	Sig. *(2-tailed)*	**0.011***		0.127
	n	6	6	6
Oral language skills (Story retelling)	Pearson correlation	0.745	0.693	1
	Sig. *(2-tailed)*	0.089	0.127	
	n	6	6	6

**Significance level is at p<0.05. The results in bold show Literacy Skills and Language Skills score at p=0.011, which is within p<0.05.*
**Correlation was significant at level 0.05 (2-tailed).*

Table 6.
Pearson correlation relationship among literacy skills with language and oral language.

Phonological awareness	Pearson correlation	1	0.737
Phonological awareness	Sig. *(2-tailed)*		0.095
	n	6	6
Reading & spelling skills	Pearson correlation	0.737	1
	Sig. *(2-tailed)*	0.095	
	n	6	6

Correlation was significant at level p<0.05 (2-tailed) in the dyslexia group for Phonological Awareness [26] and Reading and Spelling Skills tasks.

Table 7.
Pearson correlation relationship between phonological awareness and literacy skills (reading & spelling) in the dyslexia group.

result was not significant despite showing positive correlation, r (4) = 0.737; p > 0.05 and large impact size (r^2 = 0.543, p > 0.05).

4.7 Qualitative analysis of oral language skills: sentence use in the narrative by dyslexia control groups

Simple sentences were the most frequently produced sentence type by both groups of subjects, followed by coordinate sentences, complex sentences, and subordinate sentences (see **Figure 1**). The percentage of simple sentence production by the dyslexia group (77.5%) was higher than the control group (58.5%). The percentage of complex sentence production (6.25%) and coordinate sentence (11.25%) by the dyslexia group were lower compared to the control group, which produced 10.8% and 25.7% in the production of complex sentences and coordinate sentences respectively. The use of subordinate sentences was not found to be different for the two groups, with the same percentage value of 50%.

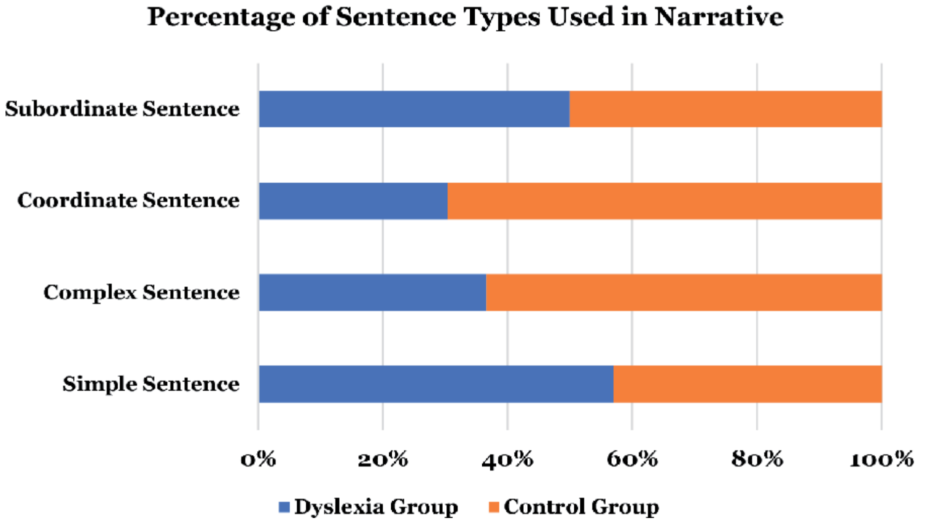

Figure 1.
Comparison of percentage of sentence types used in narrative between dyslexia and control groups.

4.8 Error analyses in narrative sample by the dyslexia group

Overall, the dyslexia group produced errors in all three language aspects. The dyslexic group made more language errors compared to the control group. The children with dyslexia produced a lot more deletion errors (**Table 8**).

4.9 Qualitative analysis of literacy skills: reading error analyses in the dyslexia group

A detailed analysis of the reading errors made by the dyslexia group was done both quantitatively and qualitatively. Quantitative descriptive analysis was used to

Language aspect	Dyslexic group	Control group
Semantics	• Substitution of major character's name • Deletion of major character's name • Substitution of noun	• Substitution of major character's name
Morphology	• Deletion of prefix • Deletion of circumfix • Substitution of prefix • Deletion of preposition • Deletion of conjunction • Deletion of pronoun • Deletion of full-reduplication	• Deletion of prefix • Substitution of prefix • Deletion of suffix • Addition of preposition • Inaccurate use of quantifier
Syntax	• Hanging sentence • Ambiguous sentence with deviate meaning • Inaccurate sentence structure • Inaccurate word order	• Hanging sentence • Inaccurate sentence structure

Table 8.
Error types in the narrative sample.

Level	Reading error types					
	Phonological	Orthographic	Morphological	Semantic	Strategy	Others
Word level	20.43%	10.75%	6.45%	19.35%	23.67%	19.35%
Paragraph	18.78%	14.08%	5.16%	22.54%	26.29%	13.15%

Table 9.
Percentage of reading error types by subjects with dyslexia.

compare the percentage of the type of errors at the single word and passage reading tasks among the subjects with dyslexia. Qualitative descriptive analysis was used to describe the types of errors in reading and spelling in detail in order to understand the aspects of difficulties experienced by subjects with dyslexia.

Reading errors were categorized into six types according to the reading test in Aston Index [35]: (1) phonological, (2) orthography, (3) morphological, (4) semantic, (5) strategy, and (6) other errors.

Table 9 shows the percentage of reading error types by subjects with dyslexia.

Most of the errors at the single word level were strategy errors (23.67%), followed by phonological errors (20.43%), semantic errors (19.35%), and other errors (19.35%), orthographic errors (10.75%), and morphological errors (6.45%). At the paragraph level, the major errors were strategy errors (26.29%), followed by semantic errors (22.54%), phonological errors (18.78%), orthographic errors (8.14%), other errors (13.15%), and morphological errors (5.16%).

Table 10 provides examples of reading error types.

Error type	Description	Examples
1. Phonology	Phonological errors were the words read that sounded similar to the letters of the target word (Gupta & Jamal, 2006). They tended to replace certain phonemes. They were confused between 'b' and 'd'. They were also confused by the phoneme /e/ which can exist in two phonetic pronunciations [e] and [ə] (eg. *rehat* to [rə-rehat]).	tin → [tən] **mencabar → [mənsadar]*** **mencabar → [məndʒadar]*** menghadapi → [məŋhadipi] bahawa → [bahaja] gajah → [dʒadʒah] yakin → [wakin] lambat → [lambau] garisan →[dʒarisan] mereka → [merəka] **rehat → [rə-rehat]****
2. Orthography	Orthographic errors were the words read that showed visual similarity to some target letters in a word (Gupta & Jamal, 2006). Errors made were considered similar to phonological errors (eg. *berkata* to [dərkata], *bahawa* to [dahawa], *sebentar* to [sədə-sədəntar]).	buih → [buah] bahagia → [bahagian] akan → [makan] **esok → [əkor]** dia → [di] lambat → [lumba] bayang-bayang → [bawaŋ- bawaŋ] **berkata → [dərkata]*** **bahawa → [dahawa]*** **sebentar → [sədə-sədəntar]***
3. Morphology	Morphological errors were on the affixes (prefixes, suffixes) and function words. Subjects faced difficulties in recognizing and reading words with a derived word (base + bound morphemes. They deleted, added, or replaced certain prefixes and suffixes.	penyelesaian → [məɲələsai-i] rangkaian → [raɲkai-i] berkumpul → [məŋumpul] berkumpul → [bərkumpulan] pada → [di] dengan → [di]

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Error type	Description	Examples
4. Semantic	Semantic errors were the semantically incorrect words or non-words (*) which does not carry lexical meaning. Children were found to substitute some words with other words or produce non-word forms (*) (eg. Binatang 'animal' to [ləmbu]'cow', mengalahkan 'defeated' to [məlihat]'to see', bersetuju;agree' to [bərasa] 'feel', ikhtiar 'initiative' to [*talan], tetapi'but' to [*səsənti], angin to [*ambit]).	itu → [unto?] binatang → [ləmbu] mengalahkan → [məlihat] bersetuju → [bərasa] siapa → [siŋa] sampai → [siapa] keputusan → [tulisan] angin → [ambit] ikhtiar → [talan] keistimewaan → [kəfandaran] takhta → [taʔpəŋahan] tercabar → [taʔtʃəkəraN] sehinggakan → [siakan] tetapi → [səsənti]
5. Strategy	Strategy errors were words that were read with repetitions and/or segmentations (eg. *angin* to [an-gin], *dataran* to [datar-an], *iklan* to [iʔ-lan]). The subjects performed poorly in segmenting multisyllabic words. They tended to repeat the syllables while segmenting them (eg. *penyelesaian* to [pən-ɲələsai-sai-in]).	**angin → [an-gin]** **dataran → [datar-an]** **iklan → [iʔ-lan]** **penyelesaian → [pən ɲələsai-sai-in]** **rangkaian → [raŋka- raŋkai-an]** Arnab → [ara-ra-nab-arnab] lengan → [lingan- ləŋan] lengan → [ləm- ləŋan] garisan → [gasi-garisan] petang → [hari- pətaŋ] **setapak → [sətapaʔ-sə-tap- sətapaʔ]**
6. Others	Other errors included words that were read by reversals, abbreviations and addition of phonemes and/or syllables (eg. *keistimewaan* to [kəsitimewaan], *bahawa* to [bawa], *tarikh* to [takitah]). At paragraph level, errors such as skipping the lines or adding own words were included in this category.	kenderaan → [kendaan] bahawa → [bawa] waktu → [waku] tarikh → [takitah] **keistimewaan → [kasitimewaan]**

**represents ungrammatical forms or words and non-words in Malay.*

Table 10.
Examples of types of reading errors produced by subjects with dyslexia.

4.10 Spelling error analyses in the dyslexia group

Spelling errors at the single word and paragraph levels involve phonologically plausible errors to bizarre spelling errors. There was a letter reversal of 'b' with 'd', inappropriate use of big and small letters within the words, eg. *aKan*, *memBasuh*, and inaccurate use of punctuation.

4.11 Copying analyses in the dyslexia group

Most errors in the copying task included omission of punctuations, presence of capital letters within a word, and small letters for names. They also omitted a few words and graphemes. However, the subjects with dyslexia did not inverse between the letter 'b' and 'd' as noted in reading tasks. They either copied the correct punctuations or omitted them. They were found to place punctuations in front of words when there was not enough space to write.

Subject	Language (%)	OLSR (%)	Literacy (%)				PA (%)	RCt
			R	S	RC	LC		
S1	58.27	23.21	55.42	26.23	50.00	20.00	77.14	Poor
S2	57.55	12.50	44.58	31.15	40.00	20.00	74.29	Poor
S3	67.63	33.93	93.98	63.93	50.00	60.00	91.43	Good
S4	61.15	26.79	80.12	22.95	70.00	60.00	74.29	Moderate
S5	71.94	26.79	95.18	65.57	50.00	80.00	90.00	Good
S6	59.71	19.64	77.71	47.54	60.00	60.00	71.43	Moderate

**Denotes as: R (Reading), S (Spelling), OLSR (Oral Language: Story Recalling) [29], RC (Reading Comprehension, LC (Listening Comprehension), PA (Phonological Awareness) [26], RCt (Reader Category).*

Table 11.
The percentage scores and reader category for each subject with dyslexia.

4.12 Individual profile of language and literacy skills of subjects with dyslexia

The percentage of individual scores for each of the subjects in the dyslexia group is presented in **Table 11** to provide a clearer picture of each child individual's language and literacy skills. Subjects with dyslexia were categorized into good readers (a percentage score between 90% - 100%), moderate readers (a percentage score between 70% - 90%), and weak readers (40% - 70%) with regard to the achievement of their reading and phonological awareness.

In the good reader category, achievement of language, oral language, spelling, and listening comprehension for both subjects with dyslexia (S3 & S5) were the highest in the dyslexic group. S5 had better listening comprehension skills but weaker oral language skills than (S3).

In the moderate reader category, the fourth dyslexic subject (S4) obtained the highest scores in the reading comprehension test, but the lowest was in the spelling test. The sixth dyslexic subject (S6) had better marks in spelling and oral language tests than S4 subject.

In the poor reader category, the first dyslexic subject (S1) obtained higher achievement in language, oral language, and reading comprehension tests, but lower achievement in the spelling tests compared to S2 subject.

5. Discussion

Malay children with dyslexia (mean age 8:10 years old) in this study showed poor language skills, weak oral language skills (story retelling), and poor literacy skills compared to the control group subjects.

Overall, based on the standardized language tool MPLAT, the performance of the children with dyslexia was poorer than the control group children particularly in the Grammatical Understanding and Sentence Repetition subtests. This is supported by [36] who studied children with dyslexia at the age of 9 years old and found that they showed significantly poor vocabulary, sentence repetition, and syntactic comprehension compared to the typically developing children. In the case of children with dyslexia, they performed significantly poorly in grammar because they tend not to focus on the morpho-syntactic features of the text [37]. A study by [38] reported that several studies [39, 40] have shown that spoken language skills in young familial risks of dyslexia (FRdys) children produce shorter sentences of lower syntactic complexity and achieve lower vocabulary scores than low-risk children. In addition, when school-aged children with dyslexia or FRdys children are compared to their typically developing peers, they are found to achieve lower scores on standardized tests of grammar (e.g., the Clinical Evaluation of Language Fundamentals (CELF). It was also reported that preschool-aged children with dyslexia performed poorly in the comprehension of sentences [41] and the correct interpretation (and production) of complex syntactic structures such as passive sentences [42]. In typically developing children, the developmental pattern in reading is that younger children would rely heavily on semantic cues while the older children focused more on the morpho-syntactic cues [43]. Therefore, the deficiency in morpho-syntactic knowledge and skills are associated with poor language skills.

A significant weakness found in the sentence repetition task for dyslexic subjects compared to the control group is because children with dyslexia have impaired verbal short-term memory and poor phonological memory. Verbal short-term memory impairment is one of the most consistent associated deficits observed in developmental reading disorders such as dyslexia [44]. Previous studies have reported that short-term memory contributes to sentence repetition abilities, and phonological memory is also related to sentence repetition [45]. Linguistic knowledge appears to be an important determinant of verbal short-term memory [44]. If linguistic representations are poorly developed, verbal short-term memory performance will be directly impacted. In the case of dyslexia, this means that verbal short-term memory impairment could be a consequence of the phonological processing impairment which characterizes dyslexia [44]. All these features correspond to the characteristics of dyslexia seen in dyslexic subjects in this study. They have a very low short-term memory index based on the cognitive test results and were found to have a high-risk index in verbal and semantic fluency tests in the dyslexia screening test DST-BM. Their errors in the sentence repetition task included deletions, substitutions, and word order movement. The grammatical proficiency exhibited in sentence repetition does not exceed the grammatical proficiency exhibited in spontaneous language after the age of six years [19]. Children with poor phonological memory will tend to drop and add words as well as confused with word order in sentences [45]. Thus, the findings of this study show weakness in grammar understanding which in turn contribute to weaknesses in language skills.

The oral language skills of subjects with dyslexia were significantly poor during the story retelling task compared to the control subjects, however, no significant difference was observed in initial storytelling. This indicated that the abilities of the dyslexic subjects were equivalent to the control subjects. However, dyslexic children were found to show poor memory, thus the plot of the story retelling had incomplete content and poor elaboration which resulted in the lack of cohesion, no climax, and a brief and shortened storyline. Dyslexic children seemed to have verbal memory deficits even though they were able to appreciate and convey the gist of the story. Certain components of memory are important for the development of reading skills, especially orthographic memory and short-term phonological memory [46]. This lack of basic cognitive function can contribute to reading disorders which are consistent with the performance of the dyslexic subjects in this study which is supported by the achievement scores of the cognitive test results in the DST-BM, and the language skills findings from the MPLAT.

There was a deficit of language skills noted during the story-telling task among subjects with dyslexia. They tended to use more simple sentences and fewer complex and coordinated sentences compared to the control group subjects. Their skills are similar to the storytelling abilities of preschoolers. Young children seemed more likely to use simple syntactic structures rather than compound or complex sentences in story retelling [47]. Overall, the results of the analysis of the narrative structure and language use of dyslexic children in this study showed that children can produce enough information in retelling activities even if the language used is less complex in terms of its syntax. Coherence can be achieved in story retelling without the use of complex sentences. Unlike conversational activities, retelling activities not only require high-level language processing skills but also involve the understanding and use of narrative macrostructures needed to produce stories.

In studying narrative skills of 5 years and 6 years old Malay children, it was noted that children's narrative skills increased with the increase in age and language development [47]. Results from our current study showed that children of the control group of the same age were indeed able to produce sentences with a dense and complex morpho-syntactic structure. Error analysis on children with dyslexia showed weaknesses in terms of sentence use, and deficits in the semantics, morphological, and syntactic aspects compared to the control group children. This is consistent with the findings that children with specific literacy difficulties/reading disorders also show impaired language ability in terms of semantics, morphology, and syntax [37, 48]. A female dyslexic subject in this study produced a narrative in a dialog format. She demonstrated her creativity by taking on the roles of the characters of the tortoise and rabbit and gave comments on the location of the setting, described the feelings of characters in the story, etc. This dyslexic child in this study exhibited great imagination that involves the production of language-related images or experiences from memory to form new images and to bring life to the story.

This study also showed that there were differences in literacy skills between the two groups of subjects. Subjects with dyslexia had significant weaknesses in literacy skills especially in reading and spelling compared to the control group children of the same age. In reading and listening comprehension, it was found that dyslexic children showed similar achievement to children of the same age, but with lower mean score differences, 0.5 and 0.2, respectively. This is in line with [24], in testing Malay children in Year 1 at a few primary schools in the Malaysian northern state of Penang and found that decoding and listening comprehension made separate contributions to reading comprehension with decoding as the more prominent predictor. Four factors: phonological decoding, phonological naming, comprehension, and short-term memory were specifically found to be problematic for Malay children with dyslexia. Their reading and spelling errors showed articulation/spelling errors which resulted in implausible phonological words to non-word forms. They read aloud words based on incorrect syllable segmentation. These difficulties were also reported by [21] that poor Malay readers used grapheme-phoneme strategies to read rather than the direct access whole word recognition strategy when spelling the word *padat* 'tight/full' → *padan* 'suitable' or *tangga* 'staircase' → *tangan* 'hand', *hospital* → *sospital, and *selendang* 'scarf' → **seledang*. Even with a transparent language such as Malay, children with dyslexia faced difficulties due to the presence of diphthongs (ai,au,oi), diagraphs (gh,kh,ng,ny,sy), and derived words via affixation. Our findings on the difficulties of Malay children with dyslexia in dealing with the different grain sizes of phonemic and syllabic sound units is also supported by [25] in the development of *MyBaca*, a Malay language word recognition intervention program for Malay children with dyslexia, and stated that this difficulty leads to partial grapheme-phoneme connection in memory. The literacy results of this study are in line with the definition of the IDA, that dyslexia is characterized by difficulty in reading accurately and/or fluently, spelling, and decoding words.

Contrary to most studies, our finding showed that there was no significant correlation between phonological awareness skills and literacy skills (reading and spelling) in this study. One factor might be the materials used which on one hand was the Phonological Awareness Test [26] which mainly has words 1–3 syllables and was originally developed for preschool children. This is in contrast to [14] which stated that the majority of Malay words are multisyllabic words. The spelling of single words on the other hand was a compilation of words taken from materials for the Level 1 Primary School books, dictionaries, etc. Therefore the disparity of the results might have been due to this.

Nevertheless, it is observed that the other results were similar to previous studies such as children with dyslexia made segmentation errors at the syllable level during reading. Children with dyslexia were still unable to correctly identify syllable structures based on their reading errors. Children with dyslexia can segment words with simple syllable structures. Still, they struggle with words containing digraphs (such as *singa* 'lion'), vowel clusters (such as *cuaca* 'weather'), and diphthongs (such as *rangkaian* 'network' and derived words with affixation. Although they did not show a significant difficulty at the syllable level in the phonological awareness test compared to children in the control group, these reading errors revealed that they were still unable to blend syllables and identify letter-sound relationships, particularly diagraphs and vowel clusters at the sentence and paragraph levels. This is supported that both syllable awareness and phoneme blending are significant predictors of word recognition and spelling at syllable and phonemic levels [21, 49]. They attributed it to the method of instruction in schools by teachers which emphasized syllable-level processing when decoding. They emphasized that fine-grain processing at the phoneme level is still important for word recognition.

The profiles of readers with dyslexia presented in **Table 11** shows three levels of readers – good readers (70–90%), moderate readers (70–90%), and poor readers (40–70%). The good readers such as reader S5 had the highest scores for spelling, reading, and phonological awareness (PA) skills whereas S3 had the highest score in reading, PA, and language. Poor readers such as S1 had the lowest scores in oral language, spelling, and listening comprehension. Another poor reader S2 had the lowest scores in oral language, spelling, listening comprehension, reading comprehension, and reading. This could be equated with [25] partial alphabetic readers and non-readers in the pre-alphabetic phase where they learn more about letter-sound connection and are able to partially link spelling of words to pronunciation in memory. Clearly, the goal of dyslexia intervention is to help them to move quickly out of the partial phase into the full alphabetic phase [25].

6. Clinical implication

There are numerous dyslexia intervention strategies, with the majority of them focusing on phonological awareness skills, reading and spelling, mainly the decoding and encoding strategies. While phonological awareness skills, reading and spelling skills are equally important, we cannot overlook the importance of language. We now understand a lot about language learning and its effects on literacy and academic achievement. The fact that language and literacy are interconnected, and most interventions focus exclusively in reading and writing strategies, it is critical to incorporate vocabulary instructions, morpho-syntax instructions, and comprehension processes while working on phonological awareness, letter-sound decoding and encoding, as all of these components are necessary for letter-sound knowledge to matter. If children with dyslexia receive only intervention in reading and spelling strategies, even if they develop the ability to decode and encode letter sounds, there will be a significant breakdown in reading comprehension skills which is required in order to be a skilled reader, especially among children with dyslexia whose language skills are less developed and as they progress onwards to upper grades in school with higher demands from the curriculum in terms of higher language load and complex subject content matter.

For speech-language therapists who manage school-aged students with dyslexia and want to undertake literacy intervention, it is time to consider language-literacy intervention. Reflection on existing practise is necessary, all the more so when there is a communication gap between medical and educational views on dyslexia intervention. While working on language-literacy intervention, speech-language therapists must make connections between the structures they intervene in the clinical setting with classroom discourse and textbook language. Besides that, rather than relying on standardized assessment instruments and intervention programmes, speech-language therapists must go above and beyond their duties in order to fulfill the diverse needs of students with dyslexia, while at the same time striving hard to keep updated on the current education curriculum and learning needs.

7. Limitations and future directions

It is important to note several limitations related to the present findings, which include several participant factors and the measures utilized. The number of participants in the study is small. Measures utilized were more general measures of morphosyntax and language use rather than measures developed specifically to capture response to intervention targets.

Future studies should consider the overall aspect of language structures and language use which are also deficit in children with dyslexia such as story retelling, relating experience, grammar (morphosyntactic structures), aside from decoding and encoding words. It is practical and functional for children with dyslexia to not only know how to decode (read, spell) words but also be able to expand this ability into other domains of language. A contextualized single-language approach to intervention appears to be a promising approach to promote changes in children's language skills across the targeted languages. More research should be focused on these aspects.

Conflict of interest

The authors declare no conflict of interest.

Author details

Rogayah A. Razak[1], Loke Xing Lin[2]* and Mohd Azmarul A. Aziz[3,4]

1 Department of Postgraduate Studies, Faculty of Education, Language and Psychology, SEGi University, Kota Damansara, Malaysia

2 Bloomkids Therapy Center, Semenyih, Malaysia

3 Speech Therapy Unit, Cheras Rehabilitation Hospital, Kuala Lumpur, Malaysia

4 Clinical Research Centre, Cheras Rehabilitation Hospital, Kuala Lumpur, Malaysia

*Address all correspondence to: rogayahrazak@segi.edu.my

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Chapter 12

Dyslexia, Dysgraphia and Dyscalculia: A Response to Intervention Approach to Classification

Charles Potter

Abstract

This chapter provides a model for classification of dyslexia, dysgraphia and dyscalculia through analysis of the response of children to treatment. The model is discussed with reference to the types of multivariate treatment applied in a particular programme which works interactively online using an electronic data-base for linking functional difficulties in learning to treatment, and through this to firm diagnosis and classification. In applying the model, initial diagnosis of learning disabilities is treated as provisional, based on functional indicators as well as test data. Firm classification becomes possible through longitudinal assessment, analysis of response to multivariate intervention as well as response to specific programmes. Diagnosis can then be linked both to concessions as well as ongoing treatment.

Keywords: dyslexia, dysgraphia, dyscalculia, reading, writing, spelling, numeracy, working memory, assessment, evaluation, response to intervention, incremental validity; multivariate treatment

1. Introduction

The field of learning disabilities has a long history, stemming back diagnostically over the past century to the work of Hinshelwood [1] and Morgan [2] in the 1890's, and the work of Orton in the 1920's and 1930's with children characterised as "word blind" [3, 4]. Methodologically, it can be traced to the techniques for treating reading, writing and spelling difficulties pioneered by Dearborn [5, 6], Monroe [7], Gates [8], Durrell [9], and Fernald [10], to the application of Orton's theories by Gillingham and Stillman [11] and to the differing conceptualisations of treatment developed by Strauss and Lehtinen in the 1940's [12] and by clinicians such as Cruickshank [13], Ayres [14], Dubnoff [15], Frostig [16], Kephart [17], Getman [18], Kirk [19], Spalding and Spalding [20], Freidus [21], and Johnson and Myklebust [22] in the 1950's and 1960's.

In teaching children to read there has also been intense debate between proponents of phonically based techniques and visually-based methods as summarised in Chall [23], as well as between those who have advocated or rejected the practice of classifying and labelling different types of reading disabilities, as outlined by Elliott and Grigorenko [24]. These debates are ongoing [25].

At this point in time, based on over a hundred years of clinical and academic work in the field, the value of teaching reading using phonologically and phonically based methods at entry point to school and also at foundation level in school has become widely accepted [26–28]. In addition, a number of different types of learning disabilities have been identified [29, 30].

Despite these advances, there is still lack of agreement as to typologies of learning disabilities, as well as to how these apply to children and adults. There is also a lack of consensus as to whether it is better to base diagnosis of learning disabilities on purely functional descriptions of the behaviours associated with how learning disabilities manifest in particular children (using terms such as "backward reading", "specific learning disorder, with impairment in reading", or "specific reading retardation"), or whether it is helpful to also apply a label such as "dyslexia", "developmental dyslexia", "dysgraphia", or "dyscalculia" to children for diagnostic purposes.

This chapter describes a programme which uses a response to intervention model of classification [31–33], working from the standpoint that classifications of learning difficulties are provisional and emergent, with the potential of changing from hypotheses to firm and persistent categories as treatment progresses. The model is based on a process of incremental and treatment validity, in which evidence concerning a child's response to particular procedures or techniques can add to an existing combination of assessment methods [34–36].

The model is then discussed in relation to the methods for assessment and treatment of functional difficulties with reading, writing, spelling and arithmetical concepts applied in the programme. As the difficulties of children are specific and manifest in the context of particular households and school environments, initial functional descriptions of behaviour are used in the programme as the basis for treating learning difficulties associated with difficulties with reading, writing, spelling and numeracy.

The approach to diagnosis and treatment is evidence-based, and described in Potter [37, 38]. Initial assessment provides descriptive information concerning a child's functioning, which is then linked to specific treatment programmes. Firm classification of dyslexia, dysgraphia and dysgraphia is then linked to both ongoing assessment and to progress evaluation linked to indicators of progress to establish effects of treatment, and through this to firm classification as learning disabled [39].

2. Classification of learning disabilities

Lyon et al. [40] suggest that classification research involves forming groups or categories, which can then be evaluated for reliability, validity, and coverage. This implies that all classifications are essentially hypotheses about variables, and the relationships between variables. Classifications applying in the area of learning disabilities thus relate to both variables indicating difficulties as well as variables relating to the treatment of difficulties. Classification researchers then evaluate the reliability, validity, and coverage of hypothetical groupings of both independent and dependent variables relating to both difficulties and treatment of difficulties. This is done by conducting and analysing research on the relationships between these variables, as well as the relationships between variables conceptualised as either dependent or independent [41].

Following this logic, classifications applying in the area of learning disabilities are based on the interrelationships between a wide range of variables based on indicators associated with the learning difficulties experienced by particular children at school. As many types of behaviour are associated with both successful and unsuccessful performance in particular school environments, it would also imply that it would be unlikely that learning difficulties can be conceptualised as related to a single disability. Instead learning disability would need to be represented as a general category, which is composed of disabilities in any one or a combination of several areas or domains as these apply to the development of particular children [42].

This is the standpoint adopted in the programme described in this chapter, based on the position previously taken by others. In the 1968 federal definition of learning disabilities adopted in the United States, for example, seven domains are identified: (1) listening; (2) speaking; (3) basic reading (decoding and word recognition); (4) reading comprehension; (5) arithmetic calculation; (6) mathematics reasoning; and (7) written expression [30, 43], while Fletcher et al. [44] have suggested that the evidence supports six subgroups of learning disability involving reading (word recognition, fluency, and comprehension), math (calculations and problem solving), and probably written expression. The latter could involve either the generation of text (handwriting, spelling) or composition. Further research would be needed on these written expression components to establish whether these are distinct categories or categories which overlap other forms of learning disability.

Within these domains, the programme described in this chapter focuses on three main subgroups of learning disability:

- Reading disabilities (often referred to as dyslexia)
- Written language disabilities (often referred to as dysgraphia)
- Math disabilities (often called dyscalculia)

Other related categories treated in the programme include disabilities that affect focus and attention, working memory, social skills, and executive functions such as personal organisation and deciding how to approach or begin a task. These difficulties are initially described functionally [37]. This is followed by a process of firmer classification based on analysis of response to intervention to programmes focused on improving functioning and performance in these areas, based on a process of evaluation which is empirical, multimethod and evidence-based [45–47].

3. Functional description of different types of learning difficulties: a response to intervention perspective

A response to intervention instructional model uses intervention as a treatment variable and response to intervention as an indicator of underlying learning disabilities. Firm classification is then based on evidence of learning difficulties which are persistent or resistant to treatment. This is the approach adopted in Dr. Charles Potter's Reading Fluency Programme [48], which is described in this chapter. Given the difficulties inherent in measurement particularly where anxiety and emotion are involved, the programme uses a response to intervention approach in which diagnosis can be emergent, based on evidence from both response-to-intervention (RTI) and norm-referenced ability testing collected over time [49].

Since difficulties with reading, writing and/or math are recognisable problems during the school years, the signs and symptoms of learning difficulties in a particular school programme form the point of departure for treatment. Functional description of different types of learning difficulties forms the basis for establishing treatment programmes. Response to intervention then provides the basis for classification as learning disabled.

Learning disabilities are thus initially defined as functional difficulties, based on evidence of unexpected underachievement in a child relative to the achievement which would be typical of other children in a particular school or learning environment. Indicators of unexpected underachievement are used at the outset to describe the difficulty, based on inability to respond to the instruction which is benefitting other children. The definition would also include other functional indicators of learning difficulties, such as ratings or test scores indicating reading, writing and spelling difficulties or difficulties with number concept and mathematical problem-solving, and would also include ratings or test scores indicating neurological markers and signs, as well as unevenness in cognitive functions.

A firm classification as learning disabled would then be based on evidence of difficulties persisting both during as well as after treatment based on longitudinal, incremental assessment and evaluation [50, 51] as outlined in **Table 1**.

The model in **Table 1** is a generic one which can be applied by others. How this has been applied in practice is described in the rest of this chapter with reference to a particular programme applying specific methods of assessment and treatment in a particular country context. As there are a number of different variables which can affect the development of reading, writing and spelling, the methods and materials used with each child vary, based on initial assessment to identify areas of strength and difficulty, as well as specific areas requiring intervention.

Intervention then takes place to address the variables related to the areas of difficulty. As this takes place, firm diagnosis and classification of learning disability

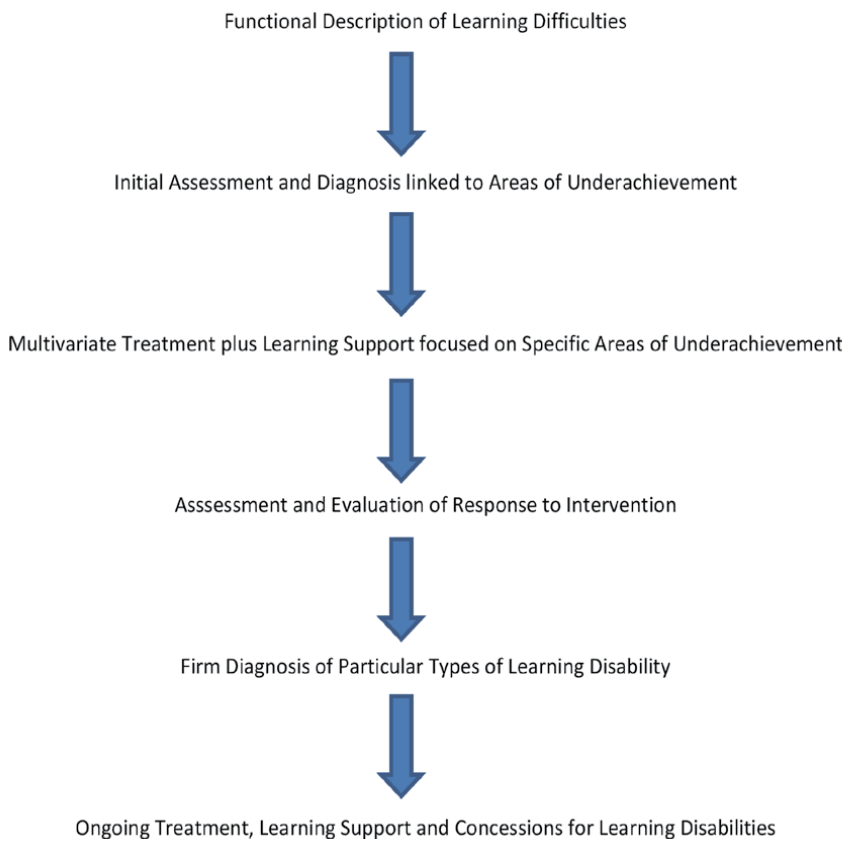

Table 1.
Classification of learning disabilities based on response to intervention.

then becomes possible, based on assessment linked to ongoing assessment and progress evaluation of the effects of multivariate treatment, based on use of particular types of methods and materials. Classification as learning disabled can then be linked to concessions to compensate for the areas of difficulty which have been demonstrated to be resistant to particular forms of treatment, as well as to ongoing treatment and learning support.

4. Initial assessment: focus on functional difficulties

The assessment process used in Dr. Charles Potter's Reading Programme[1] is based on the child's family and scholastic history in either the private or government schooling system in South Africa, which is a country classified as both first and third world [52]. The assessment procedures conform to similar procedures used by other educational psychologists in South Africa to provide evidence which can be used for diagnostic purposes against what are termed the ICD DSM IV and ICD DSM V criteria by South African medical aid societies.[2]

The ICD DSM IV and ICD DSM V criteria are designed to enable initial diagnosis to be made against functional descriptions of the learning difficulties experienced by children. These can then be used as the basis for both functional classification as well as for the development of treatment programmes.

As has been described in a previous publication on the work of the programme [37], four screening tests are used at the outset of the assessment process. These are designed to yield information about reading single words and reading words in sequence, and writing and spelling single words and words in sequence. Results on these tests are then reported using reading, spelling and dictation ages, for the reason that the South African ICD DSM IV and DSM V are based on age-related expectancies which are then used by the medical aid societies for the management of claims and benefits.[3]

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[1] Dr. Charles Potter's Reading Programme is an intervention programme linked to the author's practice as a psychologist. The programme uses electronic materials as the basis for intervention, and has assembled an extensive database of reading fluency books as well as developmental writing and spelling materials which are implemented using methods developed as part of my clinical work as a psychologist. Training is offered to prospective users of the materials and methods, and as a result there is now a network of parent, teacher and therapist users in different countries who connect with each other by cell phone and email.

[2] The ICD-10 (International Statistical Classification of Diseases and Related Health Problems – Tenth Revision) is a diagnostic coding standard owned and maintained by the World Health Organisation (WHO) [53]. The coding standard has been adopted by the National Health Information System of South Africa (NHISSA), and forms part of the health information strategy of the South African National Department of Health (NDoH). The standard serves as the diagnostic coding standard of choice in both the public and private healthcare sectors in South Africa for morbidity coding under Regulation 5(f) of the Medical Schemes Act 131 of 1998 [54].

[3] The ICD is produced by a global health agency (The World Health Organisation) with a constitutional public health mission, while the DSM is produced by a national professional association (The American Psychiatric Association). While initially using different diagnostic classification systems, the DSM and ICD have over time become very similar, due to collaboration between the two organisations, with the result that the coding system utilised by the DSM-IV [55] is designed to correspond with codes from the International Classification of Diseases, Ninth Revision, Clinical Modification, commonly referred to as the ICD-9-CM [56]. The coding system for the later revised DSM-IV TR [57] is designed to correspond with codes from the International Classification of Diseases, Tenth Revision, commonly referred to as ICD-10 [53], which has been adopted by South African medical aid societies.

Besides following the medical aid society guidelines in focusing on basic skills in reading and written expression, the assessment procedures are also based on the procedures suggested by Luria [58] for clinical assessment of reading and writing. Qualitative analysis of an initial parent interview is combined with analysis of drawings, pragmatic writing-based tasks and observation in an initial ice-breaking session with the child. This is then followed by a second session with the child during which four screening tests are used to establish levels of basic skills in reading, writing and spelling. This information is also combined with additional evidence from a biographical inventory, parental interview, analysis of school reports and more formal psychometric testing. This includes assessment of arithmetical and mathematical problem-solving skills if these are highlighted as areas of difficulty by the child's school and the child's parents.

Overall, the procedures used in the assessment process thus follow Luria's suggestion [58] that assessment should start with a preliminary conversation, and then include a careful history, detailed observation of behaviour, analysis of neurological symptoms and a series of additional objective tests. Luria suggests that the examination needs to be relatively short, and involve methods of experimental psychological investigation applied to clinical practice.

The methods of examination used in the initial sessions spent working with the child also include pragmatic assessment of repetitive and spontaneous speech, writing, reading, comprehension of texts and the solution of problems, in order to establish how reading, writing and spelling are used by the child as a functional system. This informal evidence is then combined with more formal testing of reading, writing and spelling skills, and interpreted, as Luria suggests, against a framework of knowledge of the types of difficulties normally associated with the functional system under investigation, based on current literature [59].

Assessment leads to a functional description of deficits sufficient for diagnosis of learning disability to meet medical aid requirements,[4] as opposed to an attempt to link this to possible labelling of the child as dyslexic, or labelling in terms of the other types of learning disability commonly described in the literature [37]. This is consistent with the standpoint adopted by Elliott and Grigorenko [24] and Elliott [61], namely, that adding a label adds little of clarity to a functional description of deficits for purposes of intervention. Similarly, the pattern of scores on subtests of an IQ test would best be used functionally, to indicate areas of cognitive and language strength and weakness, as well as areas in sequencing and working memory which may need to be worked with in therapy.

5. Evidence-based multivariate treatment: a response to intervention model

Following Luria [62], the aim is to move from assessment to statement of areas of deficit, and from this to specific programmatic intervention. The statement of

[4] In South Africa, due to the similarity between the DSM IV and ICD classification systems, the DSM IV criteria have been used since August 2005 for the purpose of deriving ICD-10 codes by all healthcare providers except pharmacists, clinical support and allied healthcare providers [60]. The mandatory submission of ICD-10 codes by these groups was postponed until 1 January 2006. As from this date. The criteria have been referred to as the ICD DSMIV criteria, and ICD-10 coding has been mandatory for all health providers (including pharmacists and clinical support and allied healthcare providers). At time of writing the ICD DSMIV criteria have been phased out by South African medical aids and replaced by the ICD DSM V criteria.

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areas of deficit can then be used as the basis for diagnosis for medical aid purposes, recommendations concerning the need for additional more in-depth testing (e.g. cognitive testing, speech and language and/or visual assessment, more in-depth analysis of phonological and phonic skills) or for more in-depth neurological or paediatric investigation,[5] as well as to recommend specific types of programmatic activities which can be used to address the areas of deficit.

Being based on the DSM IV criteria,[6] the diagnosis is related to the ICD10 classifications of possible types of developmental disorders affecting the development of scholastic skills, which are as follows:

- F81 Specific developmental disorders of scholastic skills
- F81.0 Specific reading disorder
- F81.2 Mathematics disorder
- F81.8 Other developmental disorders of scholastic skills
- F81.81 Disorder of written expression
- F81.89 Other developmental disorders of scholastic skills

This classification then enables parents to be able to claim benefits from their medical aid societies. At the same time, the statement of areas of deficit then enables recommendations to be made for more in-depth testing, as well as for commencing treatment. This is done matching the behaviours tapped by the tests used in the assessment process with the functional descriptions associated with the following literature-based based categorisation of types of learning disability associated with the ICD 10 developmental disorders of scholastic skills [42, 64, 65]:

Dyslexia: learning difficulties affecting reading and related language-based processing skills.

Auditory processing problems: difficulties with the sound system of the language, with phonological awareness, with listening in the classroom, and with processing and remembering the sounds associated with the letters in reading, writing and spelling.

Language processing problems: difficulties in processing spoken language, affecting both receptive and expressive language.

Reading Comprehension Deficits: learning difficulties affecting an individual's understanding of what they read.

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5 The author has worked with children under the care of a number of paediatricians and neurologists, but particularly closely with Dr. Graeme Maxwell, neurosurgeon, of Sandton Clinic until his retirement in 2020, and more recently with Dr. Dimitri Manoussakis, neurologist, of Flora Clinic. The stabilisation of focus and attentional difficulties as well as attendant attentional lapses and symptoms of cortical irritability has been an essential feature of the fluency-based interventions provided in the author's practice. Behavioural, emotional, parental as well as chemical interventions are also likely to contribute to the gains made by children treated by the programmes described in this chapter.

6 In South Africa, due to the similarity between the DSM IV and ICD classification systems, the DSM IV criteria have been used since August 2005 for the purpose of deriving ICD-10 codes by all healthcare providers except pharmacists, clinical support and allied healthcare providers. The DSM V criteria were published in May 2013, with both ICD-9-CM and ICD-10-CM codes assigned to each of the DSM V diagnoses [63].

Dysgraphia: learning difficulties affecting a person's handwriting ability and fine motor skills.

Visual, Visual perceptual or visual motor deficits: poor eye-hand coordination, difficulties in navigating surroundings, difficulties in visual tracking of print or losing one's place when reading.

Non-Verbal Learning Deficits: learning difficulties affecting the child's social interactions, manifesting in difficulties interpreting nonverbal cues such as facial expressions or body language, or difficulties relating to poor coordination.

Dyscalculia: learning difficulties affecting a person's ability to understand numbers and learn arithmetic or mathematical facts.

As the work done in my practice is related to the ICD 10 classification and medical aid codes, the functional difficulties associated with the ICD 10 codes related to the above categories (dyslexia, reading comprehension deficits, dysgraphia and dyscalculia) form the basis for the types of treatment initially developed for working with the child. Functional difficulties in the other four areas are referred to other therapists (e.g. occupational therapists, physiotherapists, visual therapists and speech and language specialists) working in the field.

This enables the work done in the practice to meet medical aid requirements, while at the same time focusing on use of particular methods and materials in working with reading, writing and spelling difficulties, difficulties with numeracy and mathematical problem-solving, as well as the attentional, emotional and social aspects which accompany difficulties at school (**Table 2**) [37, 38, 66].

The model for evidence-based classification can be represented as follows:

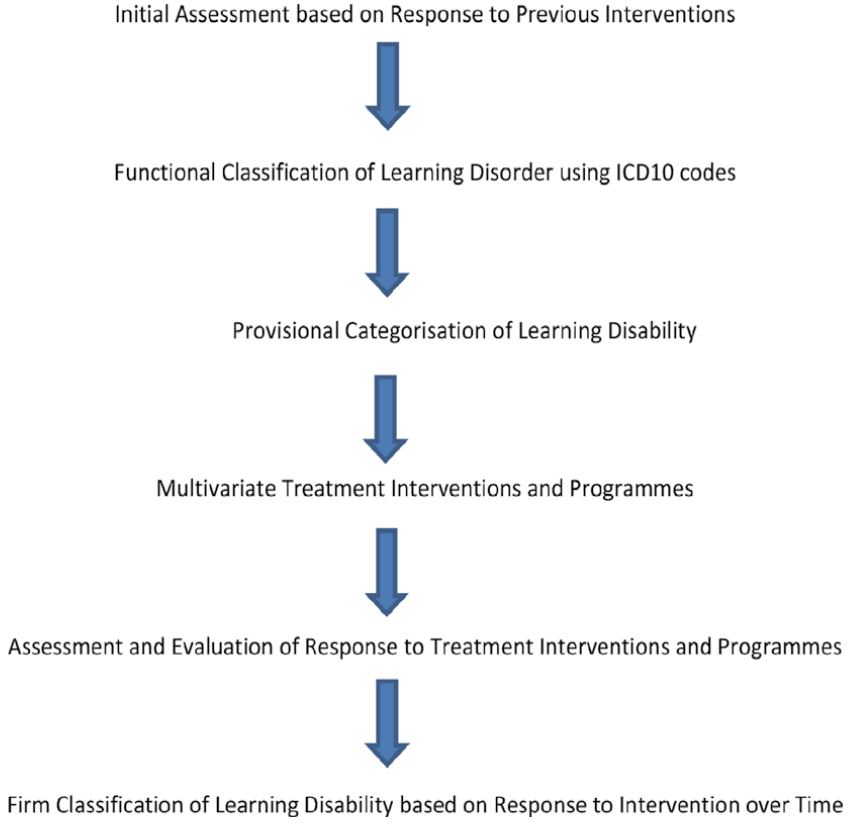

Table 2.
Diagnosis of learning disability based on response to intervention prior to, during and subsequent to treatment.

The model thus involves evidence-based multivariate treatment as the basis for firm classification of particular types of learning disability based on response to intervention over time. At each stage in the application of the model, classification of learning disability is based on incremental validity based on specific evidence relating to particular types of treatment. It is also related to the emotional, social, family and classroom issues involved in treating learning difficulties at school.

How the model has been applied in practice is outlined in the following sections. While this is done with reference to the multivariate programmes developed in the practice for treating learning disabilities, the model could also be applied in other programmes working in a similar evidence-based way.

6. Applying the model: treatment of reading difficulties

Dr. Charles Potter's Reading Programme is a fluency-based programme for treating learning difficulties [67]. The methods used for treating reading difficulties in the programme are based on the theories of the Russian neuropsychologist A.R. Luria [58, 68, 69] and have been described in a number of previous publications [37, 38, 66, 70, 71]. The materials used in the programme are electronic, and can either be downloaded or sent out by email.

At pre-reading level, the material is activity-based and focuses on developing phonological and phonemic awareness. The methods used in working with the material are described in accompanying manuals [72–86] which can be used by parents, teachers and therapists, and form the basis for the training of programme implementers.

The programme works with children from pre-reading and school readiness level. The transition to foundation level is made once the child has developed alphabetic awareness and the associations between the letters of the alphabet and the sounds used to represent the letters in English. The child is then introduced to reading through a series of fifteen foundation level reading books, using a structured language experience approach which integrates reading, writing, phonics and spelling with drawing and illustration. This is done through six activity books based on families of rhyming words, which accompany the first six of the foundation level reading books, with the methods used described in accompanying manuals [75, 82, 86].

Once the child has developed the ability to read three letter words and words based on short vowel sounds and beginning and ending consonant blends and clusters, repetitive paired reading is introduced, focusing initially on reading of sentences. Comprehension is developed through drawing and illustration of reading content.

Once the child can read and write phonically based words as well as sentences using three letter words in context, reading fluency work is commenced using large print phonically based reading books, based on the model for treatment of reading acquisition, reading fluency and reading comprehension development represented in **Table 3**.

The procedures used are documented in a user's manual which includes both theory and the methods used in programme implementation [72]. In addition, there is a parent implementer's manual which presents a step by step approach to implementation [78].

7. Methods used for treatment of reading fluency difficulties

The development of the large-print, phonically based material used for developing reading fluency in the programme has been described in a separate

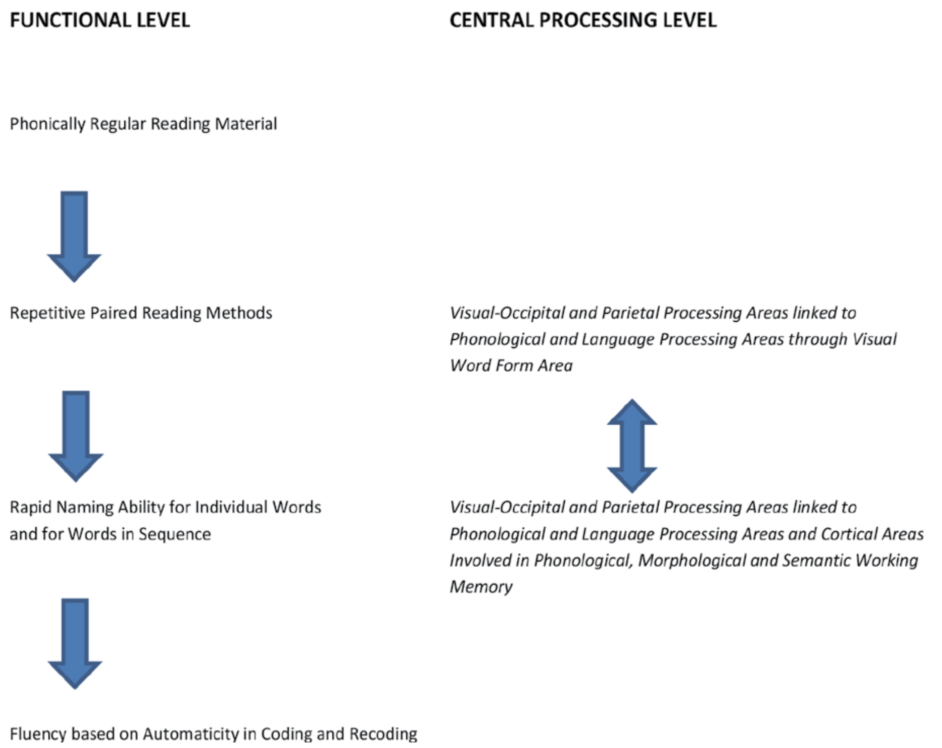

Table 3.
Model for Reading fluency development.

publication [66]. The methods used for developing reading fluency involve use of a paired reading method called the 3 x 3 Oral Impress Method. This is designed to be used with a series of electronic reading fluency books which are graded, and written in a way which builds repetition into the words used, as well as phrases used in sentences.

The material presents letters and letter strings associated with particular sounds repetitively in an uncluttered format. Repetitive oral reading is then used together with visual tracking of the printed words to develop and then automatise the associations between the configuration of the letters within phonically regular words and their sounds as used in the written language the child sees, the spoken language the child hears, and the words read by both adult and child [87].

This is done by working with the reading material three paragraphs at a time in the following way (**Table 4**).

The aim, as Luria suggests [58, 68], is to enhance cerebral organisation based on a repetitive process. This was also Heckelman's view when he pioneered the use of

Paragraph One	Child reads	Parent and Child read together	Parent reads
Paragraph Two	Parent reads	Child reads	Parent and Child read together
Paragraph Three	Parent and Child read together	Parent reads	Child reads

Table 4.
The 3 x 3 Oral impress method.

paired reading as a procedure [88–90], suggesting that paired reading is "one of the most direct and fundamental systems of reading" involving a "combination of reflexive neurological systems." We have reported similar positive results [38, 66], supporting Heckelman's position that gains made are based on increasing neurological integrity.

The model for developing using the phonically-based, large print reading materials to develop reading fluency would be conceptualised as based on the coding and recoding of phonic associations [91–93]. Following Dehaene [94, 95], what the 3 x 3 Oral Impress Method does when used with our phonically based large-print reading fluency books is to present the visual word form area in the brain with strings of letters representing sounds repeatedly. This would have the effect of strengthening the connections between the visual areas in the brain and the areas of the brain involved in processing sounds and oral language, thus enabling the child first to read, and then to read fluently.

8. Treating difficulties with rapid naming

The relationship between rapid naming and reading difficulties has been established by a number of researchers [96–102]. What has not been clearly established is whether rapid naming is a separate factor influencing reading performance, and whether it is responsive to training [103, 104]. Recent research indicates that training interventions in this area are possible [105, 106], but that more controlled studies are still necessary on whether rapid naming can be trained, and how it can be trained. The descriptions provided in this section should be viewed in this context.

Our methods focus on teaching rapid naming of letters, words and numbers, as well as teaching rapid reading. At initial stages in the programme, rapid naming of letters is conducted using phonogram cards. Rapid naming of words is conducted using key words drawn from our phonically-based large print reading material. Rapid naming of numbers is trained through rapid marking of arithmetic worksheets. Rapid reading is also taught developmentally using the 3 x 3 Oral Impress Method [72], which focuses on accurate naming of phonically regular words and sentences, and then on rapid and accurate reading of a wider range of reading material.

The material used is phonically graded as well as repetitive, and the aim in the initial stages is to work with words which become increasingly familiar to the child, to develop accurate and rapid naming ability for individual words and words in sequence. This is done through the repetitive methods used to develop automaticity in reading [74], as well as through activities in which the child is asked to name letters and numbers in worksheets based on both familiar and unfamiliar content. Tachistoscopic work is then introduced at later stages in the programme [107], working repetitively with words of increasing length drawn from an electronic dictionary, as well as with words drawn from graded revisualisation materials and the child's school books.

Using computer-based presentation, length of words presented, time exposure of the presentation of each word and time between the exposure of each word can be treated as variables. Other variables involve the ways in which words can be presented, read, revisualised and written down, following the procedures outlined in **Table 5**.

The methods used for developing rapid naming in the child's programme thus link with the methods used for training fluency in reading, and include activities methods designed to develop rapid naming of words as well as activities aimed at

Rapid Naming of Familiar Letters, Numbers and Phonically Based Words

↓

Repetitive Paired Reading of Phonically Based Words in Sequence

↓

Repetitive Paired Reading of Paragraphs in Phonically Based Reading Fluency Material

↓

Rapid Naming of Words and Numbers in Typed and Written Material

↓

Tachistoscopic Work varying Length of Word, Time of Exposure, Time between Exposure, Mode of Presentation, Mode of Response and Source of Material

Table 5.
Methods for treating rapid naming difficulties.

developing increasing familiarity with words. Based on Luria's theories of automaticity [58], repetition would be intrinsic to the development of fluency in reading. As Dehaene [95] has noted, familiarity with material influences fluency. The aim of our methods is to use repetitive paired reading to develop the coding, recoding, working memory and rapid naming abilities necessary for fluent and accurate reading, and for self-teaching [108].

9. Developing automaticity in writing and spelling

Fluency in writing and spelling is addressed in our programme through a variety of methods involving linking the teaching of phonic associations with training in basic skills in writing and copying. This is done by teaching the child how to work from print to sound, how to analyse words based on phonic analysis of how words work, and how to use the letters and letter combinations used to represent the vowels in words as the basis for remembering how words are spelled both individually and in sequence. This is done through a process we call "phonological referencing" which focuses on the coding and recoding of phonic associations [80].

This is done using word families of between five and six words, supported by sentences in which the words are analysed in sequence, revisualised and then tested. The aim is to use revisualisation of words and sequences of words as an integral part of the process of learning to write and spell, with the aim of developing the phonological, phonic and sequential working memory processes involved in writing rapidly and accurately in sequence [84, 85].

The model for using our phonically-based, large print materials for developing writing and spelling fluency, is represented in **Table 6**.

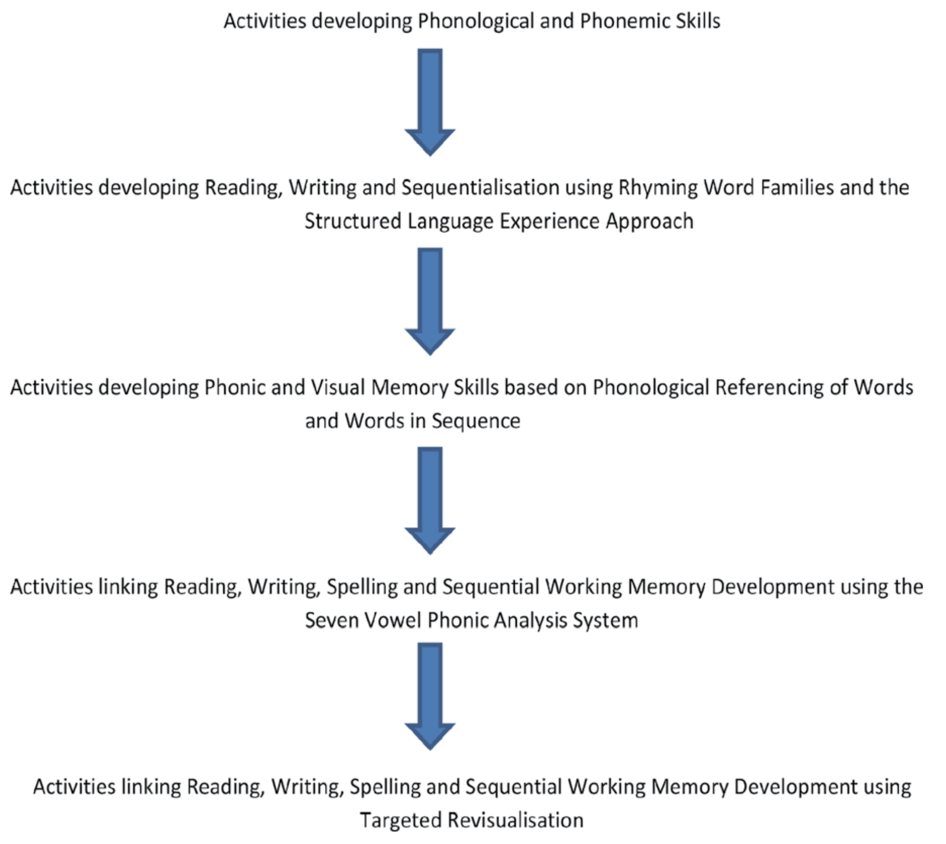

Table 6.
Model for developing writing and spelling fluency based on activities involving development of reading, writing, spelling, phonic analysis and revisualisation.

Following Luria's theories [58], our methods use repetition as intrinsic to the development of automaticity in writing and spelling fluency. As with reading fluency, the aim is to develop the coding, recoding and working memory abilities necessary for fluent and accurate writing and spelling [91–93, 108, 109].

At initial stages in the programme, the aim is to build phonological, orthographic and morphological awareness through phonological referencing [86]. This involves developing the child's phonic analysis, visual memory and sequential working memory skills by methods which combine phonic analysis and revisualisation [74].

The phonic abilities of the child are established from analysis of the child's errors on spelling tests, in the child's descriptive writing, creative writing and school work, as well as through a series of phonic inventories [79]. Based on the pattern of errors, we initially involve the child in work with word families and phonogram cards targeting specific phonic errors in the profile. In the process, the child is introduced to working with the Seven Vowel Phonic Analysis System, which is a procedure for teaching children through activities involving mapping the combinations of letters used in writing words to the sounds made when those words are spoken orally [73, 74].

The aim is to combine phonic analysis and revisualisation in developing skills in word attack, spelling and sequential working memory. This is done through activities focusing on analysis of the letters and letter combinations used to represent the vowel sounds in words, combined with revisualisation activities focused on remembering sequences of words [84]. The sequence of instruction followed, and the links between phonological referencing, the introduction and application of the Seven Vowel Phonic Analysis System, and the combination of phonic analysis and revisualisation in the Targeted Revisualisation Programme [83], are represented in **Table 7** below.

The sequence of instruction followed in implementing the programme thus integrates reading, writing and spelling through activities which are phonically-based, linking phonological, phonemic, visual memory and sequential working memory development. The methods used are outlined in a series of manuals which can be used by therapists, teachers, schools and parents [81–85].

10. Mapping the associations between spoken and written words

Both phonological referencing and the Seven Vowel Phonic Analysis System are used for point to point analysis of the links between the sequences of letters used in written words and the sequence of sounds made which the words are spoken orally. This is done through activities in which the child is taught to map the associations between the sequences of letters used in written words and the sequences of sounds used when the words are spoken orally [80].

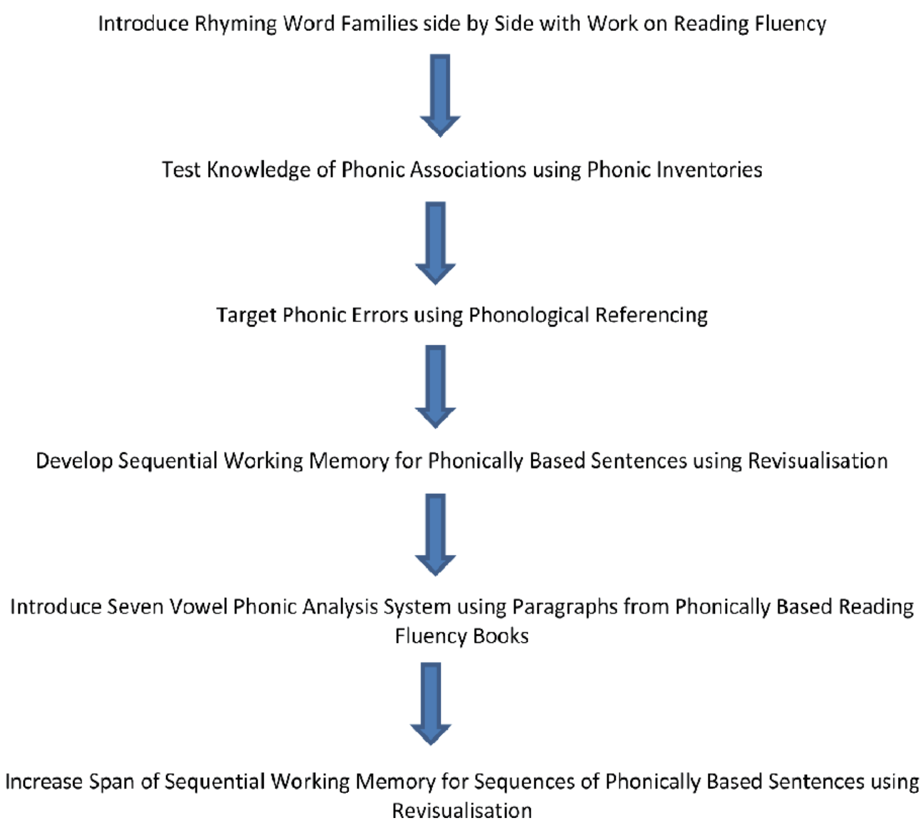

Table 7.
Introducing phonological referencing and the seven vowel phonic analysis system.

The sequence of instruction followed in teaching the child is as follows:

- After the child has learned the associations between sounds and letters, the child works with word families as well as with phonogram and rime cards, which are used side by side with the process of phonological referencing. The basis for mapping is to link the individual letters and sequences of letters with the sequences of sounds made when the words are spoken out loud, based on the principle that "what we say is what we write."

- This stage involves activities in which the hand is placed under the chin to increase the ease by which the vowel sounds in words can be identified as part of the process of mapping letters to sounds and sounds to letters.

- Particular focus is placed on identifying the vowel sounds in words (which are spoken when the mouth opens) and the consonant sounds (which are spoken when the mouth closes). The letters the child has written or typed form the departure point for linking what is written on paper with both sounds and mouth movements.

- The aim is to enable the child to identify the vowel letters and the consonant letters used in written words, and then to link these back to the sounds made when the word is spoken orally.

- Reverse mapping between the sequence of sounds in the word and the letters used in writing the word then takes place. Once the vowel sound in the word has been identified, the letters used to represent the vowel sound are then colour coded. In the process, short vowel sounds are identified as normally being made by one letter working by itself, while long vowel sounds are identified as normally being made by two letters working together.

As the focus lies on mapping the consistency between the sequences of letters used in written words with the sequences of sounds used when the words are spoken orally, the aim is to enable the child to build the variety of phonic associations necessary to read, write and spell in sequence. Visual memory, revisualisation and dictation activities are also used to develop the metacognitive and working memory processes necessary to remember and write sounds and letters in sequence, and words in sequence [110–116].

11. Increasing the transparency of written English

Much has been written about the transparency of the English language compared to other languages [117–122], for the reason that the phonic associations underpinning English orthography are varied, with similar sounds being represented by different letter combinations. This means that both reading and spelling in English are not as easy for children to learn as in many other languages such as Italian, Afrikaans, Welsh, German, or French [123–130]. This has potentially negative effects on the progress of children with learning disabilities [118, 119, 131–133].

Our materials attempt to overcome this problem at initial stages in the programme through the use of carefully chosen vocabulary. Phonic associations are initially taught through graded rhyming word activities, and then developed through activities involving reading, writing and use of working memory in spelling. Once the child has been introduced to the phonological referencing and colour coding process with individual words and families of rhyming words, he or she is also introduced to activities involving use of visual memory and revisualisation of words in sequence.

Word families of written words are used as the basis for analysing individual words, while written sentences are used as the basis for analysing words in sequence. This is done through activities based on sentences and paragraphs which include words in which the y and w combine with other letters to form long vowel sounds. These letter-sound associations are identified and then mapped using the Seven Vowel Phonic Analysis System [73, 74, 83].

In the process, the child is taught that a, e, i, o and u are the letters normally used to represent the vowel sounds in words, but that y and w can also be used to represent the represent the vowel sounds in positions at or near the end of written words in English. The Seven Vowel Phonic Analysis System is then worked with and applied through activities in which the child speaks the word out loud and then identifies the letters used as vowels in the word. Through activity-based learning, the child is introduced to the principle that there needs to be a vowel in every word, that the letters a, e, i, o and u are used to represent the vowels in all positions in words, and that the use of y and w as vowels at the end of words is both logical and consistent, applying to nearly all words in English.

The use of the Seven Vowel Phonic Analysis System thus enables the letters used to represent the sounds in both simple and complex written words to be identified through phonological referencing, and to be analysed following the principle that "what we say we write." The aim is make written English as transparent as written Welsh, in which the use of the seven vowels a, e, i, o, and u, as well as y and w, also applies [122, 123, 133], making it logical and easier for children to learn.

12. Combining phonic analysis and revisualisation in developing sequential working memory for words

The methods for teaching spelling in our programme have been described in Potter [38, 70] and follow the phonologically and phonically-based stages in spelling described by Moats [134, 135], as well as the stages in a set of three phonic inventories based on the foundation level curriculum taught in primary schools in South Africa [79]. Phonic associations are initially introduced through graded rhyming word activities involving reading, writing and use of working memory in spelling. Focus is placed on teaching through synthetic phonic approaches incorporating teaching children to isolate sounds and blend sounds into words, as well as how to create families of rhyming words based on similar phonological and phonemic elements [75].

These are introduced side by side with reading fluency activities using our foundation level and then our basic level readers, through methods which use activity-based learning to build the variety of phonic associations necessary to read, write and spell. Phonic analysis is then introduced using phonological referencing [80], which is applied working with families of between five and seven words, each of which are based on a similar consonant blend of cluster. These are then contextualised in short sentences in which the words are then phonically analysed and revisualised in sequence. The aim is to develop the working memory integrities necessary to write accurately in sequence.

In the ck word family, for example, the following words would be written in the child's writing book.

shock
brick
check
stack
cluck
trick

The vowel in each word would then be underlined in colour and matched with the way the mouth opens in making each vowel sound and the way the mouth closes in making each consonant sound. After this, the child would work with his or her reading partner and phonologically reference each word in the ck word family, by linking the sounds in each word when the word is spoken out loud with the letters used when the word is written down.

This would be done through an activity-based process, in which the child is asked to:

a. Point to the written word on the page and say it.

b. Look at the two letters at the beginning of the written word. Say the sound of these letters out loud.

c. Look at the vowel in the middle of the written word. Say the sound of this letter out loud.

d. Look at the two letters at the end of the written word. Say the the sound of these letters out loud.

e. The phonic rule applied in each of the words would then be focused on working with the reading partner. This would be done by focusing on how the beginning sound, the middle sound and the ending sound work together to make each word, and how the ck ending applies in each word.

Each of the words in the family would then be contextualised in sequence in a short sentence. The sentence would be written down by the child, and the vowel or vowels in each word in the sentence underlined in colour. After this, each word in the sentence would then be revisualised in sequence working memory tested by asking the child to rewrite the sentence from memory. These sequential revisualisation techniques would then be used further at higher levels in the programme [84].

13. Linking the development of phonic associations, visual memory and sequential working memory skills

The sequence of instruction followed with each child varies based on evidence of how the child learns, but is conducted with the aim of linking the development of phonic analysis, visual memory and working memory skills as represented in **Table 8**.

It will be apparent from **Table 8** that the aim at each level of the programme is to work to combine phonological and phonic skills development with the development of visual memory and sequential working memory. This is done through methods which to combine the process of phonic analysis with the process of revisualisation in developing sequential working memory for words [83, 84], through a longitudinal process in which:

- The child is taught to map the associations between the sequences of letters used in words and the sequences of sounds used when words are spoken orally through phonological referencing, as well as through use of phonogram and rime cards.
- The child is taught that each written word is logical and can be analysed on the principle that "what we say is what we write."
- The child is shown how to use revisualisation to remember the sequences of letters used in individual words and the sequences of words in used in sentences.

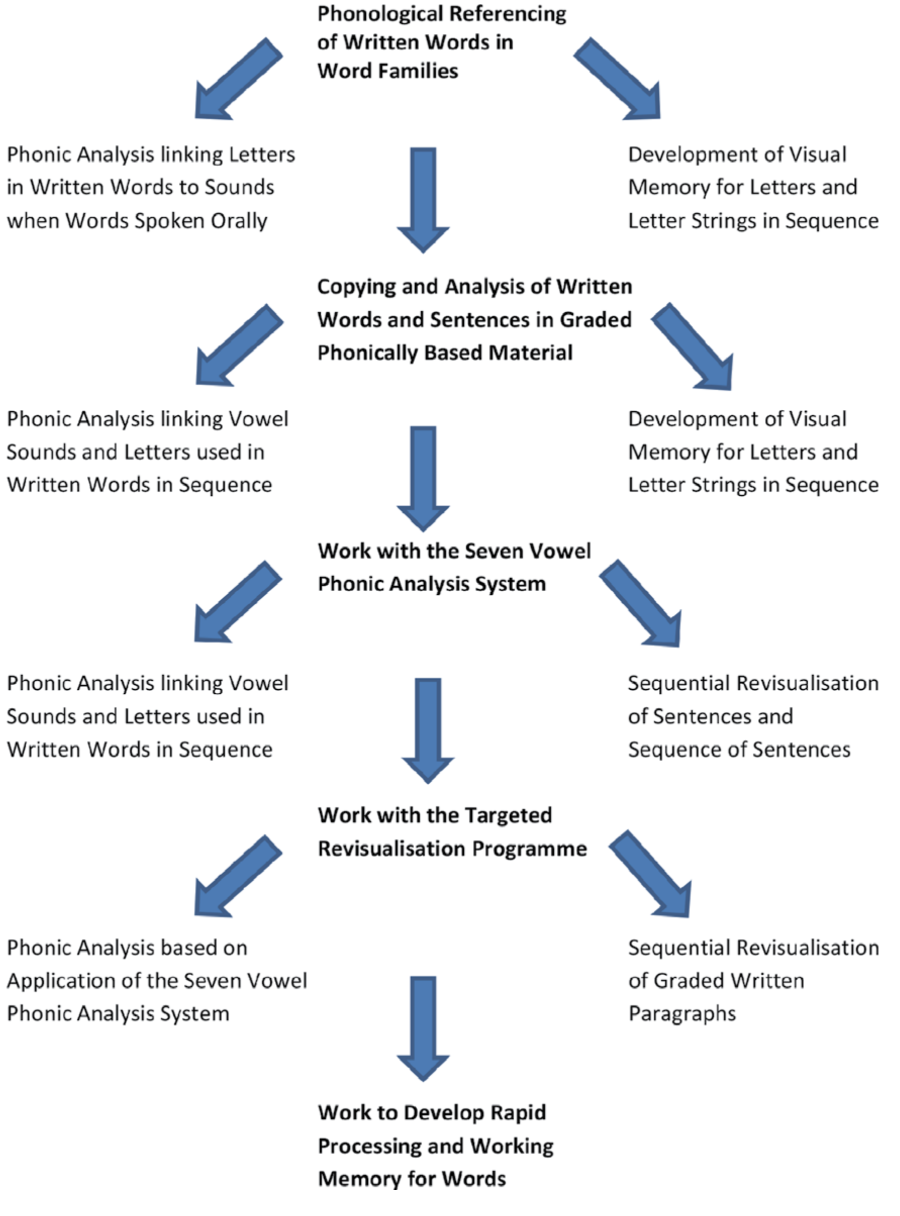

Table 8.
Methods linking phonic analysis, visual memory for strings of letters and words and sequential working memory for written words, phrases, sentences and paragraphs.

Both phonic analysis and revisualisation are thus used to develop the child's ability to store each word in working memory in sequence. This is initially done working with words in the context of sentences, and then with sequences of sentences. The child's sequential working memory is tested through dictation.

At each level in the programme, the methods used are repetitive and follow the procedures for developing automaticity outlined by Luria [58, 68, 69], and are summarised in illustrated implementer manuals for users [74, 81, 83–85]. Once the child is able to recall sentences of between five and seven words accurately, span of sequential working memory is increased by phonic analysis and revisualisation of sentences of increasing length, as well as by phonic analysis and revisualisation of increasing numbers of sentences in sequence.

As our reading fluency materials are graded and phonically based, sentences and paragraphs from these can be used as the basis for activities which link reading, writing, spelling and sequential working memory work. More complex graded paragraphs and sequences of paragraphs are then introduced once the Targeted Analysis, Revisualisation and Sequential Spelling Programme is commenced, as described in the section following.

14. The targeted analysis, revisualisation and sequential spelling programme

Once the child is able to recall the words used in individual sentences and sequences of sentences accurately, the materials used in the Targeted Analysis, Revisualisation and Sequential Spelling Programme are introduced. The methods target words with more than one vowel, which are first written, then typed, then colour coded and then syllabified. The target words are then revisualised and tested [136].

After analysing and recalling the target words, the text of the graded materials is then worked with, focusing on each word in each sentence in sequence. Sequential revisualisation techniques are used. We call this process "targeted revisualisation" as each word is targeted in sequence, using techniques which combine the procedures used for phonic analysis of the target words with the types of mental imagery the child uses in recalling words. These build on the activities linking phonic analysis and revisualisation, and the methods used for developing sequential working memory used at previous levels in the programme.

The aim is to use accuracy in use of sequential working memory for words as the basis for developing fluency and automaticity in writing and spelling [38]. This is done in four stages, as outlined in **Table 9**.

The Targeted Analysis, Revisualisation and Sequential Spelling Programme is applied using graded paragraphs, which increase in complexity as well as length. As these are worked with, the process of combining phonic analysis and revisualisation in using the Seven Vowel Phonic Analysis System is applied repetitively. This is done by working from printed word to sound, and from sound back to print. These phonological recoding skills provide the building blocks on which writing and spelling fluency is developed [71].

On a phonological and phonic level, the methods used are based on the coding and recoding of phonic associations through activities in which the child writes, types and colour codes the vowels in words by underlining the letters used to represent the vowel sounds in colour as well as using the colour coding feature in a word processing programme. This adds a visual dimension to the targeted revisualisation process, as the methods used are designed to make the letters used to represent the vowel sounds in words stand out in colour [83].

Level of mediation	Focuses of phonic analysis	Focuses of revisualisation	Focuses of use of sequential working memory
Stage One: Focus on Words based on Short Vowel Sounds	Introduce concept that vowels are used in all spoken and written words. Identify and mediate short vowel sounds a, e, i, o, and u.	Construct, deconstruct, mentally image and revisualise words and rhyming word families containing short vowel sounds.	Use working memory in writing rhyming words based on short vowel sounds in sequence.
Stage Two: Focus on Words based on Long Vowel Sounds	Identify and mediate long vowel sounds involving use of digraphs involving a, e, i, o, and u. Introduce the letters y and w as vowels in positions at or near the end of words.	Construct, deconstruct, mentally image and revisualise words and rhyming word families containing long vowel sounds, including use of the letters y and w as vowels in positions at or near the end of words.	Use working memory in writing sequences of words containing both long and short vowel sounds, including use of the letters y and w as vowels in positions at or near the end of words.
Stage Three: Focus on Sequentialisation of Words in Sentences	Identify letters used as vowels in words used in sequence in sentences.	Identify, phonically analyse, mentally image and revisualise single syllable and polysyllabic words in sequence in sentences.	Use working memory in writing single syllable and polysyllabic words in sequence in sentences and sequences of sentences.
Stage Four: Focus on Sequentialisation of Words and Sentences in Paragraphs	Identify letters used as vowels in words used in sequence in sentences, and in sentences used in sequence in paragraphs.	Identify, phonically analyse, mentally image and revisualise single syllable and polysyllabic words in sequence in paragraphs.	Use working memory in writing sentences in sequence in paragraphs of increasing length and phonic complexity.

Table 9.
Stages and focuses of mediation in the targeted analysis, revisualisation and sequential spelling programme.

Both phonic associations and visual contrasts are then used to identify the letters representing the vowel sounds in words, with the aim of enabling the child to develop working memory for individual words as well as sequential working memory for words in sequence. Fluency in writing and spelling is then based on increasing span of sequential working memory as well as automaticity in recalling the sequences of letters used in individual words, the sequences of words used in sentences, and the sequences of sentences used in paragraphs.

At higher levels in the programme, rapid reading of words and working memory for words are also developed through use of tachistoscopic methods conducted side by side with targeted revisualisation [107]. Children who have worked in this way report effects in improving word attack in reading, as well as improvements in rate of processing words, rate of reading, spelling accuracy and rate of work.

15. Treatment of difficulties with calculation and numerical problem-solving

In addition to the strands in the child's programme focused on treating difficulties with reading, writing and spelling, numerical and problem-solving activities are also included in the programme, using electronic materials which can be worked with online, as well as sent to parents and children by email [71]. The aim of using this format-based multivariate treatment system is to enable treatment of the functional difficulties identified in assessment, while at the same time addressing needs indicated by the errors made by the child in his or her school work.

The format system is flexible and comprehensive enough to be able to focus on areas of strength as well as needs, while also enabling email delivery of the activities included in each child's individual programme. Number concept development can also be linked to language and problem-solving activities, with support programmes linked to the developmental model outlined in **Table 10**.

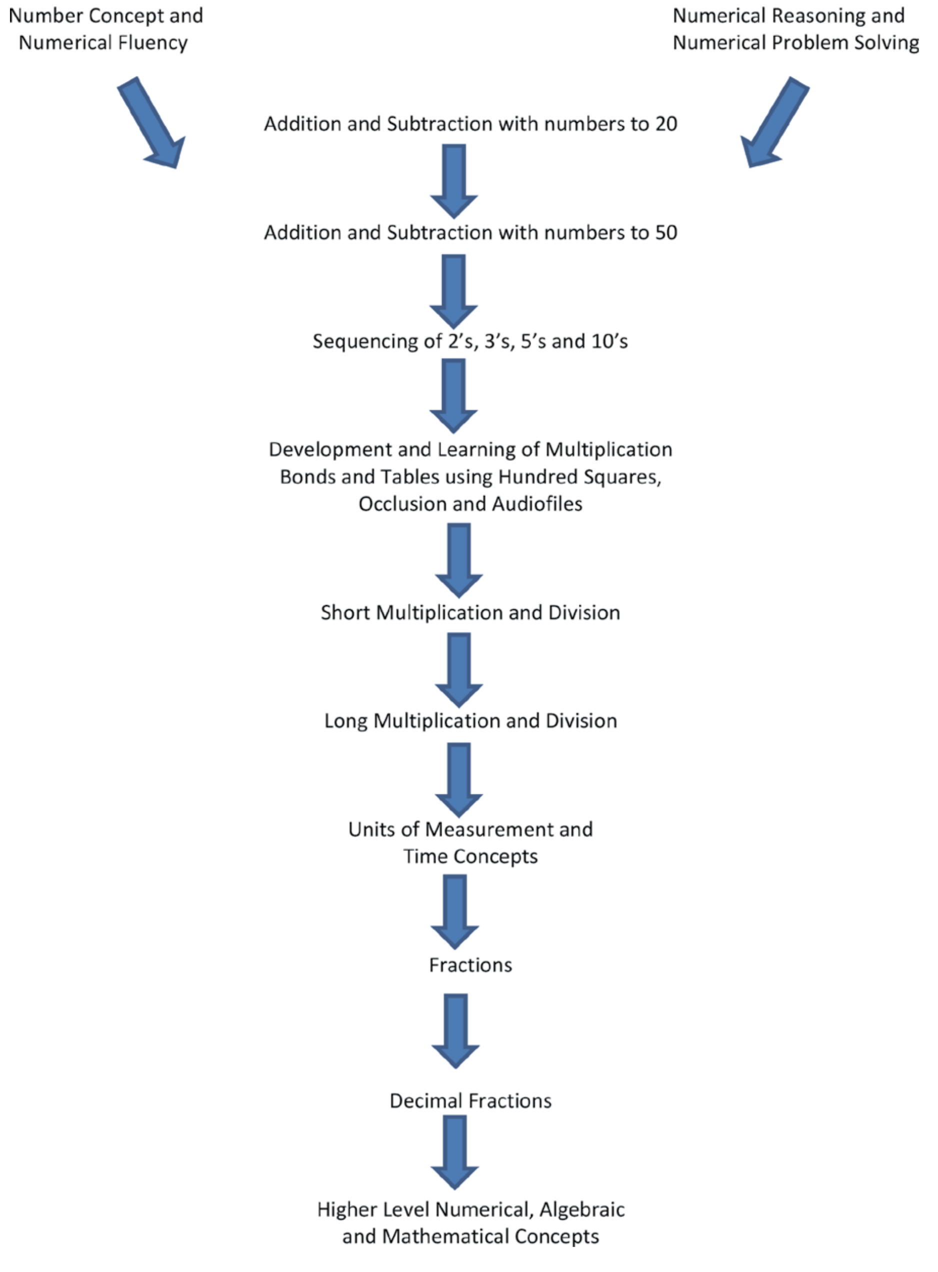

Table 10.
Model for development of number concept, numerical fluency, numerical reasoning and numerical problem solving.

These activities are then implemented side by side with the mathematical curriculum taught at school.

It will be apparent from **Table 10** that at the same time as treating numerical and mathematical difficulties identified in the initial assessment, the learning support provided is both diagnostic and based on clinical teaching, as well as linked to numerical and mathematical concepts covered in the child's work at school. As with other areas of our programme, the aim is to treat functional difficulties as well as to evaluate the child's response to specific types of interventions, as outlined in the section following.

16. Progress evaluation

Work with each child is conducted longitudinally, and is based on a cycle in which evaluation forms an integral part of both planning and implementation. Feedback on specific activities in the format is also provided by photographs sent by email or WhatsApp, enabling the planning of the next format in the child's programme to be evidence-based, linked to ongoing evaluation of learning needs. Assessment is then built into programme implementation at regular intervals.

The model used for implementation is action research based [137–139], and can be summarised as follows (**Table 11**).

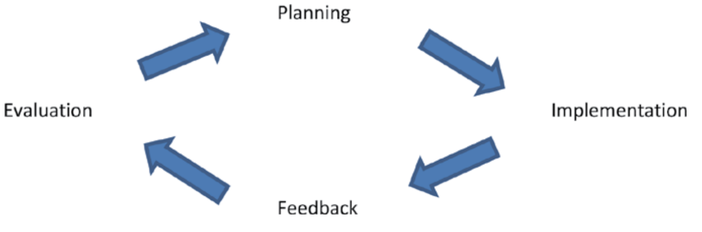

Table 11.
Action research cycle for planning and implementation of activity-based online programmes.

As the programme's data base is extensive, the planning and implementation model implies that each child's programme is evidence-based and multivariate, addressing a number of different learning needs through use of a variety of graded activities. The programme is then implemented using online sessions supported by learning materials provided by email [71].

The aim is that programme implementation can take place with support from parents, teachers, tutors or au paires as reading partners, working with a variety of electronic materials delivered by email or made accessible online via links to websites. Methods used in the programme are documented in illustrated implementer manuals, and are demonstrated working online, supported by cell phone and email contact.

Both evaluation programme activities and evaluation of progress are linked to evidence from the child's school work and school reports at regular points in primary, with full re-assessment and summative evaluation being conducted at point of transition to high school. The aim at this point is to make a firm diagnosis of learning disability which can be linked to concessions.

The aim is to ensure that firm classification and labelling of a child as learning disabled is valid [36], based both on longitudinal analysis of test results as well as response to specific interventions [140, 141], on the model described in the section following.

17. Firm classification of particular types of learning disability on the basis of response to intervention

In implementing the different types of interventions which have been described in this chapter, the programme focuses on a number of different variables related to the areas of difficulty. Interventions are normally longitudinal and conducted side by side with the curriculum taught in the child's school.

The programme works with the aim of providing fluency-based interventions which can develop basic skills and competences in reading, writing, spelling as well as numeracy. At the same time, evidence-based learning support is provided focused on areas of the school curriculum with which the child is experiencing difficulties. This type of multivariate intervention is implemented using formats based on an online session providing counselling followed by an intervention, supported by electronic materials which can then be used by parents and children working in conjunction with a teacher or therapist, or independently [71].

At the outset the child's difficulties are described functionally. This enables labelling to be avoided, until such time as the child has had benefit of focused

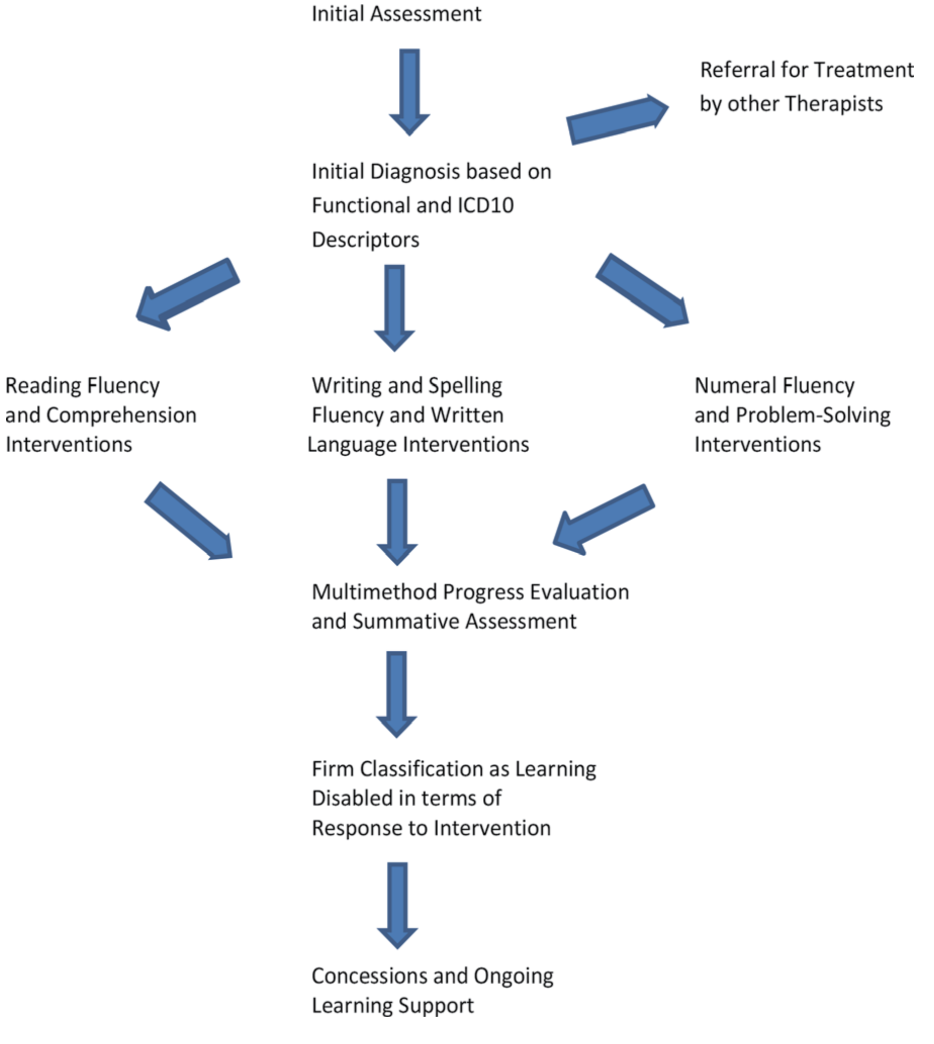

Table 12.
Classification of learning disabilities based on response to multivariate fluency-based interventions.

multivariate treatment, and is also likely to be more developmentally and neurologically mature [142–145]. As maturation takes place, firm diagnosis and classification of learning disability then becomes to the child's benefit, as it can be linked to concessions related to areas of ongoing difficulty. This can be linked both to cross-sectional assessment as well as evaluation of response to interventions which have been based on multivariate treatment using particular types of methods and materials.

In our programme, firm classification as learning disabled is thus normally undertaken at the end of a child's primary school years, based on evidence collected by use of different methods over time [146, 147], within a model of inference based on a process of incremental validity [34, 35, 148]. Diagnosis can then be linked to concessions to compensate for those areas of difficulty which have been demonstrated to be resistant to particular forms of treatment, as well as to ongoing treatment and learning support in particular areas of the high school curriculum.

The model for classification of learning disabilities is reflected in **Table 12** on the previous page. It will be noted that the model is multimethod, based on summative assessment linked to progress evaluation of longitudinal interventions conducted across a number of areas of functional difficulty, enabling triangulation across different data points over time [131].

This enables firmer conclusions as to the type of learning disability involved, as well as classification of learning disability based on specific evidence relating to response to particular types of treatment [141].

18. Summary and implications

This chapter has focused on treatment of the functional learning difficulties associated with dyslexia, dysgraphia and dyscalculia, as three dimensions of learning disability. As each of these dimensions can be associated with a range of reading, writing, spelling and working memory difficulties, the model of classification described in this chapter has been described with reference to a particular programme which uses a large data base to implement a variety of different activities with children diagnosed as having learning problems.

Owing to the measurement error implicit in testing young children who may have attention and focus difficulties in addition to functional difficulties with reading, writing, spelling and maths, the model of classification assumes that initial diagnosis of learning disabilities is at best provisional. For this reason, labelling of children is avoided at the outset. Functional indicators based on actual versus expected performance are used in preference, using ICD10 codes and descriptors as opposed to labelling using terms such as Dyslexia, Auditory Processing Problems, Language Processing Problems, Reading Comprehension Deficits, Dysgraphia, Visual Perceptual or Visual Motor Deficits, Non-Verbal Learning Deficits or Dyscalculia.

Detailed description of the initial assessment process has been provided in order to show that functional ICD 10 descriptors can be used instead of labels as the basis for establishing needs and areas of treatment. Treatments can then be targeted at these descriptors, being related to focus on specific problems with reading, writing and spelling, as well as numerical concepts and mathematical problem-solving. Difficulties outside these areas are then referred to other specialists.

Detailed description of particular methods, materials and programmes has also been provided in this chapter to indicate that once initial functional classification has taken place linked to specific areas of difficulty, multivariate interventions can then be developed and implemented. Firm classification then becomes possible based on the child's progress over time.

One implication is that initial diagnosis of learning difficulties can be rigorous despite being provisional, providing detailed descriptions of specific areas of difficulty which are made with a view to undertaking multivariate treatment. Firm classification can then be made based on response to intervention at a time in the child is likely to be more developmentally and neurologically mature, and prior making a transition to new forms of teaching and new areas of learning at high school level.

Another implication is that the process of establishing firm diagnosis and classification would best be conducted at the end of a child's primary school years, with a view to establishing concessions as well as the possibility of further treatment at higher levels in the curriculum. At this point firm diagnosis as having dyslexia, dysgraphia or dyscalculia can act to the child's maximal benefit, in maximising the chances of obtaining the concessions and further treatments necessary to making the grade.

As the response to intervention classification model described in this chapter has been successfully applied in practice,[7] a third implication is that the model is feasible and may have wider relevance. It offers the possibility that firm classification as learning disabled can be based on the child's response to treatment which has been focused, multivariate and multimethod. In terms of the model, firm diagnosis of children as dyslexic, dysgraphic or dyscalculaic becomes an outcome taking place after treatment, linked to the possibility of concessions as well as additional interventions.

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[7] The author has applied the response to intervention classification model working in association with Robert Thomas-Stark, psychologist, of the Centre for Therapeutic Excellence, Johannesburg. To maximise validity, this has involved longitudinal and cross-sectional assessment by two therapists, leading to a collaborative diagnostic report.

Author details

Charles Potter
Educational Psychologist in Private Practice, Johannesburg, South Africa

*Address all correspondence to: pottercs@gmail.com

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Chapter 13

Impacts of Dyscalculia in Learning Mathematics: Some Considerations for Content Delivery and Support

Rajendra Kunwar

Abstract

Dyscalculia is one of the important but less prioritized areas in learning mathematics. A group of students about 3–7 percent of school-age are facing problems associated with dyscalculia. They are facing problems related to number comparison, symbols and reasoning. This paper discusses the general features of dyscalculia and ways to overcome it. This article mainly focuses on the problem related to mathematics learning due to dyscalculia. It further highlights the concept and meaning of dyscalculia, types, causes of dyscalculia, common difficulty areas in mathematics for dyscalculic children, the impact of dyscalculia in mathematics learning. Finally, it also brings out the effective ways of delivering the mathematical content in the classroom teaching and ways to support dyscalculic students.

Keywords: content delivery, dyscalculia, learning deficit, learning mathematics, student support

1. Introduction

Mathematics is measured to be a difficult subject due to its abstract nature. The difficulty of learning mathematics is a worldwide issue. It is a very important and necessary subject in school education caused by its linkage to everyday human life. Therefore it is taught as a fundamental subject in schools all over the world and positioned as an important subject in the school curriculum. Mainly in mathematics and science, many students believe that it takes inherent ability or even brilliance to achieve well, rather than perseverance, good strategies, help from others, and learning over time [1]. As a result, it has always been given special attention in school education globally. Although the expected outcomes in mathematics could not be achieved to date and the students' negative attitude towards learning mathematics also could not be reduced [2]. For many years, it was believed that the numerical cognition of the children could be developed according to the child development and the learners can be taught effectively using Piaget's child developmental stages [3]. The focus of Piaget's philosophy was that the child understands space, time and causality of number and quantity and classes and relations of invariance and change [4].

In recent times, however, the researchers are focusing increasingly on the causes of mathematical learning difficulties as the procedural as well as neurobiological foundations of the learner [5]. Mathematics is conceived as a product of human activities in the process of adapting to the external environment [4]. The precise acquisition of mathematical abilities involves a broad range of different general cognitive skills including auditory and visual working memory, pattern recognition, speed of information processing, spatial perception, and attention [6]. These skills enable students to perform different mathematical activities and performance. Among them, working memory is a strong predictor of mathematical skills across time, achievement or achievement growth in mathematics [7]. It helps to perform fast and accurate arithmetical calculations in adolescence and adulthood [8]. Researchers have generally agreed that the deficit in working memory, brain-related condition, genetic cause, environment, and brain difference is considered dyscalculia [9]. These deficits affect the learners' mathematical learning capability particularly computation and reasoning [10]. Such problems of the learner gradually tend to create frustration to learn mathematical problems regarding computation and application [11]. The objectives of this chapter are to state mathematics learning components, concepts and meaning of dyscalculia, types, causes, areas of common difficulties in mathematics for dyscalculic children, impact of dyscalculia in mathematics learning, effective ways of content delivery and student support.

2. Components of learning mathematics

Mathematics is a very essential and important subject that encompasses numbers, measurement, probability, and algorithms [12]. It cannot be separated from the particular cognitive processes in operation whenever we apply our minds to a mathematical task [5]. It is sometimes expressed as a difficult subject that is inaccessible, boring, particularly for cool and engaged people and girls [13]. Mathematics is considered an integral part of our everyday life. It is used in daily activities such as cooking, shopping, playing, arranging something, etc. Ziegler and Loos [14] stated that mathematics was developed from counting, calculation, measurement and the systematic study of the shapes and motions of physical objects. Historically, it was regarded as the science of quantity, or numbers. Thus, mathematics learning is essential for each person to continue their daily life too. Mathematics learning requires three equally important hierarchical components that can help to transform the mathematical concepts, ideas and knowledge effectively. The brief accounts of these components are as follows:

i. Language component: It is the first component in learning mathematics. Language is a key component used to describe mathematical terms, notations, concepts, ideas and procedures to develop mathematical knowledge and understanding. It is also used in conceptualizing and communicating mathematical information. Mathematics learning starts from counting physical objects and gradually forward with concepts of quantity, size and comparisons. Language continues to help students move from concrete mathematical skills based on physical objects to a more symbolic mathematics ability focused on numerals [15]. Language is useful for the teacher to address and transfer the mathematical concepts, problems and procedures to the learner more clearly.

ii. Conceptual component: The second component of learning mathematics is the conceptual component. It refers to an understanding of the actual meaning and intends to increase literacy in mathematics rather than step-wise teaching to find the solutions. It focuses on explaining the processes (why) rather than performing the process (how). Conceptual learning begins in early childhood by using different effective methods, modern tools and techniques. Conceptual learning makes the students able to transfer their knowledge to new situations and contexts effectively. Thus it is essential for success not only in mathematics but in all disciplines and in the workplace.

iii. Procedural component: This component refers to the ability to apply procedures accurately, efficiently and flexibly; to transfer procedures to different problems and contexts; to build or modify procedures from other procedures; and to recognize when one strategy or procedure is more appropriate to apply than another [16]. It is more than memorizing facts or procedures. The procedural component can be used effectively when the conceptual proficiency is high. Fluency of the procedural component builds on a foundation of conceptual understanding, strategic reasoning, and problem-solving [16].

3. Concept and meaning of dyscalculia

Dyscalculia is a specific learning difficulty that affects the learner's ability to retain mathematics skills related to calculating numbers, not with every branch of mathematics [2]. Dyscalculia is an umbrella term used to represent diverse conditions that cause specific difficulties with mathematics such as developmental dyscalculia, mathematical disability, numerical learning disability, and number fact disorder among other terms [17]. Thus developmental dyscalculia is an inborn condition that affects the ability of the learner to acquire arithmetical skills. However, dyscalculia may be caused by accidental brain damage (acquired dyscalculia).

The word 'dyscalculia' has both Greek and Latin origins. The Greek prefix 'dys' means 'badly', while 'calculia', from the Latin 'calculare', means to count [10]. The term dyscalculia or developmental dyscalculia was first defined by the Czechoslovakian researcher Kosc in 1974 [18], as difficulty in mathematics as a result of impairment to particular parts of the brain involved in mathematical cognition, but without a general difficulty in cognitive function. In other words, dyscalculia is also known as 'difficulty with numbers', 'being bad at mathematics', or 'number blindness'. It is not the only difficulty with numbers but a more deeply-rooted problem than just being bad at mathematics [9]. As stated by Hornigold [9], the dyscalculic learner always struggles with the common difficulties in mathematics such as remembering number facts and time tables, counting backward in steps, learning to tell the time, calculations involving money and fractions, decimals and percentages. Dyscalculic learners may have difficulty in understanding numbers, number facts, numerical operations place value, the principle of exchange and their mathematical procedures. However, mostly, these difficulties can be overcome with extra support and intensive intervention.

The specific learning difficulty or disorder affects the learners' ability to memorize number-based facts understanding the logical steps needed for solving a mathematical problem and performing daily numerical tasks. Dyscalculia refers to the inability or disorder in basic numerical processes in mathematics [19]. Such learning disorder affects the learner in numerical processing and computation throughout their life. It is the result of specific disabilities in basic numerical processing, rather than the consequence of deficits in other cognitive abilities [20]. According to Grant [21], the specific learning deficits in mathematics have number sense, memorization of arithmetic facts, accurate or fluent calculation and accurate mathematical reasoning. Among them, number sense can be classified as dyscalculia and the core deficit of dyscalculia is the lack of numerosity or the inability to understand the concept of more than/less than [21]. The term specific learning difficulties or deficits describe a range of disorders in which dyscalculia is one. Therefore, dyscalculia is also considered as the lack of numerosity or an inability to understand the concept of more than/less than.

Dyscalculia is a neurological disorder about learning abilities in mathematics. It has a strong correlation between neurobiology and dyscalculia [22, 23]. Dyscalculia is a brain-based disorder as indicated by genetic, neurobiological, and epidemiologic evidence [24]. The common range of dyscalculia lies between 3 and 6% of school-age children [22]. Similarly, Hornigold [9] states around 6% of the children have dyscalculia and are being equally affected regarding both girls and boys. However, Sharma [5], claimed that the occurrence of dyscalculia is about 6 to 8 percent of the school-age population. As affirmed by Khing [10], children with dyscalculia consist of two types of problems-mathematical computation and reasoning. The problem related to mathematical computation affects an individual to solve mathematical calculations like addition, subtraction, multiplication, and division. Similarly, mathematical reasoning affects the learner in the case of analyzing and way of thinking [19]. Such mathematical problems usually begin at the elementary level and generally continue throughout their lifespan [9].

4. Types of dyscalculia

In the field of mathematical learning disability, different researchers have explored their ideas to categorize the major types of dyscalculia concerning the different dimensions of acquiring mathematical ability. In this context, Kosc [25], the researcher, who proposes dyscalculia into six uniform categories particularly focusing on the characteristics of knowledge deficits are as follows:

i. Verbal dyscalculia: It denotes the disturbing ability to designate verbally mathematical terms and relations, such as naming amounts and numbers of things, digits, numbers, operational symbols and mathematical performances [25]. In this dyscalculia, children can read or write numbers, but feel difficult to recognize them when presented verbally.

ii. Prognostic dyscalculia: This type of dyscalculia denotes the trouble or difficulty to manipulate mathematical real or pictured objects. Such mathematical manipulations consist of enumerations and comparisons of estimates of quantity. Children with this type of dyscalculia can understand mathematical concepts however they have trouble in listening, comparing, and manipulating mathematical equations.

iii. Lexical dyscalculia: It is a reading disability of mathematical symbols (digits, numbers, operational signs, and written mathematical operations). In this sort of disability, children may have trouble in reading and understanding mathematical symbols, numbers, mathematical expressions, and/or equations.

iv. Graphical dyscalculia: It is a disability in manipulating mathematical symbols in writing. Children can understand; however, they feel trouble while writing or using the correct corresponding symbols. They may also be unable to copy them if written.

v. Ideognostical dyscalculia: It is difficult to carry out mental calculations and understanding mathematical ideas and relations. Children having Ideognostical dyscalculia feel difficulty with completing mental operations and remembering mathematical concepts after learning them.

vi. Operational dyscalculia: It is the inability to carry out mathematical operations or calculations due to the typical occurrence by an interchange of operations, e.g., doing addition instead of multiplication; subtraction instead of division; or substitution of more complicated operations by simpler ones.

Geary [26] has divided dyscalculia into three types particularly focusing on the way of knowledge processing and procedures. The brief descriptions of the type are as follows:

i. Semantic memory: It is concerned with the deficits in the retrieval of basic arithmetic facts. When the children retrieve the facts, there is a chance of a higher error rate and when facts are retrieved correctly, they are often unsystematic. It is also known as arithmetic retrieval deficits and is caused due to working memory deficits. It does not affect reading difficulties however learning arithmetic facts and the process of retrieving them is more complicated [27].

ii. Procedural memory: It includes developmentally immature procedures, frequent errors while executing procedures. It also comprises of poor understanding of the concepts underlying procedural use and difficulties sequencing the multiple steps in complex procedures. It is due to the dysfunction of the left hemisphere pre-frontal brain and improves with age.

iii. Visuospatial memory: It denotes the difficulty with spatially representing numerical and other forms of mathematical information and relationships. It comprises difficulties with recognizing and understanding mathematical relations, interpreting visual representations of mathematical objects, placing numbers on a number line, visualizing geometric figures and interpreting graphs and tables [9].

Karagiannakis and Cooreman [28] have categorized dyscalculia into four ways based on different aspects of mathematical ability or areas of mathematics that affect the learner. The brief accounts of the types are as follows:

i. Core number: This type of dyscalculia consists of the difficulties related to basic number sense or the ability to use and understand the number and our number system, estimating, assessing numerical differences in quantity, understanding and the use of mathematical symbols, place value and placing numbers on a number line.

ii. Reasoning: Reasoning comprises the difficulties related to understanding mathematical concepts and relationships, generalizing and transferring mathematical information, understanding complex procedures including problem-solving and decision making.

iii. Memory: This type of dyscalculia encompasses the difficulties associated with remembering and retrieving numerical facts, understanding and recalling mathematical terminology, word problems, performing accurate mental calculations, remembering and carrying out procedures, rules and formulae, performing problem-solving steps.

iv. Visual–spatial: This way includes the difficulties concerning recognizing and understanding mathematical symbols, interpreting visual representations of mathematical objects, representing numbers on a number line, visualizing geometrical figures, interpreting graphs and tables.

5. Causes of dyscalculia

There are different views about the causes of dyscalculia. However, researchers are generally agreed about dyscalculia as a brain-based condition. Arguably, the specific mathematics learning difficulty (dyscalculia) can be categorized within the cognitive, behavioral and biological aspects and contextualize in teaching and learning mathematics. It can also be considered as the fundamental cause of dyscalculia or the factors affecting dyscalculic learners. The category of the fundamental causes of dyscalculia is presented in **Figure 1**.

The causes of the dyscalculia as presented in **Figure 1**, in the cognitive factor, the acquisition of number concepts and the ability to acquire arithmetical skills and understanding, some huddles during the development stages of Piaget's child development theory can the cause of dyscalculia. Similarly, the information processing theories can also be the cause to accommodate the number concept and difficulty with numbers [29]. In behavioral factors, learning environment, various aspects related to effective teaching and learning such as teaching methods, materials, motivation, classroom environment, socio-cultural factors, stress, anxiety, etc. can also be the causes to acquire the number concept and arithmetic skills [30]. Frequent learning activities or drills and practice can also help to attain the learning problem related to numbers. The biological factor comprises brain structure and genetics. In brain structure, the cause of dyscalculia depends on the differences in the surface area, thickness and volume of the different parts of the brain that are used in memory and keeping track of a task [31]. The development of brain structure may depend upon prematurity and low weight birth. It can be identified by MRI scans. In the same way, dyscalculia can be transformed from the heredity too [32]. Thus, all the aspects can cause dyscalculia in a learner.

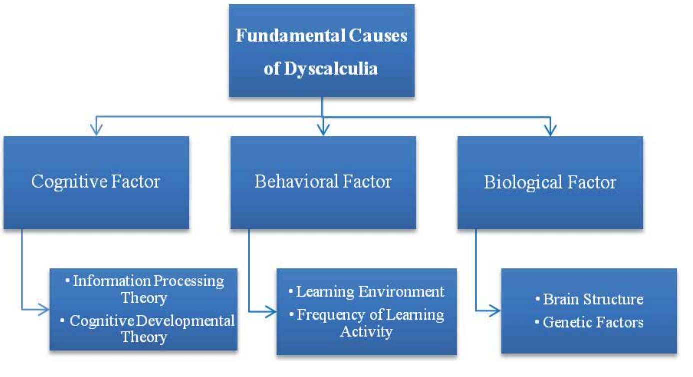

Figure 1.
Fundamental causes of dyscalculia.

6. Areas of common difficulties in mathematics for dyscalculic children

As already discussed above, dyscalculic children often struggle with number and number concepts that can lead to a diverse range of difficulties related to numbers in mathematics. Jacobson [33] stated that dyscalculic children have difficulties related to recognizing and remembering numbers, counting, associate number symbol with the number value, identifying patterns and placing things in the right order. Some common areas of difficulty in mathematics for dyscalculic children are stated below in brief:

i. Counting backward and counting in steps: Counting backward and stepwise.

ii. Sequencing and recognizing patterns: Troubles with recognizing patterns and sequencing numbers.

iii. Calculations: Choosing the correct numerical operation and applying it correctly.

iv. Direction/orientation: Difficulty immediately sorting out direction, spatial orientation, confusion over left, right, high, low and depth.

v. Estimation: Understanding place value, problem-related to estimating quantities from the given numbers or numeric values, mathematical concepts, rules and formulae.

vi. Time: Problem-related to tell the time on an analog clock.

vii. Assessing numerical quantity: Identify the number numerically larger or smaller.

viii. Money: Making sense of money and estimating quantities.

ix. Mental mathematics: Difficulty remembering procedures in mathematics recognize quantities without counting, recalling basic math facts, linking numbers and symbols and problem-solving.

x. Fraction: Poor visual and spatial orientation in fraction diagram.

7. Impact of dyscalculia in learning mathematics

Dyscalculia impacts children from the early age of schooling onwards. It affects learning mathematics as well as in daily life activities due to the inability of basic arithmetic concepts like poor number sense and reasoning. Dyscalculia can also impact children in the varied areas of mathematics. The major impacts of dyscalculia in mathematics learning in everyday activities of the children are as follows:

i. Develop a negative attitude and avoid the tasks like judging distances, direction, depth and distinguish between left and right; larger and smaller numbers.

ii. De-motivate and make it difficult to learn mathematics because of poor understanding of mathematical concepts, rules, formulae, and proper sequencing.

iii. Unable to concentrate a long time continuously on mentally concentrated tasks.

iv. Makes challenges in daily life due to their poor number sense and other mathematics skills.

v. Reduce self-efficacy of the learner about learning mathematics due to the constant difficulty on the problem related to amounts, time, distance, speed, counting, mental mathematics, and remembering numbers.

vi. Develop low self-esteem and always hesitate to argue or express the views related to mental arithmetic and numeric calculation such as addition, subtraction, multiplication and division.

vii. Makes unhappy and unenthusiastic constantly in mathematics classroom activity due to the lack of common mathematics abilities like remembering number facts, times tables, counting backward, telling the time, calculations involving money, fractions, decimals and percentages.

8. Effective ways of content delivery

Content delivery describes the process of conveying subject matter to the learner through either the physical or virtual medium. There are a large number of ways to deliver the content. Effective content delivery depends upon how clearly the learner has internalized or understood the subject matter. The effective way of content delivery for dyscalculic learners also depends upon the students' background, interest, level and capability. However, the multi-sensory techniques incorporating best suited modern tools and techniques with the need and interest of the learner can make the content delivery more effective. Some major ways for effective content delivery are accounted in brief:

i. Make it real: While teaching number and concept, use varied concrete materials available around the locality and also use readymade or prepared materials such as Cuisenaire rods, Base ten-block, Numicon, Addacus, Ten-frames, etc. so that multi-sensory approach can be used to make real learning. Such manipulative materials can help the dyscalculic learner develop number concepts, place value and mathematical reasoning.

ii. Provide sufficient time: The use of concrete materials in teaching helps to develop a clear concept about mathematical terms and understand the relationship between numbers and number systems through manipulating the materials. It further helps to develop mental arithmetic skills effectively. The learner should be provided sufficient time to manipulate a variety of concrete materials to explore the meaning, concepts, mathematical facts, patterns and understanding of the subject matter. Such activity helps the learner broaden their reasoning power and learning about them permanently.

iii. Make learning fun: The subject matter can be delivered effectively by making learning fun. Poor understanding of mathematics produces fears and unpleasant consequences [34]. Therefore, playing games with Dice, Dominoes, Ten-frames, etc. make learning fun and can also familiarize with the face of Dice, dot patterns of Dominoes and counting and number relations in Ten-frames, etc. By using such concrete materials help the learner to be familiar with dot patterns, counting and number relations.

iv. Visualize more: While teaching in the classroom, visualize the mathematics subject matter by using concrete materials if possible; otherwise, visualize by drawing diagrams to model the subject matter. The process of visualization in teaching mathematics helps the learner to grasp the subject matter effectively and is also helps to develop the learners' self-efficacy about the subject matter.

v. Make learning multi-sensory: Multi-sensory learning helps the learner to concentrate or involve more and actively in the learning process that makes learning more effective and practical. When the learners are involved actively in learning, they learn sincerely and more. Such learning retains for a long time. Thus multi-sensory learning helps the dyscalculic learner to learn difficult subject matter easily.

vi. Use collaborative learning: This learning approach can be implemented in different groups of students working together to solve the given problem or the task. In this approach, the students are given certain clues and encourage them collaboratively solving the problem. In this type of learning, the learners are actively engaged to learn and develop their understanding. It helps to motivate the learner and inspires them to engage and enjoy learning mathematics. Such learning also makes the learner positive in mathematics learning.

vii. Use modern technology: The use of Information Communication Technology (ICT) makes learning more effective as well as interactive. It can be employed to accelerate, enrich and deepen basic skills in reading, writing and arithmetic [34]. It enables the student to learn better by increasing their engagement in educational activities. It is used in the learning process which makes learning faster, easier and fun. It provides better opportunities for special needs children to play, enjoy and learn mathematics as fun. The use of technology helps the dyscalculic learner to learn mathematics in a fun and in interactive way and also motivates them for mathematics learning.

viii. Rapport building: The close relationship between students and the teacher is expected to develop a positive learning environment. It also helps the students to motivate in learning mathematics. The close relationship between students and teachers makes it easy for the students to ask questions to their teacher frequently whenever they feel difficulty in learning. These two ways of communication certainly help the students reduce their learning difficulty. In the same way, it can also help the teacher to address the students' difficulties instantly then and there.

ix. Use satellite learning approach: In this approach, the selected smart students who are good at mathematics are assigned to teach the other poor students in mathematics. Then those selected smart students are separately taught by the teacher in a small group and they are asked to teach the rest of the weak students in the class. The smart students teach their friends best to make them know/solve the given task. In this teaching approach, those poor students can be benefitted who could not ask questions to their teacher due to hesitation. It also inspires the weak students to learn mathematics and get more practiced and may feel relaxed learning with their friends.

x. Teach less but regular: In this teaching style, the subject matter is divided into small separable parts. Then the small part is taught regularly using different effective techniques. The learner feels more comfortable to learn the small part because the small part takes less time to teach and also easy to understand for students. When the students are taught a long lesson, it takes more time and the learners also feel bored and tired. Such a method can be used effectively in the lower classes and also used to teach the weak students. Similarly, most dyscalculic learners do not prefer to carry on the lengthy way of teaching or calculating strategies. In this context, shortcut ways can be used more effectively than others.

9. Student support

The student's support can help to promote their ability to process and understand information regarding mathematics for struggling children with dyscalculia. It can also assist them in conceptualizing and performing mathematical difficulties. It is essential to work with dyscalculic children both at home and at school to develop a positive attitude towards learning mathematics and provide additional support for learning mathematics effectively. Thus, the parents, as well as the teacher, should support the dyscalculic children to motivate them and overcome the particular difficult area of mathematics. The students supported by parents and teachers are accounted briefly as.

10. Student support from parent

The children spend comparatively more time at home than school and they feel closer to their parents than others at the age of primary stage. So every parent can help their children effectively in several ways who struggle with dyscalculia. Some of the supports that can be provided by the parents to their children are as follows:

i. Motivate your child about learning and learning mathematics by telling stories of success or myths.

ii. Provide plenty of time to your child for talking, playing and other funny works that the child likes to do.

iii. Provide counseling if the child is feeling depressed, anxious or discouraged. It helps to understand each other's feelings and needs.

iv. Listen to the child's interests and feeling serious and try to address them as far as possible.

v. Help your child with homework, other learning problems and timely manage the learning materials like bags, books, stationery and other materials.

vi. Help to manage the timetable for the child such as playing time, homework time, reading and writing, etc.

vii. Always acknowledge the child's struggles and praise their hard work and every success.

11. Student support from teacher

Children with dyscalculia need additional support and instruction at school and home due to poor working memory. The teacher can support the dyscalculic learner at school in the real classroom environment that is also the best place for children to deal with some of their difficulties. Such support can help the stressed children to make it easier and less stressful by creating a fun indoor and outdoor learning environment. The strategies and support in either way to help the children with dyscalculia will work well and also make them self-motivated and encourage. Some strategies to support the dyscalculic learner by the teacher are as follows:

i. Address child anxiety because the child struggling with mathematics often becomes anxious which makes them unable to concentrate on learning.

ii. Provide sufficient supportive tools for teaching and learning mathematics that can help the child to navigate difficult problems.

iii. Focus on mathematical games, puzzles and activities that can help to erase the particular misconceptions like mathematics is a difficult subject and help to revisit important topics regularly and develop interest and enjoyment in learning mathematics.

iv. Develop a positive mindset for the learner by providing encouragement, praise, and support to their every successful activity in the classroom.

v. Frequently revise the lesson and use real-life examples to make them easier to understand and more familiar.

vi. Use the technology to make teaching fun and interactive too. Use different applications, games and puzzles related to mathematics and get them to play.

vii. Use a step-by-step teaching approach so that the weak students in mathematics can understand easily. Provide continuous and extra support to the dyscalculic students.

viii. Provide maximum time for practicing the difficult areas of mathematics.

ix. Reduce homework; be realistic and do not overload the young child. Reduce homework-related tensions for both parent and child.

x. Always be cautious that learning disabilities affect families and vice-versa. So the students struggling with dyscalculia may affect themselves from their parents. Parental attitudes and parenting styles affect the children and their attitude towards learning. So the parents should be timely informed about their child's condition and progress and their responsibilities towards their child.

12. Conclusions

Dyscalculia is a specific learning disorder that influences the arithmetical abilities of children. Generally, dyscalculic children struggle to memorize number facts, understanding the logical steps needed to solve the mathematical problem. They also have difficulties in numerical calculations related to daily life. Thus the arithmetical deficits not only impact their achievement but also on other related fields beyond the class. Generally, mathematics is considered a difficult subject due to its abstract nature to all learners. Then the dyscalculic student should face more difficulty due to their weak number sense and poor reasoning towards mathematics. There are certain areas of difficulty in learning mathematics for the dyscalculic learner. In these areas, they cannot attempt in time due to the low basic mathematics fluency and reasoning. Teaching in such difficult areas of mathematics, the dyscalculic students should be provided with specialized instructions and dedicated time. Similarly, they should be cared for and well treated at school through providing classroom outside and inside learning environment. Likewise, the parents should also provide sufficient time at their home for doing homework, playing, or doing something. Thus, the efficiency of the dyscalculic students can be uplifted through utilizing effective pedagogical intervention strategies and creating a collaborative working environment.

Author details

Rajendra Kunwar
Tribhuvan University, Mahendra Ratna Multiple Campus, Ilam, Nepal

*Address all correspondence to: rajendrailam@gmail.com

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Chapter 14

Attention and Learning Disabilities

Audhild Løhre

Abstract

Impaired attention is known as a pervasive behaviour disturbance, with a negative influence on learning processes. Attention deficit is one of the main symptoms of Attention Deficits Hyperactive Disorder, ADHD. Further, impaired attention is often part of learning disorders in dyslexia and dyscalculia as well as in students with no medical diagnoses. In schools and higher education knowledge on attention and challenges caused by impaired attention, is typically scarce. Hence, this chapter aims to inform educational institutions by applying Mirsky's model of attention, discuss challenges of impaired attention, and point to intervention effects. The positive effects of real-life interventions comprising target shooting practice are explained by immediate neurofeedback combined with individual adaption and caring. Moreover, as previously hypothesised, the sequential order of behaviour at the shooting range may benefit students with impaired attention. The term concentration is frequently used in Norwegian schools and counselling services. A definition of concentration in natural situations is suggested, and possible overlaps between concentration and attention are discussed. The chapter opens for empirical and theoretical questions and hopes for more research on target shooting practice as well as on other educational programmes applying neurofeedback in the school context to investigate attention.

Keywords: impaired attention, pervasive behavioural disturbance, the Mirsky model of attention, enjoyment and concentration, individual adaption, mental and physical shielding, interventions, target shooting practice, neurofeedback, non-governmental organisation (NGO)

1. Introduction

An ordinary classroom, in an ordinary public school in Mid-Norway. The desks were nicely placed, one by one, for the seven-year-old students. At the first row by the window, there was a girl, whom I did not yet know. With books and pencils on her desk, like all students had. However, something appeared to be different. She took a box of grapes from her bag, placed it at the corner of her desk and started to eat. It must be added that the students were not allowed to eat in the middle of a lesson, but the teacher overlooked the situation. After the first grape, the girl spits the stones on the floor. One more grape, and again spitting stones, letting them fall beside her at the floor. She continued without being interrupted. Sitting there observing, I thought it was rather strange. This is one of the situations I remember very well from more than 20 years as a school psychologist. This girl, let us call her Martha, was later diagnosed with ADHD. I had the pleasure to follow Martha and her family for about 10 years until she left the municipality to attend other schools. Luckily, I met her again later.

Together with hyperactivity and impulsiveness, attention deficits are the main symptoms of ADHD [1]. Most empirical studies on impaired attention are related to young people diagnosed with ADHD. Further, interventions are typically evaluated in selected groups, like ADHD. However, in an ordinary classroom, a variety of reasons may lead to attention problems. It has been claimed [2] that there is a gap between neuropsychological knowledge on attention and clinical applications in schools. Thus, this chapter aims to illustrate how Mirsky's model of attention [3, 4] may be useful in educational institutions and further, I will add some information to inspire theoretical reflections as well as practical skills in schools.

First, I present a theoretical section on attention mainly based on Mirsky's model of attention [5], and thereafter, a section on attention, concentration, and learning difficulties, where the two concepts attention and concentration are discussed. Next, the chapter refers to relevant interventions and highlights possible differences between laboratory experiments with selected groups and real-life interventions with mixed groups. Because of promising results, one real-life intervention comprising target shooting practice is described in more detail. Towards the end, before the conclusion, I reflect on theoretical and practical implications.

2. Attention

Scientists have studied attention since research on 'reaction time' in mid-1800 [6], and theories have been developed according to scientific evidence available at the time. Mirsky and his colleagues [4] considered impaired attention to be one of the most pervasive and least understood behavioural disturbances (p. 109). So, how can we understand attention? Parasuraman [7] refers to attention as capacities or processes of how the organism becomes receptive to stimuli and how it may begin processing internal or external stimulation. During the last two decades, the fast development of new technologies like functional magnetic resonance imaging (fMRI) has shown neural circuity in large-scale brain networks. This tells us there is communication back and forth in active networks in the cortical and subcortical brain regions [6] and leads to a neuropsychological shift from suggesting attention located in specific areas in the brain to understanding attention organised in active brain networks [8]. The new findings support Mirsky's theory suggesting several components or elements of attention [5]. Further, and important to educational settings, Mirsky suggested that the components could be assessed by neuropsychological tests [4]. Below I will present the components, also denoted elements, together with practical examples. Actual tests are mentioned for the first two components. Others [5] have given a broader overview of actual tests related to each element.

The Encode element "refers to the ability to initially register information" including "immediate recall as well as the capacity for holding information briefly in mind while performing some action or cognitive operation upon it" ([5], p. 298). To test this component, one of Mirsky's suggestions was Wechsler's subtest *Digit Span*. In this sub-test, the administrator reads some numbers, and the student is supposed to repeat the numbers in forward or backward order. Concerning Martha, she performed rather badly at this subtest. As school psychologists, we sometimes experience that 14- to 16-year-old students manage at the mean level of children aged from 6 to 8. For students who otherwise have the normal or above capacity in abstract thinking and other cognitive processes, it is frustrating to fall behind in the lessons. It can be stressing not to capture what the teacher says in messages of several paragraphs, for instance in the lower grades; "When you come home, you must tell your parents to read this information, and return the book on Monday" or "pick up your math-book, go to page 13 and start at task number 9". Thus, deficits related to the Encode element may lead to learning difficulties in many subjects or specific subjects even though the student could have other cognitive capacities to intellectually understand and manage the tasks.

Another Mirsky component of special importance in schools is the *Focus/executive element*. Being able to focus is necessary for schoolwork, as it is in most circumstances in life. This component is about "the ability to allocate attentional resources on a specific task and to simultaneously screen out distracting peripheral stimuli" ([5], p. 299). Koziol et al. [5] continue by pointing to the importance of speed performance in this element: "Because 'focusing' could not be differentiated from the task demand of rapid response output, the term 'focus/execute' was coined to capture a more refined essence of this attentional component (…)." Some students with learning disabilities experience that it is very difficult to screen out distracting stimuli. If the student is unaware of deficits in screening out external stimuli, it is my experience that this may result in anger outbursts when there are more noise and disturbances than bearable. Behavioural problems can often be a challenge to teachers, and therefore, the teacher needs to know each student and remember that the limit for what is bearable differ among those in class. Mirsky suggested using the Wechsler *Digit Symbol* (*Coding*) and the *Symbol Search* subtests to measure the *Focus/executive element*. These two subtests include time limits for performance, and hence, students who are fast working may perform well enough although they have problems with screening out disturbing stimuli in the classroom.

Also, the next three components may be useful for teachers to recognise. First, the *Sustain element* referred by Koziol et al. [5] as "the capacity to maintain attention on some aspect of the environment for an appreciable interval of time for the purpose of successful task completion" (p. 298). It is a typical teacher experience that this capacity varies a lot among students in class. Some students complete their tasks easily whereas others have challenges, maybe because they are distracted, or the task is not engaging to them. For children and adolescents diagnosed with ADHD, it is typical to have problems related to this element. However, if the task is perceived as really engaging, some may sit for hours reading, playing, or drawing [9]. Further, the *Stability element* tells us how reliable a student is in attentional efforts in performing a task. Does the student typically put efforts into doing the task or does the efforts vary from time to time? The last component to mention is the *Shift element*. This component is about flexibility in changing from one idea or activity to another, defined by Mirsky as "the capacity to move from one salient aspect of the environment to another" ([5], p. 299). Many individuals with attention deficits have problems because of rigidity. It can be perceived as painful to do a change in what you have planned to do, and sometimes the person needs time to be able to agree in a change. For teachers, this is of course a challenge. Nevertheless, it is useful for people in educational settings to know the struggle that may go on in the head and body of students who have problems with the *Shift element* of attention.

Some of the elements of attention mentioned above may have blurred boundaries with other cognitive capacities. Mirsky recognised for instance that the Shift element could be seen as a feature of executive functions ([5], p. 299). 'Executive functions' refer to several mental processes that control and organise other mental processes [10] which are crucial for planning complex behaviours and adapting to the situation [11]. In considering attention, it may also be useful for teachers and other professionals to have features of memory in mind. 'Short term memory' is the simple temporary storage of information whereas 'working memory' implies a combination of storage and manipulation ([12], p. 4). At the same time, both short-term memory and working memory differ from the permanent storing of information, denoted 'long-term memory', where information can remain for the rest of our lives ([2], p. 183).

For professionals like psychologists and educators to understand possible reasons leading to learning difficulties, I consider it an advantage to know some aspects of attention. With such knowledge and insights, you have a better chance to be able to help children and adolescents with impaired attention.

3. Attention, concentration, and learning difficulties

Compared to the huge neuropsychological literature on attention, there has been far less interest among scientists on the term 'concentration'. Sometimes the two terms attention and concentration are used interchangeably, both orally and in text. However, they are not synonyms although there might be some overlap between the concepts. In the last couple of decades before the millennium, neuropsychologists, especially in Germany, discussed how to differentiate the concepts of attention and concentration [13]. Translated to English, concentration was suggested to be defined as the "ability to work quickly and accurately under conditions that normally make cognitive performance difficult" ([14], p. 9). At the end of this section, I will discuss whether this suggested definition is adequate and appropriate related to observed and perceived concentration in school lessons.

Below I present and reflect on research done in a school programme intending to increase students' concentration [15]. All 12 students aged 10–16, had harmful concentration problems, that hampered their learning. Each student, the parents, and the teacher had to agree on the student's participation in the programme. When we talked with the students in individual tape-recorded interviews, some of them initially told us their concentration was fine, but later in the interview, they detailed out how they lost their concentration when something took place at the other side of the classroom [16].

The in-depth work with the qualitative material gathered before the intervention programme started, enwidened my insight into students with so-called concentration problems. Half the students had an ADHD diagnosis, some had dyslexia or other diagnoses, and some had no medical diagnoses. None was diagnosed with dyscalculia, although most of the students had challenges in Mathematics and clearly expressed that they disliked the subject [9]. We can look at one citation where the student finds it difficult to cope with arithmetic: "Mathematics, I don't like maths because it is very difficult ... for instance some multiplication and division tasks. But I know how to do it." This student had the self-confidence that the knowledge was there, that he/she *was able* to solve the tasks, but all the same, division and multiplication stood out as challenging.

Regarding foreign language (English), only one student liked this subject, half the students disliked it, and two of those claimed it was because of dyslexia. Among the subjects, there was one favourite: Physical Education (P. E.). Eight students spontaneously said they loved P. E. and they argued it was because of activity: "It is activity, and we get to be outside."; "Because then I can move around and such things."

However, for me as a professional (psychologist, researcher, and lecturer in teacher education) the diversity in the students' likes and dislikes of subjects was interesting. For instance, a subject that one student might appreciate, another disliked and vice versa. The authors could not find any pattern related to subjects except the ratios mentioned above on Mathematics, foreign language, and P. E. On the other hand, we found an interesting pattern when we related perceived concentration with the theory of play [17, 18] and the theory of motivation; the situated expectancy-value theory [19]. There was a clear relationship between perceived concentration and enjoyment (like we find enjoyment in the theory of

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play as well as in intrinsic motivation). With higher enjoyment, the concentration was perceived as better, and when the student felt concentration was bad, the enjoyment was correspondingly low. The qualitative data indicated a high correlation, illustrated below in the previously published **Figure 1** [9].

What is special with this qualitative material? On one hand, the group is mixed, meaning that some students do not have medical diagnoses whereas others have one or more diagnoses. Both genders were included, seven boys and five girls, representing a relatively large age span from 10 to 16 years. Despite all those differences, we find the clear relationships presented in **Figure 1**. Another aspect I want to highlight from the empirical data is the importance of context versus content. Illustrated in **Figure 1**, we see that content is related to the whole range of concentration/enjoyment whereas the context was more important when the student had challenges with the tasks. To cope with those challenges, the empirical data showed both institutional strategies and personal strategies [9]. And worth noticing, all strategies were about shielding.

The institutional strategies are well known to educators. They included going to a separate room to work in small groups or individually with a teacher. Those students who told they had the opportunity to be alone with the teacher in some lessons or together with a few others, appreciated this situation. We found two reasons for their appreciation of the small room. First, they felt calmer because often there were many disturbances in the classroom, like one student said: "It is no problem if I sit by myself or together with only a few others. But if I sit in the classroom and there are many students talking I kind of become more interested in what they are doing." ([9], p. 91). This corresponds to the Focus/executive element in Mirsky's model of attention [5]. It was difficult for the students to screen

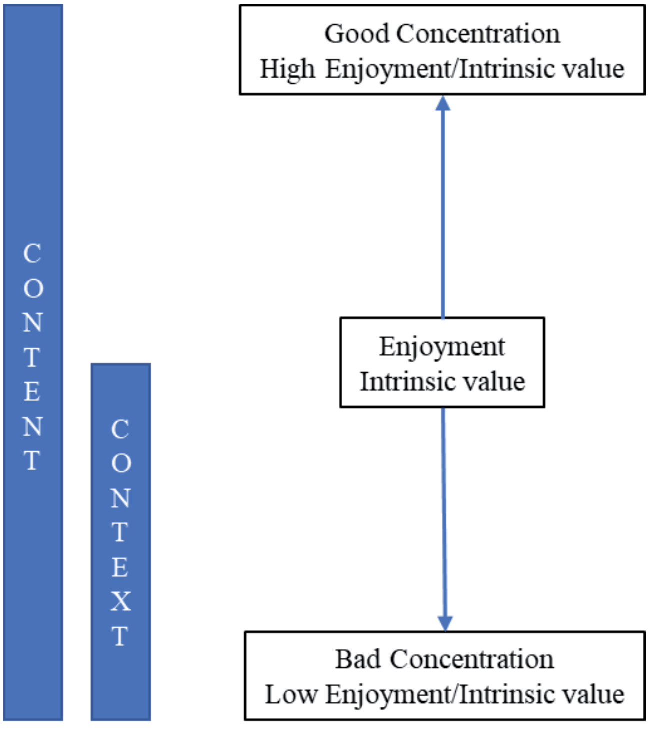

Figure 1.
The importance of content and context for concentration and enjoyment © Løhre, Vedul-Kjelsås, Østerlie ([9], p. 88).

out peripheral stimuli and simultaneously allocate attentional resources to their work. Additionally, the next reason was adapted help when needed, for instance in Mathematics. Municipalities and counties in Norway are obliged to offer special education to students considered to have this right [20]. However, it has for years been debated whether it is necessary to anchor special education as a right in the school laws. Some argue it is important to secure the rights of students with learning disabilities whereas others claim each school must support every student without binding resources to individuals [21, 22].

As we see, the institutional strategies included both mental and physical shielding. The personal strategies, on the other hand, were mostly some sort of mental shielding. Some students consciously paused from studying when they felt exhausted and unable to concentrate. Several of them started to draw or scribble and some raised to move around a little. The following citations ([9], p. 92) illustrate the students' autonomy in a shift of activities: "I cannot sit too long, then my concentration disappears, it does. Then I need to take pauses and such"; "[...] Oh, yeah, I need to have a little pause now and then."; "Then I take a few minutes off." Regarding this last citation, the interviewer asked what the student did in those "few minutes" and the student answered: "Draw a little. When I draw, I become quiet. My thoughts sort of disappear." The interviewer followed up the conversation and wondered if someone had suggested for the student to take pauses, upon which the student answered: "No, it's something I have found out for myself." The empirical data does not tell us if any of the other students' shifts in activities were agreed upon with the teacher, but obviously, teachers accepted.

From a professional point of view, I find the conscious shift in activities interesting. Like teachers who typically think students are daydreaming when they sit scrabbling on a paper and do not listen, I had thought the same when I was observing in classrooms. The finding of autonomous shifts was thought-provoking to me. I had often in my years as a school psychologist advised teachers to find ways to give a student pause when needed, for instance, leave the classroom to do something else, but it was new to me that impaired attention trigged some students to initiate pauses, almost to survive. Going back to Mirsky and the Encode Element [5], the exhausted student was not even able to register new information. In accordance with Danish findings [23], this shows us that classroom behaviour is not always what we think it is. The researcher who studied students with ADHD and their peers from a sociocultural perspective suggested that the behaviour and actions of students with ADHD often were intentional and led to interaction with peers in the classroom. Thinking of Martha, the little girl who introduces this chapter, I might have drawn the wrong conclusions the first time. I considered it obedient to eat grapes and spit stones on the floor. Perhaps she needed a mental pause. Talking with Martha thirty years or so later, she did not remember the grape episode, but reflecting around it she proposed the lesson might have been boring to her and therefore she started to eat the grapes.

Martha was a quick, smart girl and creative with a fabulous fantasy. She did the best to make her world funny. This is in line with what we found in the material with the 12 students [16]. Those with hyperactive behaviour often initiated something to have fun, and their high levels of activity were perceived as nurturing friendships. When the interviewer asked how friends would characterise him/her, one student answered: "hyper, funny and frisky" (p. 12). Concerning Martha, she did not have specific learning difficulties, no dyslexia or dyscalculia, but the impaired attention gave her challenges in learning. Hence, she did not go straight forward and finish an education. She needed more years than her peers.

At this point, I would like to go back to the earlier presented definition of concentration ([14], p. 9): "ability to work quickly and accurately under conditions that normally make cognitive performance difficult". We must keep in mind that the suggested definition was derived from experimental tests. For our purpose, we need to analyse the content, and therefore I divide it into parts:

1. ability
2. to work quickly and accurately
3. under conditions
4. that normally make cognitive performance difficult

I fully agree that ability (point 1) is necessary to be able to concentrate. This corresponds to Mirsky's model of attention [4]; you need the ability to succeed in the different components. In terms of the second point, I think you should not ask a student with impaired attention to work quickly and accurately. In my opinion, the student must be allowed to work in an individual tempo to avoid getting stressed. The empirical material cited above [9], showed that some students consciously paused from studying when they felt exhausted and unable to concentrate: "I cannot sit too long, then my concentration disappears […]."

The third point indicates *certain* conditions, *not all* conditions that we find in ordinary classrooms. The fourth and last point says those conditions are abnormal, as they normally make cognitive performance difficult. Surely, noise and movements might challenge concentration in classrooms, but this should not be the normal situation. Hence, the suggested definition above seems irrelevant to students with perceived concentration problems in school, although it might be valid in experimental test situations.

Concerning students with perceived concentration problems, our data, as well as field observations, indicate that both ability and effort are necessary to be able to concentrate. The term effort is what the person does and may comprise the person's energy and motivation to engage. Based on the knowledge and experiences presented above, I suggest the following definition of concentration: the ability and effort to apply cognitive resources to an object or topic of interest. As proposed by others [13], I think there are overlaps between attention and concentration. Furthermore, the definition indicates that concentration is a broader concept that may include other cognitive resources in addition to attention.

4. The impact of laboratory interventions

Although associations of attention with academic achievements have been explored in population studies, including mixed groups, in municipalities [24, 25], most intervention studies measure effects on attention in selected groups. Three recent reviews report intervention effects among children and adolescents diagnosed with ADHD. Two of them are quantitative and one is a literature review, and all applied rigorous inclusion criteria.

The literature review [26] explored 29 studies published before April 2016. The authors looked at the effects of physical activity on cognitive capacities. They divided the material into cardio activities, such as cycling or treadmill running, versus non-cardio activities, for instance yoga. The cardio activities showed some improvements on various outcomes whereas the results of non-cardio activities were questionable. In terms of attention in children, the results were inconclusive. Some studies reported no effects whereas others found significant effects.

One of the quantitative reviews [27] also studied the effects of physical activity. This review included nine of the same studies as the literature review [26] above. The meta-analysis of 20 studies demonstrated no significant effects on children's attention, and there were neither any effects on academic achievements nor disruptive behaviour. However, the analyses showed significant improvements for internalising problems. In general, the cardio activities with running and cycling (here denoted aerobic activities) benefitted the children more than relaxation training and yoga (denoted non- aerobic activities).

Exploring studies with cognitive outcomes in several types of non-pharmacological interventions, the second meta-analysis [28] is of special interest to discussions in Section 5. With rigorous inclusion criteria including objective neuropsychological outcomes, the analysis comprised 18 out of 854 records published in the period 1980–2017. The authors had two research questions. First, they asked which non-pharmaceutical intervention was most effective for ADHD's cognitive symptomology and secondly, they asked which cognitive symptoms were most amenable to change (p. 42). The analysis showed physical exercise (Morris d = .93) to be most effective. Thereafter, followed cognitive behaviour training (Morris d = .70), neurofeedback (Morris d = .61), and cognitive training (Morris d = .45). The different types of interventions were not assessed in relation to specific cognitive functions, due to the low number of interventions. The results answering the second research question demonstrated attention and working memory to be least amenable to change. The highest improvements were seen for inhibition, followed by flexibility and higher executive functions.

In addition to the main analyses, the review [28] presents an overview of studies that specifically assessed attention outcomes (p. 52). These studies altogether produced 14 effect sizes, showing an average Morris d = .41. Among the various types of interventions, neurofeedback turned out to be one of the types with the highest effect sizes. This is interesting related to the findings in target shooting practice, reported below. Lambez and colleagues [28] acknowledge that the results reported in the review were limited to laboratory tasks and therefore, they recommend in a closing-up message that interventions should be performed outside the laboratories.

5. Interventions with target shooting practice

In accordance with the recommendation from Lambez and colleagues [28], target shooting practice is conducted in real-life situations. As far as I know, we find target shooting practice integrated with public-school education only in two Scandinavian countries. Denmark was the first country to introduce this type of intervention for students with ADHD or ADHD-like symptoms. In the years 2012–2015, altogether 462 students were included in the FOKUS project [29] where instructors participated voluntarily. As both students and leaders reported positive experiences, further research was planned [30].

The Danish initiative soon spread to Norway, and in 2014, a public school in Mid-Norway started an educational programme for students with harmful concentration problems [15]. The programme is still running, and the selection of students is based on the agreement between the student, parents, and the school, assisted by professionals in the counselling services. Students are recruited from classes 5 to 10, corresponding to the age-group from 10 to 16 years. All training takes place outside the school area, in localities about five minutes' walk from the school, and consists of theoretical lessons as well as shooting exercises. Step by step throughout the school year, the theoretical lessons prepare the students to improve in the target shooting practice. The theory includes how to behave, how to treat the weapon, and

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how to breath to be able to focus on the target. And above all, security is highlighted. All instructors in the programme are certificated by the Norwegian Civilian Marksmanship Association (Det frivillige Skyttervesen, DFS), and both certificated teachers and certificated volunteers from the local club of the NGO organisation DFS participate.

At the shooting range, each student gets adapted help by one of the instructors, see **Figure 2**. Typically, the students appreciate the care and involvement they receive from the instructors. The young adolescents thrive and perceive mastery [15, 31].

Researchers at the NTNU Department of Teacher Education were hired to evaluate the implemented intervention. Data were gathered in the school year 2016/2017 and included questionnaires, individual interviews, observation at the shooting range, and objective neuropsychological tests [15]. Two qualitative publications on pre-data [9, 16], gathered before the seven months' intervention started, have already informed this chapter. Additionally, quantitative results have shown statistically significant improvements on neuropsychological tests [32]. To the best of our knowledge, those results are the first worldwide to show significantly improved attention after one school year of target shooting practice. Further, the improved attention corresponds to basic components in the Mirsky model of attention [5], indicating that the intervention made everyday life easier for the students. It must be added that controls showed no statistically significant improvements on the neuropsychological tests. Concerning the intervention students, qualitative post-data from individual interviews support the quantitative results [32]. Moreover, Danish results [33] have recently demonstrated increased differences between intervention students and controls on a couple of other cognitive tests, not included in our study.

Getting promising results after target shooting practice, urge us to analyse what can be possible active ingredients in the intervention. We have suggested [32] that immediate neurofeedback is one of the important ingredients. When the student shoots and the bullet reach the target, an electronic visualisation of the target, placed beside the student, immediately shows the result, see **Figure 3**. Supporting our suggestions, the importance of neurofeedback is shown in the review by Lambez and colleagues [28]. Otherwise, we think the whole package included in the intervention; theoretical lessons, and adapted help by caring instructors, contribute to the results.

Also of great interests, are qualitative Danish findings [34] that report inhibition of impulsiveness after two or more years with target shooting practice. Our preliminary findings [15] indicate the same. However, a one-year intervention is possibly too short to impact impulsiveness outside the shooting range. In accordance with the Danish

Figure 2.
Adapted help by the certificated instructor. Photo Trond Jære.

Figure 3.
Immediate response on electronic target. Photo Mona Isene.

findings [34], the Norwegian instructors underline that they see this sort of change in students who have participated in the programme for at least two years. Maybe the length of intervention time is one of the reasons why a review [27] found no effects of physical activity on disruptive behaviour. Except the length of intervention, another reason behind the promising Danish results [34] as well as the Norwegian instructors' experiences, maybe the theoretical lessons advising how to breathe and behave.

6. Implications for practice

I agree with Mirsky [4], who thirty years ago argued that impaired attention is a pervasive behavioural disturbance. Attention seems to be one of the ground pillars for learning. Having impaired attention the student will meet a lot of challenges, and so will parents and teachers. To help the student, there are two main roads to follow. One is to facilitate improved attention through interventions, and the other is to facilitate learning in the here and now situations.

The great variety among students with perceived concentration problems [9], points to the benefits of knowing each student. The teacher needs to know individual preferences and learn to understand signs of poor attention as well as individual signs of a student losing attention during work. This is of course a high-hanging star and aim to reach but anchored in the Norwegian school laws [20], school leaders and teachers must do their best to reach the aim.

Previous research [9] has shown the importance of enjoyment in subjects and tasks for students with perceived concentration problems. The better they enjoyed the subject, the better was their concentration, cf. **Figure 1**. Further, the students highlighted adapted help and shielding, in accordance with their preferences. It was obvious that students who were to be included in the target shooting programme, administered their pauses in class when perceived as necessary to calm down, like one of them said: "When I draw, I become quiet. My thoughts sort of disappear." This reminds me of the title: "ADHD attention deficit hyperactive disorder: an autobiography of survival" [35] and corresponds to autonomy as the suggested main force in motivation [36]. More autonomy could be given to students who struggle with impaired attention, – making agreements on self-regulated pauses and other individual learning strategies might create trust and strengthen the relationship between teacher and student.

At the first glance, ideas of student autonomy might seem to contradict previous recommendations [37] of structure and predictability for students with ADHD. Nevertheless, the two strategies can be combined, as exemplified in an ordinary public classroom [38]. Teachers make the frame and rules, and students fill the reserved time, for instance three hours, with self-chosen activities in the tempo and order they decide for themselves. Comprising the whole class, every child in class, is a great advantage of this educational programme, and as such, it is a health-promoting strategy aiming for thriving and wellbeing among all students. At the same time, there are some indications of better concentration for students with ADHD attending the programme [39].

For cognitive capacities in general, hard exercise has proved to be better than relaxing practices [26, 27]. Turning back to impaired attention, the theoretical and empirical knowledge we have to day points to specifically designed programmes to improve attention. Being recognised as one of the cognitive capacities most difficult to change [28], it is important to search for effective programmes. Interventions offering neurofeedback are among those with the most positive results [28]. In target shooting practice referred to above, immediate neurofeedback plays an essential role together with adapted help and caring. For countries that have target shooting sport in their communities, it might be an idea to initiate a partnership between local NGO shooting clubs, schools, and the municipality. The human resources found in the local shooting clubs in Denmark and Norway have provided valuable individual and adapted help at the shooting range, meaning a lot to young adolescents. Offering human resources, materials, and localities for free, the local NGO clubs additionally contribute to the school economy.

7. Further research and theoretical aspects

We have many challenges related to attention and impaired attention among students in educational institutions. First, the knowledge is scare on the impact of attention in different age groups. Next, we need to do more real-life interventions to investigate possible effects on attention. Further, more controlled longitudinal studies are needed to measure the effects of target shooting practice.

Although our research on target shooting practice is small-scaled, it has opened some windows into the understudied world of attention in students, and opening windows, gives room for new questions: Are our results on improved attention reliable? Will studies in other communities and other countries show corresponding results? What about the time span; is more than one school year of target shooting practice necessary to observe changes in the classroom? With higher numbers of students included, will possible differences between age groups and gender be uncovered?

Aiming to improve attention with neurofeedback seems promising. Thus, alternative interventions comprising neurofeedback should be developed, for instance with computer-based programmes in schools. Moreover, we need to expand the knowledge on autonomy and self-regulation in students with impaired attention.

In a paper reporting on results after target shooting practice [32], we hypothesised that the sequential order in shooting is beneficial to students with impaired attention. Hence, the role of sequential order must be further investigated, and if this point is crucial, it could be adopted to other educational situations. Furthermore, it is interesting in a theoretical perspective to study the impact of sequentially ordered activities versus activities based on simultaneous handling. Do persons with impaired attention prefer and succeed better in sequentially ordered activities?

The last theoretical question for me to present is about relationships between attention and concentration. Will the suggested definition of concentration be reliable in other settings and is it appropriate to see concentration as a broader concept than attention?

8. Conclusion

In this chapter, I have highlighted that more students than those diagnosed with ADHD have impaired attention. This may apply to students with other diagnoses like dyslexia, dyscalculia, or for example, undiagnosed or not well-medicated hypothyroidism that can occur in childhood or adolescence. Thus, we understand that many students in school and an ordinary classroom may have challenges due to impaired attention.

To help students with learning disabilities, it is beneficial to have knowledge on attention. One main goal of this chapter was to inform professionals in educational institutions by illustrating attention through Mirsky's model of attention. Insight into the different components of the model can support teachers to better understand academic achievements, behaviour, and emotional reactions in students with impaired attention, and thus, give foundations for individually adapted teaching. For instance, realising that an otherwise smart 15-year-old student register and recall information (c.f. the Encode element in Mirsky's model) at the mean level of students 8-year-old, can be thought-provoking for the teacher.

The term concentration is widely used by students and teachers in Norwegian schools. In our research, concentration was closely linked to enjoyment in schoolwork, despite great variations among the students in a heterogenous community group [9]. On the other hand, concentration did not seem to influence wellbeing or friendship [16]. The terms concentration and attention are sometimes used interchangeably, but they are not synonyms. I have suggested a definition of concentration for natural settings.

Further, the chapter presents interventions designed to improve cognitive capacities. Attention is found to be among the capacities least amendable to change [28]. Nevertheless, a seven month's intervention comprising target shooting practice demonstrated increased attention on objective tests, and the results were supported by qualitative data [32]. Reasons of the success may be related to immediate neurofeedback in a caring and educational context at the shooting range. The suggested effect of neurofeedback finds support in other studies [28]. Proposals for practical implications and further research are put forward.

In this text, my purpose was to write in a language understandable for professionals outside neuropsychological circles, and thus, reduce what is pointed to as a gap of knowledge [2] in the field of practice. Additionally, one goal has been to remind me and the reader about possibilities of turning impairment into success. *Just look back at Martha. Now she is about 40. She is well educated and recognised in her professional job. She has a lot of energy and gets things done. Her friends envy her energy*.

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Author details

Audhild Løhre
Department of Teacher Education, Norwegian University of Science and Technology, Trondheim, Norway

*Address all correspondence to: audhild.lohre@ntnu.no

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Chapter 15

Autism Spectrum Disorder (ASD): From Molecular Mechanism to Novel Therapeutic Approach

Hagit Friedman

Abstract

Autism spectrum disorder (ASD) is the joint name for neurodevelopmental impairments characterized by abnormal social interaction, communication difficulties, limited range of activities and areas of interest, and typical motor impairments. There is a remarkable increase in the prevalence of ASD over the past 30 years. Studies indicate that genetic, neurological, and environmental factors are involved in the emergence of ASD, and recent works describe the neuromolecular mechanism implicated in the basis of ASD. 3LT has now developed into a therapeutic procedure that is used for three main goals: to reduce inflammation, edema, and chronic orthopedic disorders; to promote healing of wounds, deeper tissues, and nerves; and to treat neurological injuries and pain. 3LT may treat neurological injuries by lowering levels of inflammation proteins and by stimulation of mitochondria to increase the production of adenosine triphosphate and neural growth factors. This review aims to discuss the current evidence for the effects and mechanisms of 3LT at the cellular level and the effects of 3LT-induced changes in brain development and function. Early and effective intervention, through the developmental time window of high ASD susceptibility, using tools that are directed to the mechanism of pathology, may minimize neurological and functional deficits.

Keywords: brain development, brain injury, ASD, autism, 3LT, low-level laser therapy, mitochondria

1. Introduction

Autism spectrum disorder (ASD) displays early in child development, during the time of human synapse formation and maturation [1], and usually results in long-term difficulties in social, communicational, emotional, adaptive, and cognitive functions [2]. The frequency of ASD occurrence continues to rise—from 1:110 in 2006 to 1:54 in 2016 [3], with at least one diagnosed coexisting neurodevelopmental disorder in most of the children [4]. Early diagnosis and treatment are very important as they may minimize neural injury and functional difficulty.

As ASD is still diagnosed only by behavioral criteria, it has been difficult to connect the numerous neurophysiologic findings to the clinical characteristics of ASD and to draw the mechanism and etiology of ASD [5]. This would allow an accurate treatment, directed to the mechanism of injury, with the best chance to make a change in the impaired developmental route.

The search for ASD brain mechanism may be reviewed from the neural circuit to the molecules and organelles involved.

In the late nineties of the twentieth century, a laboratory in Italy first documented neural activity from brain cycles, later named "Mirror Neurons" [6]. The innovation in its discovery was that it connected fields of neural control that were considered separate—motor and vision, that is, the same specific neuron cycles work both when a person does something and when he or she watches another person perform the same action, making an instant translation from visual to motor control [7]. This act of neural translation is considered the basis of the human ability to imitate, to anticipate others' goals, and to empathize others' pain or misery [8–11].

"Mirror Neurons" brain cycles showed altered activity in children with ASD, hinting that they are involved in the mechanism of ASD [12–14].

The scientific findings about mirror neurons and the possibility that their development may be related to the time window of temporary subcortical plate neurons (connecting thalamic and future cortical cycles) are indeed amazing [15]. But the mechanistic discussion in the level of neural cycle leaves many open questions—what may cause damaging alterations in these brain cycles? What cellular and molecular components are involved, and how can we target the therapeutic process to them?

Loss of synaptic stability and plasticity, or dysregulation of activity-dependent signaling networks that control synapse development, function, and plasticity, may cause injuries in neuronal circuits and contribute significantly to brain diseases, including ASD pathogenesis [16, 17].

Hence, alterations in synapse function, synaptic molecules, receptors, and neurotransmitters have been targets to research about the mechanism of ASD syndrome for the last 20 years. Studies showed that alterations in Glutamate receptors and enhanced GABA receptor–mediated inhibitory synaptic transmission are involved in ASD [18–20]. There may be various causes involved in psychiatric and neurologic diseases, including ASD—genetics, drug use, neurodegeneration, viral infections, and more. However, dysfunction of neuronal synaptic communication is almost always the underlying cellular mechanism. Epigenetic changes in synaptic genes encoding for synaptic adhesion molecules (neurexin, neuroligin, and N-cadherin) and for PSD proteins (i.e., Shank1, Shank3, and more) are involved in neuropsychiatric disorders including ASD, causing alterations in synaptic transmission [16, 21–25]. Studies have found that failure of the cellular machinery in pathways upstream of the synapse leads to synaptic dysfunction and neuropsychiatric characteristics. In addition, small non-coding microRNAs that repress the translation of target mRNAs seem to be important pathophysiologic mechanisms for neurologic and psychiatric diseases, and abnormal regulation of protein turnover, chromatin remodeling, and genomic imprinting may lead to synapse pathology. In some neuropsychiatric disorders, the basic neurobiological mechanisms underlying the symptoms are simple and easily solved, but the model of loss of function of a single gene or a limited number of genes is not suitable for most neuropsychiatric disorders, which are etiologically heterogeneous and complex and likely determined by the combination of variants/defects in multiple genes. For example, genome-wide association studies identified polymorphic variants in genes encoding synaptic proteins as important determinants of the risk of developing ASD [26–28].

2. Molecular mechanistic common denominator involved in ASD etiology

Multiple studies show that a mitochondrial disease or abnormality is involved in the etiology of ASD [29, 30] affecting about 80% of the children with ASD.

Mitochondria are the "cell powerplants," being responsible for most of cell energy production. Sufficient energy is required for everyday vitality and for brain survival and function. Brain cells need a lot of energy to function. Apart from energy production, mitochondria participate in the cellular metabolic processes of iron and the balance of calcium. The mitochondria are associated with normal and abnormal cell proliferation and participate in programed cell death. Each cell has hundreds to tens of thousands of mitochondria, depending on the role and energy consumption of that cell. Mitochondria are inherited only from the mother, through the ovum. They can develop mutations as they multiply and lack almost any repair mechanisms. Most of the proteins that make up mitochondria are encoded in the nucleus. Only 13 proteins are encoded by the circular mitochondrial genome.

As the mitochondria are inherited from the mother, hence, we do not have a "backup" from the father's genome when mutations or damage occurs. But since the ovum contains a lot of mitochondria to start with, some may be damaged without any clinical manifestations. Mitochondrial damage may be manifested over the generations; when the grandmother had a few damaged mitochondria, the mother happened to develop from an ovum with a greater concentration of damaged mitochondria, and her son already has very few normal mitochondria. A problem is revealed in such cases. A damage to mitochondria may be caused not only by maternal inheritance, when cells divide to form the fetus, but also by a coding error called "de novo mutation" (a new mutation in fetal cells or in mitochondria), due to environmental / epigenetic influence. Hence, when a diet contains fewer carbs, there is an increase in the number of mitochondria in liver and large muscle cells.

Mitochondrial abnormalities include either decreased [29, 31, 32] or increased [33–36] mitochondrial function; depending on the cause and developmental time window, they may lead to neurodevelopmental regression [30, 37–42] and the typical comorbidities of ASD (i.e., gastrointestinal problems, seizures, tiredness, and sensory dysregulation) [30, 43, 44]. The first findings, leading to this conclusion go back to the eighties of the twentieth century [45], reconfirmed about 20 years later [46] and continue with studies that examine the biomarkers of mitochondrial dysfunction [30, 47]. Neurodevelopmental regression, as typically described for many children with ASD, may be the hallmark of a mitochondrial disorder and abnormal mitochondrial physiology in ASD [38, 39].

As mitochondrial function is highly influenced by environmental factors, these findings connect mitochondrial dysfunction in ASD with environmental hazards [29, 30].

3. Therapeutic approaches

Since ASD was first defined, numerous treatments have been employed, with partial/sporadic mechanistic justification. Most of the treatment approaches target behavioral abnormalities of children with ASD and aim to improve the social and communicational function of the patient [48–50].

The website of the American Association of Communication Clinicians describes 30 common treatment programs for children with autism, divided into seven classes; however, parents cannot be given definite treatment recommendations, because of the heterogenous characteristics of children with ASD and because many therapies have not yet been investigated in a controlled and satisfactory manner.

In November 2020, the Australian governmental CRC top organization published a 502-page document written by 12 scientists. The paper is a meta-analysis based on 58 review articles analyzing more than a thousand research articles that examined the effectiveness of 111 different autism therapy programs [51].

The authors sorted the programs into nine categories (cognitive, behavioral, educational, developmental, animal assisted, sensory-based, naturalistic, technology-based, others). The review showed that intensive behavioral programs achieved good results, but the results were focused on specific goals in which the child has been practiced; only some of the developmental plans showed improvement, mainly programs that included parental involvement; only one sensory program has achieved clear results of reducing stimulation and improving learning habits and participation in the community; music therapy helped interpersonal communication and improved mental well-being in the family; various computer applications have improved cognitive ability but not mutual communication; alternative supportive communication programs have resulted in good results in communication, motor behavior, game levels, and learning ability. The authors note that in each category, only a very small number of studies were made in a controlled and satisfactory manner, meaning that the results should be treated with caution.

Altogether, children with autism spectrum disorders can be treated in a way that will lead to functional and communicational improvement, using various therapeutic approaches. These treatment plans are tailored to the unique behavioral profile of each child and each family at each point in time throughout their life journey with autism. However, as these treatments focus on external behavioral symptoms, and not on the internal mechanism, they aim at functional improvement and not actual repair of neurological damage. Hence, according to this approach, autism is not a "curable injury" but a developmental disorder whose treatment helps patients develop functional skills, improve communication skills, and rely on their strengths despite the disorder that will always remain a part of their lives.

Should we be satisfied with the important achievements of symptom-oriented therapeutic approach, or perhaps a persistent search into mechanistic questions may lead to a mechanism-oriented therapeutic approach?

Few therapeutic approaches for mitochondrial disorders were examined in clinical studies in children with ASD. These include cofactor supplementation and ketogenic diet. Nutritional supplements aimed to support the mitochondria, redox, and folate pathways, and contained L-carnitine, coenzyme Q10, and additional factors. They improved mitochondrial function and ASD symptoms [52–57], However, discontinuation of the supplement treatment caused worsening of the ASD behavior in children [31, 58].

Ketogenic diet has been studied for ASD, resulting in a mild-to-moderate improvement with 58% of the children who tolerated the 3-month diet [59–61]. In one out of three studies, worsening outcomes were observed. In the studies that used biomarkers to better understand the physiology of the ketogenic diet, an increase in chromium and creatine and a decrease in ornithine, acetoacetate, cesium, and N-acetylserotonin across the treatment period correlated with better outcomes [60, 61]. In addition, the ketogenic diet improved sociability and repetitive behaviors in two environmentally induced mice models of ASD [62–64]. With these results, the ketogenic diet needs more study for its use in children with ASD. In addition, the important limitation of the ketogenic diet is the child's ability to tolerate the diet, as dietary therapies are difficult to implement with children. For other dietary treatments, outcomes are related to the ability of the family to implement the diet adequately [65], and if it is impossible for the family to apply the diet properly, the expected outcome may not be achievable and other therapeutic options may be a better choice.

4. Low-level laser therapy (3LT)

Alternative medicine has become vastly used for managing health problems and developmental injuries in the modern western world, consisting of various approaches stemming from traditional medicine combined with modern empirical techniques [66, 67].

Acupuncture and auricular therapy have been employed all over the world for the treatment of chronic and acute medical situations [68–71], for coping with pain in elderly [72, 73] and children [74–78]. For example, it was found that acupuncture increases the secretion of the natural neuromodulator adenosine, also known as anti-inflammatory and pain relief substance [79].

Lasers (light amplification by stimulated emission of radiation) are devices that generate electromagnetic radiation, which are uniform in wavelength, phase, and polarization. Low-level laser (3 L) is a special type of laser that affects biologic systems through nonthermal means [80, 81]. Low-level laser therapy (3LT) is the application of red and NIR (near infrared) light over injuries or lesions to improve wound and soft-tissue healing, reduce inflammation, and give relief for both acute and chronic pain (analgesia) [82–84].

3LT applies a therapeutic laser for the excitation of specific acupuncture points. This technique is considered nonintrusive, safe, and painless [85] and became an important tool for the treatment of patients at risk, such as premature neonates [86–92]. For example, excitation of specific pain acupuncture points using 3LT creates a local photochemical effect [93] that causes specific changes in neuronal brain activity [94, 95], apprehended by the patient as reduction in pain severity. These changes can be measured and quantified by imaging [96, 97].

3LT has a photochemical effect, meaning that when the correct parameters are employed (intensity and location), red or NIR light reduces tissue oxidative stress and increases ATP levels [98–101]. This improves cell metabolism and reduces inflammation. In addition, 3LT was proven to increase nociceptive threshold by altering the axonal flow [102] and elevate opioid-receptor binding [103] and endorphin production [104].

In the clinic, 3LT was found to cause an immediate decrease in acute and chronic pain and an increase in function [102, 105–107]. 3LT showed promising results for myocardial infraction [108], rejuvenating mesenchymal stem cells [109], skin injuries [110–113], brain trauma, TBI [114–116], diabetic retinopathy [117], oncology [118], and more.

3LT is a technique of noninvasive stimulation of which the irradiation of specific infrared wavelengths can penetrate the body [119]. These effects produce various biological responses, such as enhancing the formation of adenosine triphosphate (ATP), deoxyribonucleic acid (DNA), and ribonucleic acid (RNA); releasing nitric oxide (NO) and cytochrome c oxidase (CCO); regulating reactive oxygen species (ROS); and altering intracellular organelle membrane activity, mainly in mitochondria, calcium flux, and stress proteins [66, 120–124]. 3LT produces a shift toward higher oxidation in the overall cell redox potential [125] and briefly increases the level of ROS [111, 126]. This change in the redox state of the mitochondria regulates several transcription factors [127]. These include redox factor-1 (Ref-1), cAMP response element (CREB), activator protein 1 (AP-1), p53, nuclear factor kappa B (NFjB), hypoxia-inducible factor (HIF-1), and HIF-like factor [127]. The activation and regulation of redox-sensitive genes and transcription factors are thought to be caused by ROS induced from 3LT [126]. In turn, both ATP levels and blood flow increase, improving oxygenation found in damaged areas of the brain [127].

5. Therapeutic potential

A wide range of seemingly unrelated disorders, such as schizophrenia, bipolar disease, dementia, Alzheimer's disease, epilepsy, migraine headaches, strokes, neuropathic pain, CP, TBI, diabetic retinopathy, Parkinson's disease, ataxia, transient ischemic attack, cardiomyopathy, coronary artery disease, chronic fatigue syndrome, fibromyalgia, and SARS-CoV-2, have underlying pathophysiological mechanisms in common, namely reactive oxygen species (ROS) production and the accumulation of mitochondrial DNA (mtDNA) damage, resulting in mitochondrial dysfunction [114, 128–130].

3LT has been long recognized as an efficient therapeutic tool for brain injuries. Recent deciphering of the role of mitochondria in ASD etiology and in the 3LT therapeutic process gives us a great opportunity to improve mitochondria function and brain neural development, using suitable parameters of 3LT energy on specific ear and body locations.

Author details

Hagit Friedman[1,2]

1 Simaney-Derech Clinic, Zichron-Yaakov, Israel

2 Haifa University, Haifa, Israel

*Address all correspondence to: drhagitfriedman@gmail.com

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Section 4

Treatment Strategies

Chapter 16

Evidence Based Reading Strategies for Struggling Readers with Learning Disabilities and Emotional Disorders

Argnue Chitiyo

Abstract

Students with learning disabilities often exhibit academic and functional skills challenges that include limited ability to read, write, listen, speak, or complete other academic or functional tasks. A large proportion of children with LD are also at increased risks for emotional or behavioral problems. When LDs are not properly addressed, children with LD may begin to exhibit behavioral challenges that may further impede their academic performance. One of the key areas of deficit in academic performance among children with LD lies in reading. Research shows that students with EBD or LD perform approximately 2.2 grades below standard performance in reading. Part of the reason for their reading deficits is attributed to proliferation of instructional methods that are not backed by empirical evidence. In order to address this reading performance-gap, there is a need to examine closely what instructional practices are effective and under what circumstances. This chapter examines some commonly used reading interventions for this group of students with EBD and establishes the evidence supporting their effectiveness. Recommendations for future practice are suggested.

Keywords: Emotional Disorder, Behavior disorder, Learning Disability, Reading, Evidence Based Practice

1. Introduction

The population of students aged 3–2 with learning disabilities (LD) in USA was approximately 33% of the total number of students receiving special education services under IDEA as of 2019/20 [1]. As a result, LD has been considered the most common disability category among individuals aged 3–21. Learning disability constitutes a group of brain disorders that affect a broad range of academic and functional skills including the ability to read, write, listen, speak, reason, or complete mathematical tasks [2]. Although there is a technical definition for LD [3], LD are not identical across all individuals. Instead, the types of LD vary from individual to individual [4]. For example, while one child with a LD may struggle with reading and spellings, another child may love reading but struggle with math. Some children may struggle with understanding communication, whereas others struggle with organization. In other individuals, LD may exist as specific difficulties involving coordination, self-control, or attention. Such difficulties extend to schoolwork and can impede learning to read, write, or do math.

According to research, some categories of LD can appear more common in certain age ranges compared to others. For examples, signs and symptoms that are typically common among preschool children include problems pronouncing words, trouble finding the right word, difficulty rhyming, trouble learning the alphabet, numbers, colors, shapes, days of the week, difficulty following directions or learning routines, difficulty controlling crayons, pencils, and scissors, or coloring within the lines, and trouble with buttons, zippers, snaps, learning to tie shoes [4]. Among ages 5–9, the most common signs and symptoms include trouble learning the connection between letters and sounds, inability to blend sounds to make words, confusing basic words when reading, slow to learn new skills, consistently misspelling words and making frequent errors, trouble learning basic math concepts, and difficulty telling time and remembering sequences [4]. Finally, signs and symptoms common to students aged between 10 and 13 include difficulty with reading comprehension or math skills, trouble with open-ended test questions and word problems, dislike of reading and writing, poor handwriting, poor organizational skills, trouble following classroom discussions and expressing thoughts aloud [4].

LD can affect an individual's quality of life. Research shows that approximately 75% of students with LD exhibit social skills deficits that distinguish them from their non-LD peers [5, 6]. Some studies have reported high unemployment rates among adults with LD [7–9], low literacy and adult adjustment to economic issues [10], and social and emotional problems in adult life [11, 12].

2. Connection between LD and EBD

Learning disability and emotional disorders have been observed to potentially co-occur or interconnect [8, 13, 14]. According to the Learning Disabilities Association of America, most children with LD usually have comorbid conditions, most of which include behavioral/emotional issues and ADHD [8]. If LDs are not properly addressed at younger ages, they can develop into behavioral disorders when the children grow into adolescents [14]. Sections of prior research also show that some children with LD often exhibit challenges associated with creating and maintaining social relationships [15, 16]. This is usually a result of processing problems which make it difficult for children with LD to pick up social cues. Other related emotional problems common in children with LD include poor concentration, attention deficit, lack of social interactions and self-confidence, and emotional distractions among others [17]. Another earlier study [18] indicated several learning and behavioral characteristics commonly occurring in children with LD, which include attention disorders, social skills deficits, psychological processing deficits, and information processing problems. Smith et al. [19] asserted that several characteristics of LD often create challenges associated with social and emotional regulation. Other sections of previous research have also reported higher than normal rates of behavioral problems among children with LD [20]. Given the connection between LD and EBD, some interventions designed for students with EBD may often be effective to address academic and functional skills deficits across students with LD.

3. Reading challenges in LD

One of the key areas of deficit in academic performance among children with LD lies in reading. Research shows that a large proportion of learning disabilities are often associated with reading deficits [21]. When LD interconnects with behavioral disorders, students perform approximately 2.2 grades below standard performance in reading [22]. Reading skills deficits among children with LD present several problems in other areas including poor performance in other subjects, lower academic grades, behavioral problems, and inattention [8]. Worse more, poor reading outcomes have been shown to be associated with numerous lifelong problems including high school dropout, juvenile delinquency, and high probability to enter juvenile justice system [23].

There are two types of reading deficits in LD, basic reading problems and reading comprehension problems [24]. Basic reading problems occur when students have a difficulty understanding the relationship between sounds, letters, and words [24]. The basic reading problems are generally considered the elementary reading skills that are an essential pre-requisite for students to be able to develop higher order reading skills like comprehension. Reading comprehension problems occur when students are unable to understand the meaning of words, phrases, and paragraphs [4]. Reading comprehension is more complex as it involves a lot more "cognitive and linguistic skills" [25]. Overall, signs of reading difficulty include problems with letter and word recognition understanding words and ideas reading speed and fluency general vocabulary skills [4].

In LD, reading problems are considered to be the most common learning deficit more than any other area of academic performance, yet the skills are so fundamental that they affect other learning areas [26]. The National Reading Panel Report Reading identifies 5 areas essential to effective early reading, which are phonemic awareness, phonics, fluency, vocabulary, and comprehension [27]. Students with learning disabilities in reading generally show severe deficits in the 5 areas as shown by poor phonemic awareness, challenges in learning phonics and decoding words, and struggles to comprehend written materials due to language processing deficits [28].

Decoding constitutes the most elementary reading skill that emergent learners need to acquire before they can begin to work on fluency. The skill consists of a set of sub skills that include word recognition, word identification, word attack, and sight word recognition. Emergent readers rely on decoding skills to read text until they build sight word vocabulary, or words they can remember without decoding. The ability to decode depends on several sub skills related to sound/symbol relationships embedded in phonics. Decoding is particularly important in predicting early learners' future skills in reading comprehension and other complex reading skills. Previous studies show that early coding skills are associated with improved and wider reading habits in and out of school [29]. On the other hand, children that struggle with decoding early on usually tend to worsen in reading skills in later grades [30].

Oral reading fluency. Early readers rely on good decoding skills and sight word vocabulary in order to become fluent readers. Emergent readers who are beginning to learn and apply decoding skills may have very limited fluency. When students lack fluency, it implies that they are not yet reading with confidence and may still be struggling with decoding some of the text. Fluency is more likely to build as new readers become more aware of advanced phonemic skills like deleting, substituting, and reversing phonemes. In some cases, students may be familiar with many sight words but find it difficult to read fluently, for example, they may read in a choppy, word-by-word manner. In cases like these, such students may have speech or language processing issues that prevent them from becoming fluent readers. In other cases, text may be too challenging, or the reader may not be getting enough practice to build confidence, thereby making it difficult for them to develop fluency. Common fluency problems include omissions, substitution, mispronunciation of words, hesitation, and inversion.

Reading comprehension deficit entails a difficulty understanding the meaning of text read (e.g., the sequence, relationships, inferences, or deeper meaning of text). Whilst many students develop elementary phonemic awareness skills, a substantial number of students with LD will face difficulties developing comprehension skills. Reading comprehension is particularly complex as it requires the coordination of "multiple levels of language and cognitive functioning" ([31], p. 2). Children with LD think, process, and understand information differently from other students. Reading comprehension skills deficits in children with LD are often compounded by several factors that include lack of vocabulary or understanding of words, inability to connect ideas in the text to larger issues, difficulties recalling basic facts, difficulties recalling sequency low attention or concentration issues while reading, and a challenge in determining important ideas in text.

4. Evidence based strategies

In order to address reading deficits in students with LD, there has been an increased emphasis to adopt evidence-based instructional practices that are supported by strong empirical evidence. Part of prior research on this topic indicated the existence of practices that are either ineffective or are not empirically demonstrated to be effective [32, 33]. Furthermore, prior research indicates some obstacles associated with finding evidence-based practices by teachers [34]. For instance, lack of trust of research in preference for personal experience by teachers tends to lead teacher to rely more on practices they perceive to be effective as opposed to research based. Sometimes, teachers' personal beliefs and feelings of self-efficacy tend to result in them picking up practices that they perceive to be effective even if they are not backed by data.

Evidence based instructional practices are characterized by four elements of focus, namely experimental research, high quality methodological rigor, more supporting studies, and demonstrated quantitative effects [35]. Regarding experimental designs, the expectation is for an instructional approach to be supported by empirical studies conducted using experimental designs that demonstrate a clear functional relationship between interventions and target outcomes. In educational research, these include group or single case designs. Group designs are typically considered the gold standard in education and other fields and have traditionally been used in majority of experimental research in social science. Although these methods have been demonstrated to be effective, they tend to mask individual differences among individual participants. The nature of populations in special education particularly makes it difficult to entirely rely on group designs. Single case designs on the other hand evaluate the effectiveness of an intervention on a single unit of analysis. The single subject acts as both the control and experimental unit, with pre-treatment scores serving as baseline and intervention scores functioning as the posttest scores.

The second factor considered in identifying EBP is the quality of research supporting a practice [35]. Essentially, research quality is targeted at ensuring validity of research findings [36]. In order for a study to be valid, researchers must control for potential threats to validity to the greatest extent possible (e.g., history, maturation, statistical regression, selection, experimental mortality; [37]). Researchers using SCDs and group designs take measures to control for extraneous variables that either correlate with independent variables of interest in influencing the outcome variables, or influence both independent and dependent variables in a manner that makes it difficult to ascertain the nature of relationship between the variables of interest [36]. Failure to control for extraneous variables can result in biased outcomes, whose findings cannot be applied to participants (i.e., lacking internal validity) or non-participants (i.e., lacking external validity; [38]).

Quantity of studies supporting an instructional practice must be sufficient enough to ensure that findings are generalizable to populations not included in the primary studies [35]. Studies conducted in a single environment, with the sample of participants drawn from a single population limit the chances that findings are generalizable to non-participants. More studies investigating a single intervention, conducted at different times, in different places, and with different participants therefore increase the possibility of findings being applicable to individuals who did not participate in the studies [39]. Finally, EBP further requires that researchers demonstrate, in quantitative terms, the magnitude of effect of the researched interventions [35]. More specifically, researchers use statistical methods to assess the changes in outcomes of interest that are a result of interventions. In educational research, meta-analyses are typically used to synthesize quantitative effects of interventions across multiple studies. In order to determine the EBP recommended in this chapter, we conducted a meta-analysis study which also examined the methodological rigor of the primary studies on reading interventions for EBD [40].

5. Evidence based reading strategies for LD and EBD

Phonological awareness constitutes the most basic or elementary skill in reading. It involves the detection and manipulation of sound. It is regarded one of the strongest predictors for a child's future reading success [41, 42]. Phonological awareness creates the skills to segment and blend words together to produce reading and spelling. Children with weak phonologic awareness skills are likely to struggle to read and write properly [42]. All other future reading skills like fluency, comprehension, and vocabulary build from an initial set of these important skills.

As indicated before, children with LD typically struggle to develop the basic phonological skills. However, previous research has demonstrated some potentially effective strategies for teaching phonemic awareness. The Phonological Awareness Training for Reading (PATR; [43]) is an early reading curriculum program which is designed to teach students sound structures. The program is divided into four phases which include warm up, sound blending, sound segmentation, and reading and spelling. The four phases are organized strategically to build the reading skills from learning sounds, blending the sounds, segmenting the words to make meaningful words, and subsequently to present the phonemes in words and apply to reading and spelling. Several studies have examined the efficacy of PATR in improving phonological skills and subsequent academic improvements in behavioral and social domains (e.g., [44–47]). The studies listed were examined for methodological rigor using the Council for Exceptional Children Quality standards (i.e., CEC: [39]). Across the studies, researchers found significant improvements in academic, social, and behavioral outcomes. For example, Lane et al. [46] reported significant improvement in reading fluency measures indicated in the DIBLES and reduction in total disruptive behaviors, negative social interactions. Other studies have been reported to have found positive effects of PATR on phonological awareness across populations with LD (e.g., [48, 49]).

Corrective reading is a direct instruction remedial reading program that is designed to teach a wide range of reading skills among struggling readers. It involves creating step-by-step lessons focusing on two main domains which are decoding and comprehension [50]. Each of the two domains have four sequential levels of instruction that focus on teaching foundational skills for non-readers to 7th grade-level materials. When used in decoding instruction, corrective instruction targets to address core reading deficits like word identification errors, addition and omission of words, erratic grasp of grapheme and phoneme relationships, and poor comprehension. Reading challenges associated with comprehension include inability to follow multi -steps directions, poor auditory memory and statement repetition, poor analytical skills, and deficient vocabulary [51]. This manual specifies the corrective reading strategies that are tailor made for decoding skills across three levels of decoding (word attacks, decoding strategies, and skills applications) and comprehension (thinking basics, comprehension skills, and concept applications).

When examined for literacy skills for adolescent readers, literature shows some mixed findings regarding the efficacy of corrective reading for this group of students. A synthesis of literature by the What Works Clearing House indicated a lack of evidence regarding the efficacy of corrective reading for struggling adolescent readers [38, 52]. When examined for methodological rigor using the WWC evidence standards, several studies on corrective reading were found lacking in evidence due to failure to address the WWC standards (See [38, 52]). However, a recent review of literature analyzing the methodological rigor of primary studies on reading interventions for students with EBD using the CEC quality indicators showed that corrective reading was supported as an effective instructional practice across at least 4 single case design studies and 2 group experimental studies [40]. All across, the strategy was observed to close the reading achievement gap for students with EBD. Corrective reading intervention strategy has also been identified as a tier 3 EBP ideal for the learning needs of students who are most at risk or who fail to respond to tier 2 instructional methods [53]. The publisher for corrective reading instructional programs list various formats of the program that are tailored for different grades and content areas (see [53]).

Concept mapping strategies consist of creation of visual organizers of elements in reading texts, the aim for which is to help readers organize new information and make meaningful connections between ideas in a text. Ideally, concept maps target reading comprehension skills. Commonly used strategies for teaching concept mapping include modeling the identification of ideas or concepts in a text, organizing ideas into categories of similar or related information, or using lines and arrow to indicate connections in ideas [54]. Other methods of concept mapping that have been investigated include the use of graphic organizers [55–57]. A meta-analysis examining the efficacy of graphic organizers among students in grades 4–12 identified with LD indicated reported increases in various literacy areas including vocabulary, comprehension, and inferential knowledge across studies [58]. In our meta-analysis of reading interventions for EBD [40], there was not sufficient studies to support the minimum necessary studies to supporting the efficacy of concept/story mapping among students with EBD. However, when literature was further examined for use of concept mapping on students with learning disabilities, more literature emerged which reported significant increases across various outcome domains in reading comprehension (e.g., [55, 56, 58]).

Direct instruction is an explicit or systematic teaching approach that breaks down learning into smaller steps and uses various approaches to deliver the skills, including lectures, tutorials, participatory learning, discussion, recitation, and observations. Direct instruction to teach reading has taken many formats including one-on-one to group instruction. In both formats, teachers use strategies like drilling, storytelling, sequencing, scaffolding. When using scaffolding, teachers model uses of concepts. More common formats of direct instruction that have been thoroughly researched include explicit model of instruction using scaffolding [59]. This approach breaks down DI intro 5 steps consisting of orientation, presentation, structured practice, guided practice, and independent practice.

It has been used to teach varying forms of reading skills including phonemic awareness [46, 60, 61], reading fluency [62, 63]. In our meta-analysis [40], there were no studies that applied direct instruction for comprehension-based outcomes. Across other reading outcomes (i.e., phonemic awareness, vocabulary, and oral reading fluency), direct instruction methods were examined in at least 5 group designs and at least 14 single case designs [40]. Several other meta-analyses have examined the effectiveness of direct instruction on academic outcomes for students with LD. For example, a meta-analysis examining effectiveness of reading instruction in science for students with LD reported positive effect sizes for reading instruction across various reading outcome in science, including vocabulary, reading fluency, and comprehension of science materials [64]. When examined for the evidence base for direct instruction, the WWC did not contain any studies across different direct instruction mediums.

Peer mediated instructional approaches are a variation of instruction that involves two or more students work together to problem solve. PALS have been identified to be very helpful for students with disabilities since they promote academic, social, and communication skills to all learners. Peers participate in orientation sessions where they learn social and academic support strategies for use within both teacher-directed and student-initiated activities. As students with and without disabilities gain familiarity with working together, school staff fade back their direct support gradually to promote student independence. In the studies that utilized PALS, high performing students were paired with low performing students and were coached to take turns in being mentees and mentors. The approach was modified to include adult modeling of desired skills immediately before completion of the activities by students. In another study [65], students were paired together to alternate roles of coach and reader and were taught decoding skills that corresponded with teacher directed instruction for the day. Students would alternate the roles, with the stronger readers beginning the sessions as coaches. The study findings indicated that PALS was effective in increasing students' reading outcomes on letter sound correspondence and blending probes. Other studies in which PALS were examined include Lane et al. [45], Staubitz et al. [66], and Sutherland and Snyder, [67]. Across the three studies, authors reported positive reading outcomes in the domains of oral reading fluency and comprehension. Other earlier studies have also documented positive gains in reading among student with LD as a result of PALS (e.g., [68]). Other studies have examined PALS across multiple learning outcomes (e.g., [69, 70]).

6. Conclusion

When selecting instructional practices for teaching reading skills to students with LD, it is important for teachers to adopt methods that are sufficiently demonstrated to be effective. As indicated in prior research, some teachers had relied on instructional practices that were not evidence-based. Part of the reasons for this was teachers' lack of knowledge regarding what practices are effective or not, lack of skills to find EBP, and a traditional preference for methods they perceived to be effective. The emphasis on EBP in the field ensures that teachers are selecting interventions that are backed by data and empirical evidence, as well as high quality research. With EBP, teachers can substitute the practices that were formally dominant with interventions that are more likely to produce positive results for students. Evidence-based reading interventions for students with LD can help close the skills gap in this group of students.

Author details

Argnue Chitiyo
Ball State University, Muncie, IN, United States

*Address all correspondence to: achitiyo@bsu.edu

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Chapter 17

The Use of Assistive Technologies in Writing Situations with Dyslexic and Dysorthographic Students

Nadia Rousseau, Michelle Dumont and Carl Beaudoin

Abstract

In the context where dyslexic and dysorthographic students have great difficulties in writing, this study aims to describe and analyze the perceived relationship between the use of assistive technologies (AT) in writing situations as well as academic self-perception, feeling of self-efficacy and exam anxiety in dyslexic and dysorthographic students. Using standardized questionnaires and semi-structured interviews, data were collected at the beginning and end of the school year from 28 dyslexic and dysorthographic students aged 12 to 13. In terms of quantitative analyses, the average score for each of the scales on the questionnaires was calculated. As for the qualitative data, they were analyzed using a network analysis approach. The main results show that students who can use ATs in a writing situation have a significantly higher self-perception and feeling of self-efficacy than those who do not. Moreover, their use is promising since it is associated with less anxiety at the time of exams at both measurement times. The results obtained are discussed in relation to actions to be encouraged in schools.

Keywords: Assistive technology, Dyslexia/dysorthographia, Writing, Self-efficacy, Self-perception, Exam anxiety

1. Introduction

In the early 1980s, [1] proposed a model of written text production. This model, revised a few years later by [2], is still a reference in most French didactic studies [3]. It is based on the implementation of three main writing processes: planning, drafting, and reviewing [1, 3, 4]. While planning involves generating and organizing ideas according to a topic, an audience, an intention, and the type of text to be produced [5], drafting the text involves putting into words and sentences the ideas developed in the planning stage [3]. Reviewing involves redrafting and editing the text [1]. In the case of inexperienced writers, reviewing will begin with the word and will gradually extend to the entire text, depending on writing conventions and ideas they wish to convey [6]. Given the requirements linked to activating and articulating many mental processes, some of which being related to reading, as well as the large number of levels of organization in the text, the writer must have sufficient cognitive abilities to manage and coordinate all the writing processes [3, 7–9]. The production of written texts in French is even more complicated because French spelling is one of the most complex of the alphabetic languages [10]. In addition to the complexity associated with the writing process and the French language, it is important to focus on dysorthographic and dyslexic students, who present reading and spelling difficulties that persist over time [11–14] and have a major impact on writing skills [15, 16]. Indeed, these students produce shorter texts with a significant number of spelling and punctuation errors [7, 9, 17]. Another consideration is that the writing process in dyslexic students is also associated with the development of a negative academic self-perception, which can lead to anxiety, disengagement in a writing context, and even discouragement and loss of motivation [18–20]. Research shows that dyslexic and dysorthographic students in primary and secondary schools have a lower feeling of self-efficacy when faced with a writing task than their peers without these disorders [21, 22], although this is overestimated with regard to their actual performance [21, 23]. These students also show a lower level of effort when faced with a complex task, which, according to [22], is the result of a low feeling of self-efficacy. Finally, students with dyslexia and dysorthographia are reported to be more prone to exam anxiety than their peers without the disorder [23–25].

Given the difficulties experienced by dyslexic and dysorthographic students, it is important to consider how to better support them academically. Thus, assistive technologies (ATs) attract attention. In fact, technological advances have allowed the development of ATs associated with the writing process, namely lexical/syntactic proofreader, speech synthesizer, word predictors and voice dictation. Several US studies reveal the contribution of reviewers on the correction of spelling errors [26] as well as lexical and syntactic spelling, readability, organization, and coherence of the texts produced [27–29], although reviewers fail to identify one third of lexical homophone errors [30]. As for the word predictor, severe dysorthographic students show great difficulty in using this AT effectively, while a gain is observed in those with moderate difficulties [31]. Finally, voice dictation was associated with significant improvements in the quality of writing and in the accuracy of lexical and syntactic spelling, compared to unassisted writing in students with dyslexia-dysorthographia. These results are not observed for ordinary students [32, 33]. Since almost all the studies on the effectiveness of ATs on the act of writing are from the USA and focus on the analysis of the texts produced, it is necessary to study this means of adaptation, in particular on academic self-perception, feeling of self-efficacy and exam anxiety in a writing situation.

2. Terms of reference

2.1 Self-perception

Self-perception refers to how a person perceives themselves [34]. The educational psychology perspective recognizes the importance of the self in learning. This is referred to as the "self as learner" [35]. This growing interest in the self as learner is also present in the conceptualization of self-perception proposed by [36], who subdivide the school dimension of self-perception into two domains: "learner" self-perception (felt in relation to one's own ability to learn) and "student" self-perception (felt in relation to one's own ability when faced with school tasks). As explained by [36], as a person's self-perception develops, he or she distinguishes between his or her ability to perform, look good, stand out, excel in school (student self-perception) and his or her ability to develop new learning (learner self-perception).

Students with learning disabilities often exhibit negative self-perceptions [20, 22], which are characterized by feelings of not being up to the task, being inferior to peers, or being different [37]. In addition, researchers find that the difficulties engendered by writing contribute to the development of a negative academic self-perception, which can lead to anxiety, disengagement in the writing context, and even discouragement and loss of motivation [19, 20].

Scientific literature also reports positive relationships between low self-perception and different components of school life: lower academic performance and increased academic difficulties [38, 39], less academic effort and perseverance [34], lower confidence in one's academic abilities [36], lower academic motivation [22, 38, 39], as well as lower expectations and less ambitious academic aspirations [36].

2.2 Feeling of self- efficacy

To be effective in the school context, learning French spelling must be supported by strong motivation throughout the school years. According to Bandura's social-cognitive theory [38, 39], the feeling of self-efficacy refers to a person's confidence in his or her ability to deal with demanding, new or problematic situations. Several research findings suggest that students who report high levels of self-efficacy compared to those who report low levels of self-efficacy have less psychological and physical distress, higher levels of academic achievement [40], higher academic aspirations, spend more time on homework, feel more effective in managing their school activities [41], and demonstrate a more serene attitude toward even complex tasks [40]. In terms of writing, students who have a high feeling of self-efficacy engage more easily in the task, are more motivated, participate more in class, persevere in the face of difficulties, and are better able to manage the anxiety they feel in exam situations [42]. On the other hand, learners with significant learning difficulties have a lower feeling of self-efficacy than their peers without difficulties [21, 22]. Specifically, in spelling, students who overestimate their proficiency perform above expectations, while students who underestimate themselves perform less well [43]. Research shows that dyslexic and dysorthographic students in primary and secondary schools have a lower feeling of self-efficacy when faced with a writing task than their peers without dyslexia and dysorthography [21, 22].

2.3 Exam anxiety

Students who suffer from exam anxiety anticipate failure, believing they will not be able to meet requirements; for them, their performance is indicative of their personal worth [44]. They also tend to anticipate all sorts of situations in which their personality might be threatened [45], especially if they are likely to be judged, lose face, or be publicly humiliated. Moreover, exam anxiety is thought to be related to fear of meeting social expectations, lack of confidence in their own abilities, fear of failure, fear of memory loss, and physiological manifestations of stress [46].

More specifically, [47] report that students with academic difficulties who experience exam anxiety have higher scores for worry, defeatist cognitive blocking, and inattention than those who do not have learning problems. According to the same authors, anxiety could absorb students' ability to activate the working memory needed to solve complex problems. They also find that students with learning disabilities are likely to have had fewer positive academic experiences due to repeated failures, which would make them even more nervous in exam situations. Although anxiety experienced during an assessment is commonly observed in many students, if severe, it can have a negative impact on their academic progress [48], which could jeopardize their future. Given the many factors associated with this type of anxiety, it is not surprising that students with dyslexia and dysorthographia suffer from it to a greater extent than their peers without dyslexia and dysorthographia [25].

2.4 Word processing and assistive technologies

In order to better support the learning of students who have more difficulty in French than others, the ATs associated with the writing process (lexical/syntactic proofreader, speech synthesis, word predictor, and voice dictation) are used to support this type of problem. Indeed, there is a positive effect of the use of word processing on the quality, organization and length of students' writing, spelling performance [49], self-perception and engagement, in addition to being a teaching and learning aid [50]. However, it should be noted that the use of text processing is not in itself a sufficient support to improve the act of writing in all its complexity [51].

2.5 Research objectives

The purpose of this research is to describe and analyze the perceived relationship between the use of ATs in writing situations as well as the academic self-perception, feeling of self-efficacy, and exam anxiety of dyslexic and dysorthographic junior high school students.

3. Research methodology

This research combines a multi-case study [52] and the use of quantitative and qualitative tools [53]. In the context of this research, each school setting participating in the study (n = 3) is a case in itself, and each student with dyslexia and dysorthography also refers to unique cases (n = 28), which makes reference to literal replication rather than theoretical replication design. While the former aims at studying similar cases, the latter aims at studying contrasting cases.

3.1 Participants

The participants come from 3 high schools in 2 administrative regions. The students, aged 12 to 13 (16 boys and 12 girls), are all French-speaking (first language), AT users, entering their first year of secondary school, and identified by the school community as having dysorthography or dyslexia problems (n = 28). The preliminary assessment of the degree of difficulty in writing of the students participating in the research using the Chronodictée tool [54] reveals the presence of very severe spelling difficulties for all the participants, ranging from very severe (3), very, very severe (10) to extremely severe (15).

3.2 Data collection process

Data collection took place through a sequence of activities involving or not ATs in a writing situation, both in the fall and spring of the same school year and only in the spring of the following school year. More precisely, they were asked to write a summary, with and without technological assistance (at one-week intervals), and then to complete the questionnaires mentioned above. A 5–6 minute video vignette (silent short film featuring various characters in a short story sequence) is viewed twice (as a group). First, the students watch the video carefully, and then watch it again, while taking notes in a notebook provided for this purpose. These notes can then be used when writing the summary.

3.3 Time period for data collection

The data collection tools include three standardized questionnaires and an interview protocol. Standardized tools include Fleming and Courtney's *Feeling of Inadequacy Scale* [55]—alpha = 0.93). This questionnaire includes 36 items measuring 5 dimensions of self-perception using a 5-point Likert scale, ranging from "very often" (1) to "almost never" (5). However, based on the work of [22], only the dimensions of confidence (12 items) and academic skills (7 items) were used (Cronbach's alphas in order: 0.87 and 0.77). Building on the work of [43], inspired by [56, 57], participants also completed a questionnaire probing their feeling of self-efficacy with regard to writing [43]. This questionnaire consists of 8 items on which participants are asked to comment using a 6-point Likert scale, ranging from "strongly disagree" (1) to "strongly agree" (6). The original questionnaire [43] has satisfactory internal consistency and good construct stability (pilot study 0.80 and main study 0.79). Finally, the Exam Anxiety Scale (*Friedman Exam Anxiety Scale* [58], translated and adapted by [59]—alpha 0.91), a 6-entry Likert-type scale ranging from "doesn't look like me at all" (1) to "looks like me perfectly" (6), is used. The tool includes 23 items divided into 3 subscales: a) social anxiety; b) cognitive interferences (worry); and c) physiological reactions (emotionality).

On the other hand, the semi-structured interview protocol, inspired by the Steinhoff and Owens questionnaire [60], invites students to express themselves on the object under study by using a brief description, an image or a metaphor (e.g., *For me, writing with [name of the tool or assistance function] is… because…).* This type of question has been shown to be beneficial in several studies on the experience of young people with academic difficulties, in particular because of the structure of the question which facilitates the expression of a key idea, while encouraging the verbalization of an individual response free from any influence on the part of the interviewer [61–63].

3.4 Data analysis

First, in terms of quantitative analysis, the average of the scores on the different scales of the three standardized questionnaires is calculated using the *SPSS Statistics* software (version 23). This data processing makes it possible to position the participants in terms of their feeling of self-efficacy, their perception of self in writing, and their exam anxiety, depending on whether they use ATs in a writing situation. Second, an inductive analysis of the qualitative data obtained from the semi-structured interviews was conducted using the network analysis approach [64], using the ATLAS Ti qualitative analysis software, a key tool in network analysis [65].

4. Results

In what follows, we will first present the quantitative results for each of the three dimensions studied (feeling of self-efficacy, self-perception, and exam anxiety). Next, we will highlight the qualitative results obtained on the use of ATs by participants.

4.1 Self-perception in writing

Whether at the beginning or at the end of the school year, the results indicate that students with dysorthographia or severe dyslexia who can use an AT to summarize a story report a statistically significantly higher self-perception feeling than when they cannot (t [26] = −2,601, p = 0.05). This result was expected.

4.2 Feeling of self-efficacy in writing

As expected, the results indicate that students with severe writing difficulties who have the opportunity to use an AT to summarize a story have a statistically significantly higher feeling of self-efficacy than those who do not, both in the fall (t [26] = −6,382, p = 0.001) and in the spring of the same school year (t [26] = −4,493, p = 0.001). It should be noted, however, that contrary to expectations, the use of ATs was associated with a statistically significant decrease in feelings of self-efficacy as the school year progressed (t [26] = 2,142, p = 0.05).

4.3 Writing exam anxiety

Contrary to expectations, the use of ATs was not associated with a significant decrease in the three components used to describe the writing exam anxiety questionnaire (social depreciation, cognitive blocking and body tension) for students with severe dysorthographic and dyslexic difficulties. On the other hand, the results associated with social depreciation as well as cognitive blocking are in line with expectations, since the score obtained on these two subscales is lower at the end of the school year, when the student has had the opportunity to become more familiar with technological tools.

Although the result is marginal (t [26] = 1,136, p = 0.059), the overall mean writing exam anxiety score is consistent with expectations, as it is lower in a context with ATs at both measurement times, particularly in the spring, than in the context without ATs.

4.4 Minimal use of the assistance functions available to participants

In the individual interviews, the students' comments highlight both the benefits and limitations associated with the use or non-use of technological tools in the writing context. As such, the benefits associated with the use of ATs mentioned by the students include the possibility of obtaining a better performance ("*Well, assistive technologies help me do better, it's basically like a part of my brain*") and the improvement of their working methods (*"It helps me to proofread properly…").* Similarly, they mentioned feeling a greater sense of well-being (*"It makes you feel more confident"*) and having the perception that significant help is given to them (*"It's for learning well, I don't really know how to say it… Then, that's it, it helps me learn".*).

As for the limitations associated with these technologies, students sometimes mention limiting features ("*Well sometimes it bugs, then sometimes when you don't record, it gets erased.*") and the feeling of being different from other classmates ("*I feel embarrassed in front of everyone to have a computer… I feel as if I am different, and I don't like it.*"). On the other hand, students verbalize the presence of some persistent difficulties in writing ("*Well, I still have difficulty, even though I have my assistive technologies.*"), a less accessible performance ("*Well, I feel like … you have to like to read it a few times, a few times to understand.*") and more difficult to establish work methods (*"Disorganized…").* Finally, some students mentioned a lower sense of well-being ("*I think that I have more difficulties, that I have real problems*") as well as a number of difficulties experienced with regard to writing ("*And there, the maximum that I can do is to take the dictionary, and for that, well, I need you to check my agreements, and so on*").

The analysis of the video recordings made during the drafting process shows that little use was made of the AT provided to the participants. Thus, for Antidote users, only three of the 239 available functions are used by students. For Word Q users, only 9 out of 12 functions are used. Regarding the use of the Lexibar software, the video recordings show that the students use 7 of the 10 functions of the software. For Lexibar users, 7 of the 10 available functions are used. From these results, we can see that, regardless of the software, the assistance functions used by the students are particularly present at the text drafting stage and often absent at the text correction stage. Also of interest is the fact that many participants use Word as their primary word processor, including clicking on underlined words to assist in the correction process. However, this software is not in itself a technological assistance tool.

5. Discussion

The results of this study confirm those of the scientific literature to the effect that the use of a technological assistance tool is associated with benefits, including a more favorable self-perception in writing as well as a greater feeling of self-efficacy than if one is left to deal with one's writing difficulties [66]. This increased perceived self-confidence and feeling of self-efficacy were observed both at the beginning and at the end of the school year. On the other hand, the current analyses do not demonstrate whether the technological assistance tool promotes better performance on the writing task than without it. In contrast, responses to open-ended questions about self-perception in writing suggested that students with dysorthographia or severe dyslexia felt more worried, stressed, and anxious in the absence of technological support than when it was available. Perform A previous qualitative study also highlighted the increase in stress for dyslexic/dysorthographic students when they were required to perform tasks without technological support [67]. This qualitative analysis also shows that the use of ATs is associated with stress management strategies that de-stress them and increase their confidence in writing. For example, some report feeling more competent, well, confident, less stressed or stress-free, better prepared, more successful, as if they were writing by hand, well organized, "normal."

On the other hand, and contrary to all expectations, the feeling of self-efficacy in writing showed a statistically significant decrease between the beginning and the end of the school year, in the condition allowing the use of ATs. Three explanatory hypotheses can be proposed to explain this unexpected result. First, it is possible that students at the end of the school year become more aware of the severity of their difficulties in the French language, particularly in spelling, which in turn would affect their feeling of self-efficacy. In fact, the requirements in French, particularly in writing, increase between the end of elementary school and the beginning of secondary school (length of texts, types of texts) [68]. Second, as the school year progresses, teachers and parents may lower their performance expectations (grammar, syntax, etc.), which has a downward effect on feelings of self-efficacy. Third, it should be noted that for all students, entry into secondary school corresponds to a decline in their feeling of self-efficacy [42].

Contrary to what was expected, the use of ATs was not associated with a significant decrease in the "social depreciation" dimension of anxiety relative to writing exams for these dysorthographic or severe dyslexic students. "Social devaluation" was the concern that one would no longer be loved by one's parents or that one would be judged "stupid" if one failed an exam. Although the score is lower at the end of the school year than that observed in a context without AT, it appears that these technologies are insufficient to significantly reduce this component of exam anxiety in this type of student.

The study shows similar results for the "cognitive blocking" dimension of the writing exam anxiety questionnaire. This component of the questionnaire highlights the feeling of having "*an empty brain*," of having "*forgotten everything you have learned, ideas you have organized or ordered in your head*." Again, although the score on this scale is lower at the beginning and at the end of the school year than that obtained in the context without ATs, it is possible that the use of ATs for students with significant writing difficulties is insufficient to compensate for deficits in metacognitive skills such as organizing, synthesizing, and understanding the content of a text. This hypothesis is supported by [69], who reports that the negative effects associated with exam anxiety may be exacerbated by poor metacognitive skills and less effective use and selection of study strategies, as evidenced by the poor performance of the participants in his study under conditions that did not present any external exam pressure. According to this author, being aware of their deficiency in preparing adequately for exams, the emotionality and helplessness felt at the time may prevent students from dealing effectively with the exam situation. This interpretation would apply all the more to students who are severely affected in the learning of a language as complex as French.

For the "body stresses" component of the writing exam anxiety questionnaire, again, the use of ATs was not associated with fewer symptoms in the spring, while there was no difference for students with or without ATs at the beginning of the school year. We even find that this type of stress measured in the spring (being stressed, agitated, having a rapid heartbeat, being afraid of an exam) is slightly higher in a context of ATs than in the one without the possibility of using them. This result is contrary to expectations. It is possible, however, that the use of ATs for dysorthographic or dyslexic students is imperfect or insufficient to compensate for the presence of physiological symptoms often observed in stressful situations and which may prove to be a detriment to concentration and memorization of the subject matter [70]. It is not uncommon to hear adolescents express such stressful reactions in the context of an exam: "*I froze on the spot during a public performance*," "I had studied, but I forgot everything at the time of the exam" [71].

Finally, as expected, the average overall writing exam anxiety score was borderline to being statistically lower at the beginning and at the end of the school year when the student used ATs. This result is most apparent when students have been able to familiarize themselves with the software at the end of the school year. Although encouraging, ATs alone are not associated with a significant reduction in writing exam anxiety.

5.1 Actions to be encouraged in schools

This study suggests that efforts in schools should be encouraged by promoting the development of self-knowledge and self-esteem in young people, thus contributing to their action planning and reflective action [72]. Already, experimentation with activities related to self-awareness, learning disability, and compensatory functions of ATs in a secondary school is proving promising [67]. Payne [73] furthermore states that behaviors aimed at self-awareness are one of the themes related to the success of schooling. Another intervention target is to develop a feeling of self-efficacy in writing through workshops on self-esteem, story co-construction [74], and more effective work methods for exam preparation. Both qualitative and quantitative data from this study suggest the need to reduce writing exam anxiety through stress management workshops [75]. Finally, the school needs to ensure that students have an understanding of and facility in using the full potential of ATs in the completion of academic tasks.

6. Conclusion

Whether at the beginning or at the end of the school year, the results indicate that dyslexic and dysorthographic students who can use assistive technologies to summarize a story show significantly higher self-perception and self-efficacy than those who do not. Although the use of ATs was not associated with a significant decrease in writing exam anxiety, the results showed a trend for marginal significance since the scores obtained were lower in a context of assistive technologies than in a context without ATs. Given the numerous testimonies of young people suffering from exam anxiety and the observation of teachers and psychosocial workers, it is important that research be able to better understand this type of anxiety, because negative concerns in exam situations (before, during and after) could cause students to underperform in relation to their real potential, which will certainly have consequences on their life choices. In addition, considering these results, a review of teaching and assessment practices in spelling is required. These practices must be considered in such a way that consolidates the self-assessment of students' competence rather than weakens it. In particular, the teacher must take his time. There is no point in rushing through an array of grammatical concepts and rules that make students feel dizzy and incompetent because the task seems impossible. It is important to ensure that essential learning is solid before introducing exceptions that will undermine the students' knowledge system. The teacher must provide adequate support for the concepts and not rush their teaching.

In conclusion, the original contribution of this study lies in a conception in which students' achievements are not only related to their cognitive background, but also to a complex interface between the latter and their affective and motivational system [76], hence the variables that were analyzed in this study. Thus, a better self-perception in writing as well as a greater feeling of self-efficacy in writing are associated with the use of ATs when completing an academic task. To a lesser extent, however, ATs-assisted writing appears to be associated with slightly less anxiety on exams than when students are left to their own knowledge. Let us not forget that the school has a role to play in making ATs available and the best ways to use them for students. Therefore, it is important to focus on three types of support in order to gain a better understanding of the use of ATs in writing contexts [77]: remedial support (students take ownership of the assistive features in the writing process with the support of the remedial teacher), learning support (students use the assistive features to learn in the classroom in a writing situation) as well as instructional support (the teacher models their use in the classroom, for all students). Finally, it should be noted that the results of this study cannot be generalized to clients other than those with dyslexia or dysorthographia.

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Conflict of interest

The authors declare no conflict of interest.

Author details

Nadia Rousseau*, Michelle Dumont and Carl Beaudoin
Department of Educational Sciences, Université du Québec à Trois-Rivières, Trois-Rivières, Quebec, Canada

*Address all correspondence to: nadia.rousseau@uqtr.ca

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Chapter 18

Lecturers Awareness, Inclusion and Implementation of Wearable Device as a Means of Enhancing Educational Development in Nigerian Universities

Ayodeji Olayemi Obafemi

Abstract

For the 10% of individuals in Nigeria that have utilized a wearable gadget, an increment in use is expected sooner rather than later. The utilization of Smartwatch innovation has been accounted for in numerous instructive practices; suppliers have utilized smartwatches for an assortment of purposes including addresses, courses, and online classes. Be that as it may, the impacts of Smartwatch innovation on the quality and adequacy of upgrading instructive headway in colleges and bastions of learning stay obscure. Input components that are unpretentious and productive in preparing enormous information continuously are needful to gauge quality learning experience in such huge homeroom settings. With the most recent effect of infiltration and reception of web and portable advancements in most creating areas, wearable innovation is an achievable answer for oversee and screen homeroom inclusion; as continuous understudy criticism can be coordinated in the plan and conveyance of guidance all through the study hall. The outcomes from SPSS statistical analyses of the data gathered exhibited suppliers' high proclivity for utilizing Smartwatch gadgets for instruction and dissemination of lecture curriculum and educational plan, yet further exploration is expected to distinguish components by which keen frameworks can be incorporated into the schedules and work processes of lecturers and students.

Keywords: wearable technology, smartphone, smartwatch, performance expectancy

1. Introduction

1.1 Overview

In decades, wearable technology attracted reasonable awareness from educational technology experts. To a layman's idea, this new concept of wearables offers a new form of technology by using psychomotor level of carrying handheld devices. The smartwatches and health tracking bracelets are the most common, even though many of the characteristics included in these types of device represent additional phases beyond anything that is already available in existing hand-helds and other technology know-how. Given this, the buzz around wearables may seem disappointing; they are nothing more than new and useless electronic toys to those who can afford them. In this perspective, wearables tend to generate initial interest and then quickly fall out of favor (for example, consider the ups and downs of the asymmetrically designed Google Glass wearable camera and head-mounted display system). Not surprisingly, there are staunch skeptics as to whether Wearables and their fans will have much to offer the future of education [1].

Wearable technology refers to computer-based devices that users can wear, examples jewelry, glasses, clothing, shoes or jackets. The advantage of wearable technology is that it can easily incorporate outfits to monitor sleep, association, whereabouts, and social interactions. Using Oculus Rift and other VR headsets, wearables can establish simulated reality. Recently, a new device that integrate seamlessly with the handler's daily existence and engagements. Smartwatches from Apple and other tech giants already allow handlers to crisscross their email and interact with the interface. Acknowledgments to metered measure, this technology can update movement, actions and time [2].

Eventually, adoption and impression of wearables in training and learning services remains invisible. Nevertheless, the guiding locus is that the most efficient forms and usages of wearable technology for prescribed and familiar learning contexts are under developmental exploration. Technology in Education must realize that wearables are not monumental as a set of technologies that will flourish or nose-dive for enlightening commitments. There is diversity in devices and forms of technology incorporation and in user familiarity. Smartwatches and health trailers are some of what is available and possible. Incorporating educational technologies, the efficiency and worth of wearables will finally depend on many collective and anthropological factors and will fluctuate between environments.

Therefore, this article raises the main argument and future questions educational technologists about wearable technologies should be unequivocal about how wearable technologies are used and how their proposed use supports certain forms of teaching and learning. Despite advances in technological innovation, the education area has been unwilling to admit technology to assist learning, even though the introduction of machines in education, predominantly in the instruction of science, is well dispersed in history. Furthermore, technology usage is primarily restricted to moralistic training and knowledge approaches, where teaching is simplified by using computers and the availability of automated teaching resources. Nevertheless, the usage of digital technology behind wearables is not limited to the use of computers, electronic materials and must be well-matched with a student-focused methodology as an option in augmenting the student knowledge involvement.

To ensure full implementation of the national computer education policy in Nigeria, the state government introduced computer education and literacy in secondary schools in 1997 [3]. The general objectives of the computer literacy program are: to encourage computer literacy in every state of Nigeria; develop the use of computers as teaching tools in all subjects and familiarize students with the use of information technology; to enable the current generation of high school students to appreciate the potential of computers and to be able to use computers in various aspects of life and in subsequent work; and to expose teachers and students to the latest scientific knowledge and skills.

Another major effort to increase the integration of wearables in Nigerian society is the 2001 National Information Technology Policy, labeled "US IT" [4]. As a result of these measures, over the years, the education sector has seen a major increase in the capacity of application of wearables in learning and teaching all aspects of the tutelage system. Conversely, the situation in schools, especially in secondary and primary schools in rural areas, has not been fully addressed over a period of time.

Tella et al. [5] compared the 1987 Nigerian Computer Strategy with current school practices and establish that computer training in Nigeria is restricted towards Centralized Institution and is hardly presented in public schools that cover larger percentage of 80% of Nigerian citadel of learning. Nonetheless, the involvement in the private sector to the education structure has increased the usefulness of wearables in probably all private and public schools, especially in metropolitan areas of Nigeria. For example, in a recent study on computer knowledge levels in private and public secondary school students in metropolitan areas of Nigeria. Pitler [6] found that private high school students had more computer access and use than public high school students.

No significant difference was found in terms of Internet access. Given the situation of schools in urban areas, knowledge about the state of computer literacy in rural areas is still little studied. Do schools in rural areas implement the national education policy in Nigeria? And how are rural schoolchildren responding to this new technology in their environment? In response to the global influence of wearables on education, governments and non-governmental organizations in developing countries are now investing in educational technology to bridge the digital divide and enhance teaching and learning in the new information society. In line with these global developments, the federal government of Nigeria, in its national education policy, recognized the major role of wearables in the modern world and has integrated it into education in Nigeria [7].

For example, in 1987, the federal government, at the 32nd meeting of the Council of Ministers of the National Council of Education, established a national committee for computer education, which is tasked with setting national policy on computer education. The universal objective of the plan is to certify that the community gains the effect of information technology on today's civilization; and to enable the current age band of schoolchildren at all levels to appreciate the potential of computers and enable them to be able to use computers in many aspects of their later lifetime [8].

The main objective of this study is to find out how lecturers are responding to wearable technology and admission to the Nigerian educational system. The specific objectives of the study are:

1. Determination of the level of knowledge and acceptance of smart watches by the respondents

2. Measurement of the most influential factors for the acceptance and use of smart watches by the respondents

3. Determination of teachers' perception of the use of the smart watch for teaching and learning.

4. How do lecturers rate the use of smart watch technology in their work?

The presentation of wearable in education has exaggerated instruction and knowledge in various. Wearable is claimed to possess the possibilities of accomplishment used to satisfy the training needs of individual students, promote equality of instructive opportunities; offer top quality learning resources, increase self-efficacy and independence of learning among students, and improve teachers' proficient improvement [9]. Its presentation also ensued to modification within the approaches of training and book learning within the new era teaching space. Olakulehin [10] notes that "this shift which has been driven by the excess information and communication devices now gradually reachable to students in class and reception, each of which offers new affordances to teachers and students alike for improving student accomplishment and for meeting the mandate for new era skills." Related studies have recognized numerous varieties of wearable attainable for training and education.

Agreeing with [11], wearable obtainable in classrooms take account of modest tool-based demonstrations like Microsoft word, wired depositories of methodical data, main ancient brochures, handheld processors, and two-way remoteness knowledge teaching space. In order to efficaciously function within the newly introduced technology learning setting, identifying wearable implements turn out to be indispensable in place of teachers teaching and students learning. Raij et al. [12] reported that notwithstanding the deceptive remunerations of the utilization of wearable for informative persistence, research revealed that, the teaching possibility of wearable is deprived as many teachers and students are still not fully aware of wearable experience.

Profits derived from the utilization of wearable within learning areas can be exploited when impending handlers are capable within the usage of the newest technological innovation. Research revealed there are connections concerning wearable skills and its application for teaching and learning. And this is why [13] posit that an individual without the working knowledge of computers within the modern technological world will not be ready to go far in life as far as his career options are concerned.

Studies have shown that using wearable in education enables students to take a more active role in their learning rather than a passive observer or listener [14]. Given the part awareness of wearable knowledge affects the new information culture; accepting the Nigerian Policy on Education and executing in secondary schools in the rural regions of Nigeria has grown into noteworthy. Common of reports on the state of wearable in the rural areas only recognized inadequate wearable without insight as to how the situation affects students in the rural communities. According to [15] wearable development and application are not well established in rural areas of Nigeria because of poor information infrastructure.

Zheng et al. [16] say that more than 40% of Africa's population is located in areas not covered by telecommunications services and, as a result, schools located in those areas will have subjectable connectivity issues. However, the full integration of technology into education is far from being achieved. A 2010 study of more than 60,000 classrooms, from elementary to high school in 34 states with various socio-economic backgrounds and levels, found that 63% of teachers and 73% of students did not use technology [17]. Even as technology advances rapidly, the integration of

Figure 1.
The evolution of wearable.

applications such as those for iOS/Apple products (including the iPad) into education is still in its infancy [18], that is just 2 years ago (**Figure 1**).

According to [10] "a previous review of educational technology research found that the ways in which student and teacher use of technology were measured were often limited," usually measurement using self-report surveys. Few studies measure technology integration through direct observation in the classroom, although observation "can provide a rich source of data to better understand technology use in the classroom" [14]. Although a single case study cannot tell researchers, decision makers and end users all about technology use In schools, it is important to collect as much data as we can to contribute to a general understanding of what is happening in rural schools regarding today's use of technology. Examining how the types of technology used in schools help educators and the research community grow in understanding the issues and needs associated with successful technology integration to improve teaching and learning, in this particular case, regarding the adoption and allocation of rural school technology/iPad funds for those technologies.

2. Adverse effects of educational technology integration

Numerous dynamics stance encounters to effectively incorporating technology into learning. The major factors are support from administrator and wearable awareness quotient. Research revealed that faculty management and backing is necessary in fairly technological skilled improvement enterprises, alongside simple governmental procedures for supervision, misunderstanding, and culpability. With regard to funding, Wearable should provide adequate funding and resources [14] and resources (e.g. computers, iPads, etc.), as teachers report a lack of technology along with major barriers to technology affecting their practice in the classroom [9]. Another obstacle faced by many faculties is the lack of adequate technical support and infrastructure to ensure success with technology [8]. Technical challenges can include the need to carefully plan synchronization logistics and mobile device management as well as to ensure school infrastructure and bandwidth are adequate, powerful enough to support multiple devices directly. These are some of the types of barriers that this study seeks to examine, although administrative support is important for successful technology integration, teacher familiarization with technology is also important. In study [16], respondents classified ignorance with technology as a major barrier impacting teachers' technology integration. Teachers who wish to learn how to incorporate new technologies into education may let their fears interfere with their effective use and may not be motivated to improve their current practice [6]. Studies show that teachers' comfort level with technology affects how often and how they use it in their daily lessons [19].

Furthermore, teachers' confidence in the mastery of new technologies and their perceptions of the usefulness of the latest technologies are important factors in their intention to use them as teaching tools [5]. More important than teacher discipline or level of education is teacher commitment to technology, as teachers typically maintain their students' use of technology in schools, and better "buying" will translate into greater implementation [5]. Another barrier is the lack of professional development adequate for schools that can be subject to technology integration [1]. Interviewing teachers and managers, [4] they identified one of the main adverse effects to technology having much greater effect on teacher instruction as inadequate CPD that boosts teachers to work in partnership so that they would not feel compelled to understand separately in describing the best way to integrate innovative technology.

Teachers reported inadequate time to discovering newest technological abilities, experimenting, planning in preparing teachings as contests to technology [3, 4, 17]. A comprehensive professional development program must be sustainable, relevant, and connect educators through a supportive community practice which includes modeling, observation and interesting lesson scenarios using technology [18]. Efficient models for professional development are for workers to teach each other about how technology can support education and include peer coaching to improve student achievement [12]. Studies show that without effective and continuous professional development focused on quality education, investment in wearable technology will not have the expected outcome [20].

3. Lecturers beliefs, wearable and pedagogy

References [4, 9, 18, 21] have all pointed to the potential of communication technologies for transforming the models and processes of teacher development within the less developed countries (LDCs), as well as for enabling access to quality resources and professional support. Borthwick et al. [1] recommend that wearable agrees that:

Framework tools, which support teachers' construction and understanding of current professional knowledge;

- New learning environments and contexts, enabling teachers to experience new situations, practices and people;
- Communication tools, which facilitate structures of social participation between teachers and other educators (eg collaborative assignments);
- Metacognitive tools, which allow teachers to reflect on the training process, both individually and in groups (eg conferences; shared products such as electronic self-assessments).
- Olakulehin [10] you argue that in this way wearables can make some aspects of teacher pedagogy more efficient, which also has the potential to add to and change the teaching-learning method itself.

4. Integrating wearable into teacher education

Teachers need formal training, but also constant and on-going support from their peers to help them find the best way to integrate technology into their teaching. The use of wearables can enhance teachers' professional knowledge and skills by enabling new forms of collaboration between teachers. Teachers learn to rework their classrooms from a static environment where there is a one-way flow of data from teacher to student, to a student-centered dynamic environment where students interact with peers as a team, both in their own classrooms and in the classroom.

The proceeding with proficient improvement of educators is basic to the accomplishment of innovation and schooling programs. Exploration concentrates like the Digital Education Enhancement Program (DEEP) report that there is no huge relationship between educators' earlier information and potentially experience in the utilization of wearables and subsequently the capacity to effectively foster wearable homeroom rehearses [3]. Instructors need formal preparing, yet in addition consistent and continuous help from their companions to assist them with tracking down the most ideal way of coordinating innovation into their educating. The utilization of wearables can upgrade educators' expert information and abilities by empowering new types of joint effort between instructors. Educators figure out how to improve their homerooms from a static climate where there is a single direction stream of information from instructor to understudy, to an understudy focused unique climate where understudies interface with peers collectively, both in their own study halls and in the virtual classroom.

Obviously, precise abilities cannot be attained without universal talents, and therefore general abilities are not very useful if teachers do not have detailed abilities to relate wearable clothing in their teaching activities. Zheng et al. [16] identifies four main approaches by which the laptop could be adopted for teacher training and professional development.

This last purpose shifts the stress to construing wearable as a result of the medium additionally because the message of teacher education. Oni and Adebisi [11] concludes that it's potential to support acceptable and property teacher education programme is immense, however that we have got barely began to grapple with these problems effectively. It looks that wearable tools currently gift an opportunity to influence the growing shortage of qualified academics in SSA, and whereas full-time, centre-based teacher education is impractical for in-service provision, a mix

Figure 2.
Portable model in a continuum of portable application approaches for teacher education and development.

of victimization wearable for open and distance learning [8], indicate that alone this could bring its own problems) aboard school-based teacher development offers an attainable and relatively cheap solution (**Figure 2**).

5. Wearable in education

There are few empirical studies that examine the employment of wearable technologies in education [6]. Tella et al. [5] tested the utilization of Google glass medical training. The analysis team terminated that wearable devices have the potential to provide distinctive potentialities in role-play-based learning contexts. Another study examined the employment of Google Glass [18] in academic psychology, and so the researchers terminated that this technology fits seamlessly into the teachings, permitting students to need images and video recordings of learning activities.

Certainly, there are several pedagogic possibilities additionally as problems related to the utilization of wearable technologies. However, so as for academics to integrate wearable technologies into their learning styles and to effectively use them among the classroom, they have to 1st perceive the potential areas of use of the devices [20]. Within education there has been analysis examining however wrist-worn devices will support and assist students with intellectual and organic process disabilities in learning [11]. Oni and Adebisi [11] concluded that wearable have promising potential to support students by conducive to their autonomy and reducing the stigma of obtaining a personal assistant who follows and monitors the disabled students' activities. The potential use of wearable has additionally been studied in regard to e-learning [3, 13, 18, 19], wherever analysis targeted on how the blending of wearable technologies with e-learning systems may support omnipresent learning and collaboration. A study by [6, 17] emphasized moral problems with the employment of wearable in education. Besides the pedagogic opportunities, there are major considerations in terms of privacy, copyright and accessibility There have additionally been studies on using physical activities aboard wearable pursuit technology as a begin line to indicate students regarding acquisition and applied math data. These findings imply a principle for the potential of wearable computers in education, throughout this study; we tend to conceive to understand however wearable computers are used and plan to gain insight into the challenges which can arise in using this kind of technology among the classroom.

6. Methodology

This study was conducted in all departments at Tai Solarin University of Education, Nigeria as a pilot study. Thirty (30) Lecturers in different faculties participated in the study. There were two surveys used for this study. The survey consisted of 15 items and the quarterly survey consisted of 10 items. The items used from these surveys were intended to measure general perceptions of and intention to use mobile technology. Specifically, it included perceptions of: education, hindrances to the adoption of technologies, and participants' intentions to use the device in their own practice. Upon completion of the research they were asked if they would continue the utilization of the Smartwatch in their educational settings.

6.1 Research setting

Tai Solarin University of Education, Nigeria was purposefully selected as the case study for the study. The selection of the school was based on the fact that it is a pioneer University of Education, located in a rural community, and serving educational needs of people living in that rural community and beyond.

6.2 Data collection and analysis

Two types of data were collected for this study: responses to online surveys and information from focus groups. The researcher asked participants to fill out a series of surveys at the start of the study and then at 3 months. These surveys were distributed via physical means. The surveys asked about everyday use of the Smartwatch and did not collect any sensitive information. The raw data was put into SPSS for basic statistical analysis, including descriptive statistics and 297/parametric analysis. SPSS was used to analyze archival data of the initial survey as well as the follow-up surveys administered after 3 months. The researcher used quantitative inquiry to investigate educational professionals' perception and use of Smartwatch devices in curriculum dissemination. We examined whether the participants' usage rates increased from the start of the of the research study to its completion by applying an Independent Samples t-Test to all responses to the three common questions of the two surveys. We used an Independent Samples t-Test to compare means. In an attempt to examine lecturers' differences in Smartwatch usage, a one-way ANOVA was used to compare the mean response between lecturers and determine whether the type of exposure may have influenced any part of the results.

6.3 Results

The purpose of this study was to identify lecturers' perceptions about the use of Smartwatch technologies for educational enhancement. The results section provides data analysis results about lecturers' perceptions to use of mobile technologies, particularly Smartwatch technology.

6.4 Demographic data

Initial data was collected from 30 participants; at the end of the study, 5 participants were lost at follow-up (N = 25). The demographic data of age, gender, highest level of education, and gender are shown in the following **Tables 1**–**3**.

Table 1 shows that the most common age range among participants was 30–39 years old (37%). The least common age group was 40–49 years old (13%).

Table 2 reflects the highest levels of education for participants in the study. A total of 15 individuals (65% of participants) had a post-graduate degree. The researcher assumed that individuals in this category were comprised of Professors and Associate Professors. A total of 10 (35%) had a least a Bachelor's degree; we can confidently assume that these individuals accounted for the lecturers generalization.

Table 3 reflects the gender of participants enrolled in the study. A total of 17 participants (61%) identified as male. Traditional lecturers are male so this level of participation is representative of the population.

Table 4 indicates how many participants were already using wearable technology at the time of enrolment. A total of 17 participants (71.15%) were not currently using wearable technology.

Table 5 indicates lecturers' perceptions of the value and utility of wearable technology. Mixed reviews on the value of wearable technology for educational enhancement were seen. While perceptions of value of wearable technology at baseline were mostly classified into the "agree" (range: 32–47%) and "strongly agree" (range: 35–47%) category for all of the six questions, there were also some lecturers

Age	Percentage (%)	Count
18–29	27.78	5
30–39	37.04	5
40–49	12.96	5
50+	22.22	10
TOTAL	**100**	**25**

Table 1.
Age of participants.

Response	Percentage (%)	Count
Bachelor's degree	35.5	10
Post-graduate degree	64.5	15
TOTAL	100	25

Table 2.
Lecturers' highest level of education.

Response	Percentage (%)	Count
Female	38.89	8
Male	61.11	17
TOTAL	100	25

Table 3.
Gender of study participants.

Response	Percentage (%)	Count
Yes	28.85	8
No	71.15	17
TOTAL	100	25

Table 4.
Current use of wearable technology.

who answered "neither agree nor disagree" (range: 10–28%). These mixed results may be attributed to the fact that some lecturers were unfamiliar with the use of wearable technology, as noted in **Table 4**.

6.5 Descriptive statistics

Researcher used an Independent Samples t-Test to compare the means of the two surveys. For the statement, "My Smartwatch is a valuable education tool," participants' perception of value at 1 month ($M = 3.49$, $SD = 1.05$; $t [96] = 1.29$, p value 0.2) was slightly higher than their perception of its value at the end of the 12-month study ($M = 3.20$, $SD = 1.79$). There was no significant difference in means. During the one-month follow-up, lecturers' rates of "agree" and "neither agree nor disagree" responses to this statement were comparable to those at the 3-month follow-up. There was a trend of decreasing perception of the value of the Smartwatch for education at the end of the study (**Figure 3**). After examined differences in Smartwatch usage. A one-way ANOVA was used to compare the mean response between lecturers and thereby determine whether the type of enhancement may have influenced any part of the results. We found no statistically significant difference between the group means ($p > .05$). Therefore, we cannot reject the null hypothesis, and we cannot accept the alternative hypothesis.

6.6 Discussion and recommendations

The study focuses on the awareness, inclusion and implementation of wearable in enhancing educational development in rural areas. A pilot study was conducted in Tai Solarin University of Education, Nigeria, to authenticate the objectives of the study. It was revealed that even though the utilization of wearable is not required,

Question	Strongly disagree (%)	Disagree (%)	Neither agree nor disagree	Agree (%)	Strongly agree (%)	Total
Wearable technology devices are valuable educational tools.	4	0	12	47	33	17
Wearable technology devices are valuable assessment tools.	2	0	10	45	43	21
Wearable technology makes it easier to communicate with colleagues.	2	2	14	35	47	20
Wearable technology facilitates increased productivity and efficiency at work.	2	2	16	45	35	25
Wearable technology can help students achieve better health outcomes.	2	0	26	36	36	24
Wearable technology can facilitate better students awareness	2	0	28	32	38	22

Table 5.
Perceptions of value of wearable technology by lecturers.

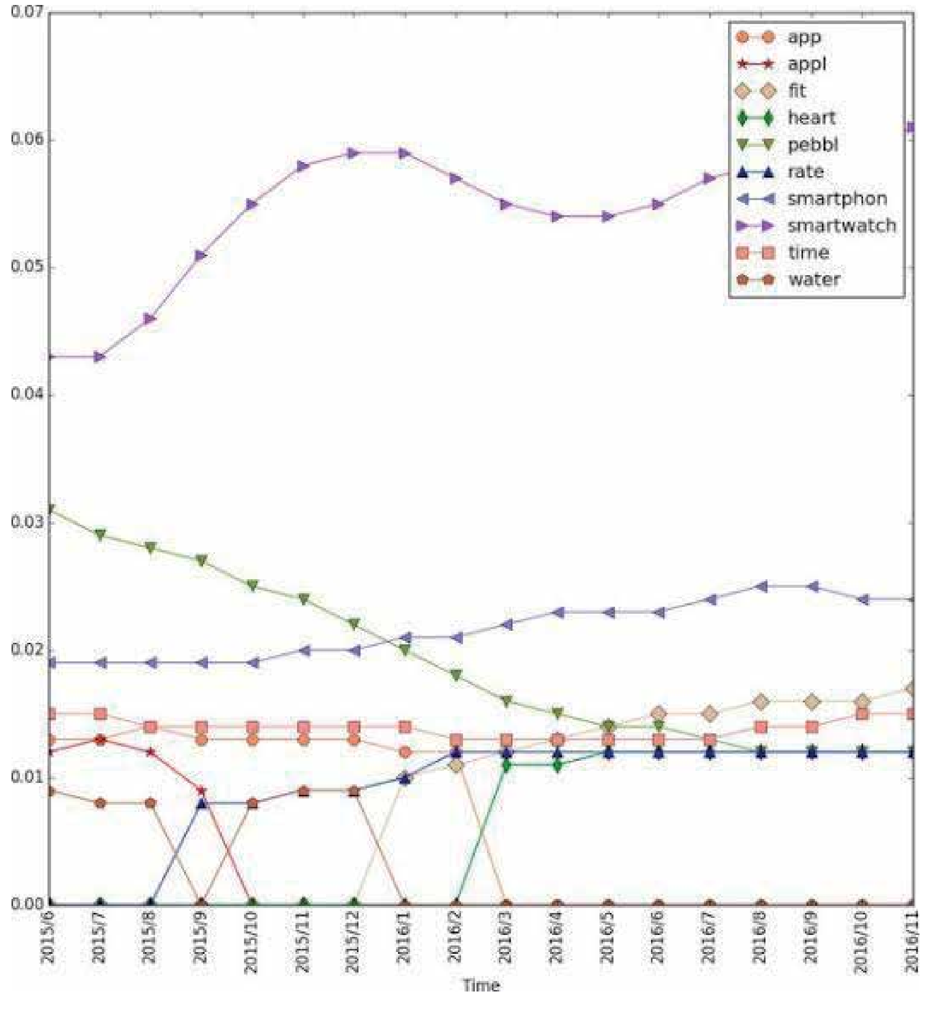

Figure 3.
Graphical trends in wearable technology usage.

nevertheless the magnitude of acceptance among the staffs is still low-slung. The challenges to wearable practice among academic personnel arrays commencing from insufficient resources, incapacitated training, inadequate finance by the college management, incapability to acquire personal ICT facilities, inadequate ICT facilities at workstation, poor power supply, inadequate ICT knowledge, deficient time due to capability, inadequate interest in learning.

The use of printing technologies may include learning from electronic books and other computerized support systems. Positive visual learning strategies can include digital storytelling using multimedia software / presentations or story creation websites. By actively participating in digital storytelling and visual support, students have the advantage that they can draw pictures and images in their own words. In terms of high-tech support, there are support materials that would help the reception of the students and materials that would help in the class. There is a wide variety of educational software that is used to improve reading skills. These include The Waterford Early course of study (www.waterford.org), Headsprout Early Reading (www.headsprout.com), PLATO Focus (www.plato.com), Academy of Reading (www.autoskill.com), LeapTrack (www.leapfrogschool.com/), READ 180 (www.hmhco.com/products/read-180), Scholastic (http://www.scholastic.com/home/), Knowledge Box Central (www. knowledgeboxcentral.com/), and Pearson Digital Learning (www.pearsonschool. com).

Recommendations made were that, all employed teachers in Federal, State and personal schools should undertake mandatory training and retraining on ICT programmes in introducing them to new technological trends in enhancing teaching and learning within the 21st Century. This is usually to supply them with sensible and useful information of computer, internet and associated areas of ICT for improved effectiveness and potency. The government ought to develop policies and pointers that may support teachers in their educational work and students in their learning.

Author details

Ayodeji Olayemi Obafemi
Department of Educational Technology, University of Ilorin, Ilorin, Nigeria

*Address all correspondence to: ayodejiobafemi37@gmail.comv

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Chapter 19

Functional Model for Emotional Information Processing: A Validated Model to Support Social Competence of Students with ADHD

Mourad Ali Eissa Saad

Abstract

Many students with ADHD have emotional dysregulation which is increasingly recognized as a core feature of attention-deficit/hyperactivity disorder (ADHD). Functional Model for Emotional Information Processing is supposed to be a useful tool to be used when observing, explaining, and predicting a human being while responding to emotional scenarios. It is a promising model to support social competence of students with ADHD. While research on this model is still in its infancy, it borrowed much of its theoretical base from both Crick and Dodge's SIP model and Mayer and Salovey's ability EI. It is a useful to improve social competence of children with ADHD.

Keywords: Functional Model for Emotional Information Processing, Social Competence, Students with ADHD

1. Introduction

Functional Model for Emotional Information Processing [1] is supposed to be a useful tool to be used when observing, explaining, and predicting a human being while responding to emotional scenarios. As shown in **Figure 1**, this model involves 5 steps, borrowed from Crick and Dodge's SIP model. They are: Encoding, Cue Interpretation, Goal Articulation, Response Selection and Prediction, and Enactment.

2. Step 1: encoding

When an individual (student here) faces an emotional event and its internal and external cues, the first step he/she performs is to attend to it. This is what is called encoding in Functional Model for Emotional Information Processing [2]. With the help of social cues, environmental conditions, and personal beliefs, an individual must be able to attend to, perceive, interpret, and categorize information. This information is of sure related to the setting. When thinking deeply of this first step,

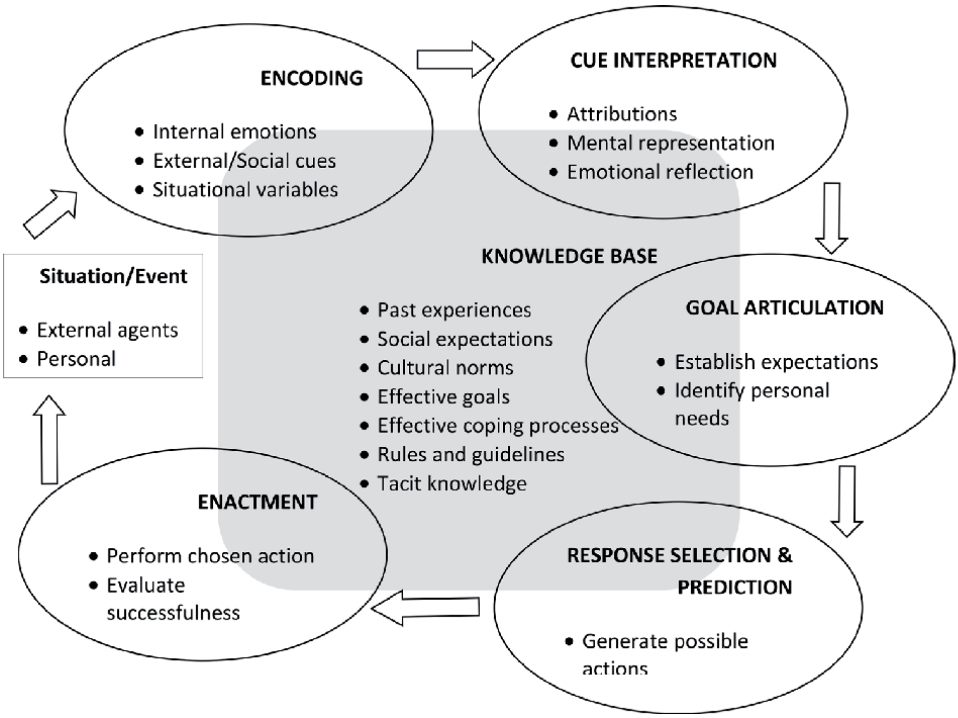

Figure 1.
Emotional information processing model.

one guess how it is related to the first branch of Mayer and Salovey's ability EI model where an individual is supposed to perceive emotions. The individual recognizes and examines emotions that have an internal locus as well as information gathered from others that they interact with [2]. While emotional dysregulation is increasingly recognized as a core feature of attention-deficit/hyperactivity disorder (ADHD) [3], and thus need to be trained in, those with high ability EI are able to master this ability, and thus can easily interpret emotional data. This mastery of encoding personal emotional messages helps us identify our own emotional states as well as others' emotional states or tendencies. Additionally, it limits biased interpretations of situational factors [2].

3. Step 2: cue interpretation

One guesses that this step can be said to be an extension of the previous one; that is, encoding process. When the individual attends to and perceives the information from the social and internal systems, he is supposed now to be able to interpret the meaning that those cues want to convey. This step goes from the same direction of the emotional integration and understanding branches in Mayer and Salovey's ability model. This step helps interpreting and understanding the cues received in the encoding step, and triggering cognitive actions related to processing the emotional event. Moreover, the emotional information that has been processed can have implications. While students with ADHD may have a deficient knowledge base which may will lead to poor interpretation of social or internal cues, misattribution of intent from others, or inaccurate labeling of emotional states (e.g., confusing anxiety with anger) [4, 5], those with high EI have a strong representation for emotional knowledge or have an elaborate and detailed repository of tacit knowledge that can guide the interpretation of practical situations [2].

4. Step 3: goal articulation

This steps comes after interpreting the social and personal cues in the emotional event by the individual. These goals supports the individual in his endeavor to produce specific outcomes. It also help him/her to refer back to past situations as well as examine social and cultural acceptance for specific goal frameworks. While students with ADHD are emotionally dysregulated, and may set "poor goals" [6], this knowledge base helps other students promote positive behavioral action and self-regulation, and thus can establish "good goals" [2].

5. Step 4: response selection and prediction

This an in-depth step where the individual comes to examine his/her interpretation of the situation, thinks deeply of the goal he/she has established for the situation, and accordingly, he/she generates valid solutions that may meet the goal within the situational parameters. While children and adults with ADHD are said to have lower ability in recognizing emotions [7], and thus those children are less successful than their peers in understanding social cues, are not flexible in their responses and are incapable of modifying their behavior according to the demands of environmental changes [8–11], those with high EI will have an involved base of social and cultural knowledge to help determine effective solutions for specific contexts, a repository of potential solutions to choose from, and the ability to weigh the potential outcomes for selected responses [2].

6. Step 5: enactment

His is considered to be the application step where the individual is supposed to carry out the selected response or coping strategy, the enactment of the solution naturally changes the emotional situation. Then, he/she go back again to first step to determine the efficacy of the chosen solution, the change in emotional state caused by the coping strategy, and the current needs facing him/her [2].

6.1 Using functional model for emotional information processing to support social competence of students with ADHD

ADHD is a neurodevelopmental disorder characterized by impulsivity, hyperactivity, and/or inattention according to the Diagnostic and Statistical Manual of Mental Disorders 5th edition (DSM-5) ([12]; American Psychiatric Association, 2013; [13]). Children with ADHD may have difficulties in controlling their behavior. These difficulties, in return, may lead to their failure in school and may show showing difficulties in interpreting social cues, in their interpersonal skills, and therefore, in their relationships with others, which are often not as satisfactory as they should be [14]. Children with ADHD are not able to maintain interpersonal relationships with their classmates [15].

Functional Model for Emotional Information Processing was found to be a useful to support social competence of students with ADHD. Eissa [2], in a study, which was supposed to be a practical application of this model, investigated the positive effects on the Social Competency in first grade children with ADHD. The effects of training using Cassady and Justin's Functional Model for Emotional Information Processing on social competence of first grade children with ADHD were assessed using Mann–Whitney U test, Wilcoxon signed-rank test, and Z Value.

Findings from this study indicated the effectiveness of the Emotional Information Processing (EIP) model Intervention employed in increasing Social Competency of the target children.

7. Conclusion

Emotional Information Processing (EIP) model may be a useful tool to observe, explain, and predict human agency in response to emotional scenarios. This model can be considered a framework for further research and application. It can be a promising model for improving certain behaviors in children, especially those with ADHD.

Author details

Mourad Ali Eissa Saad
KIE University, Egypt

*Address all correspondence to: profmouradali@gmail.com

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Chapter 20

Educational Intervention in Social-Emotional Competence in Students with Autism Spectrum Disorders (ASD)

Marina Jodra

Abstract

The core symptoms of Autism Spectrum Disorders (ASD) consist in the presence of difficulties in social communication, flexibility and imagination, in addition to presenting comorbidity with other psychiatric disorders and medical pathologies. This characteristic symptomatology of autism has repercussions on learning environments, which must adapt to them and become inclusive and pleasant environments. This chapter analyzes the social–emotional symptoms of ASD, their direct repercussions on the learning style of these students and their influence on educational environments. Regarding social communication, the socioemotional style and communication characteristics are analyzed in order to understand the need of specific programs for socioemotional development and specific training for professionals. From this perspective, the need to structure environments and activities, reduce and adjust the number and intensity of stimuli or implement emotional stimulation activities, among others, is explained.

Keywords: Autism Spectrum Disorders, socioemotional development, Theory of Mind, educational intervention

1. Introduction

From the first descriptions of cases of people with Autism Spectrum Disorders (ASD), special emphasis is placed on the difficulties observed in the social area. Reading the description of cases made by Leo Kanner [1] it can already be appreciated that this social dysfunction is nuclear in these persons, with observations such as: "none of these remarks was meant to have communicative value. There was, on his side, no affective tie to people. He behave as if people as such did not matter or ever exist. It made no difference wether one spoke to him in a friendly or harsh way. He never looked up at people's faces. He allowed his boarding mother's hands to dress him, paying not the slightest attention to her" (pp. 127–128).

Currently, the deficit in the social–emotional area is one of the 2 diagnostic criteria necessary when diagnosing an ASD. In the DSM-5 it appears as the first symptomatic domain together with communication disturbances [2].

For its part, the World Health Organization (WHO) considers that there are persistent deficits in the ability to initiate or maintain social interactions and social communication [3].

One of the main theories in ASD considers that the social–emotional deficit is the result of the various difficulties observed in people with autism in the capacity of mentalization or theory of mind [4, 5]. This deficit implies a difficulty in understanding "other minds", the intentions, emotions and thoughts of others, also affecting the ability to empathize with other people [6].

The socioemotional deficit in autism could also be explained by the theory of "weak central coherence" [4, 7]. According to this theory, people with ASD tend to have a more fragmented perception of reality, which leads to the development of a socioemotional deficit since the social world is characterized by the demand for rapid integration of contextualized information. Weak central coherence is explained by studies showing low connectivity between some brain regions; this atypical functioning could be the reason why people with autism do not adequately use social cues to understand social–emotional phenomena [8].

Baron-Cohen [9] also speaks of the Empathy-Systemizing Theory to understand the socioemotional profile of people with ASD. This theory classifies people according to empathy and systemizing abilities: Type E, empathy more developed than systemizing ("female brain"); Type S, systemizing more developed than empathy ("male brains"); Type B, similar scores in both empathy and systemizing; Type E Extreme, very high scores in empathy and very low scores in systemizing; and Type S Extreme, very high scores in systemizing and very low scores in empathy. This theory argues that people with ASD tend to score higher on systemizing and lower on empathy, approaching Type S Extreme. This would partly explain the social behavior and cognitive profile of these individuals.

The few longitudinal studies about the progress of emotional competence in people with ASD speak of the influence of IQ on this development [10]. Social context, chronological age, or symptom severity, also has a strong influence on emotional competence [11, 12] but most research studies emotional recognition in isolated laboratory situations. There is debate about whether these assessments possess predictive ability over spontaneous behaviors in natural conditions [13].

2. What do we know about emotional perception in people with ASD?

Within the social–emotional area we can talk about expression, perception, comprehension and response to simple and complex emotions. There is a significant number of studies that defend the existence of a deficit in people with autism in the recognition and understanding of emotions, after comparing them with control groups [12, 14, 15]. Some studies delimit the deficit in the recognition of specific emotions such as fear, sadness or "negative" emotions, showing in general lines less attention towards them [16]. This deficit in emotion recognition is accompanied by a certain lack of interest on the part of people with autism towards the emotions of others, and less attention to social stimuli. In addition, people with autism are less expressive in social interactions, showing more neutral expressions than people with intellectual disability and typical development without ASD [17].

Emotional recognition has also been studied in people with High Functioning Autistic Disorder or Asperger Syndrome, observing an adequate recognition when dealing with simple emotions and a deficient recognition when emotions are more complex [18], when dynamic social scenes are presented to evaluate complex emotions or mental states and less coherence when interpreting emotional events. On the other hand, a deficit has also been observed in identifying and describing one's own emotions and in other basic skills in social–emotional development such as imitation or joint [19]. In addition to observing a problem in people with high-functioning autism when processing their own emotions, a greater tendency to have depressive traits and show more negative emotional responses has also been observed [20].

Regarding the ability to respond to the emotions of others, atypical behaviors have also been detected in persons with ASD. Responses tend to be less empathic and less pulsation has been recorded in persons with ASD in response to others' emotions, compared to typically developing persons. In people with intellectual disabilities and autism, less arousal was observed in response to the gaze direction of another person or to dangerous situations [21].

In the specific case of emotion recognition through the face, a dysfunction has been observed in people with autism [22], being for many theorists a core deficit of the disorder. This deficit manifests itself with both static and dynamic stimuli.

In studies with children with autism, less attention to faces and a deficient response to the human voice are observed. In general terms, 1- and 2-year-old children with ASD show difficulties in directing attention to social scenes, both to faces and to the activities shared among the protagonists of the scene. This deficit is central to the later development of language or social skills [23].

Many theorists believe that the deficit in face recognition is one of the first indicators of an atypical development of the "autistic brain" and one of the basic pillars that enable the subsequent development of more complex abilities such as empathy or those that enable social adaptation in adults with ASD and intellectual disabilities [14]. The existence of an evident correlation between verbal ability and the identification of emotions leads to a certain caution when interpreting all these findings.

Studies on mechanisms of rapid extraction of emotional content using facial stimuli have shown a deficit in groups with ASD compared to typically developing groups [24]. Individuals with autism with intellectual disabilities have also shown difficulties in identifying age or gender through the face, when performing face memory tasks, or in detecting small changes in gaze direction.

Along with this deficit in the processing of information through faces, people with autism have also shown different patterns of gaze fixation when perceiving social scenes [25, 26] and faces. In particular, less gaze fixation time was observed in people with autism in the eyes of the face they are perceiving, the eye area being one of the areas that provides the most information about the mental state of others. On the other hand, there are also studies that have observed that people with autism have different patterns when looking at the mouth of the perceived face. In some research, people with ASD who perform worse on emotional recognition tests were shown to look less at the eyes and more at the mouth than those who performed better. In general, people with ASD show greater attention to these areas of the face during face recognition tasks and during face gaze [22, 27]. It has come to be found that decreased gaze fixation on the eyes of the other is a typical response pattern in infants aged 2 to 6 months who are subsequently diagnosed with ASD [28].

3. Phases of development in the theory of mind

In order to study in depth the development of social–emotional competence, it is important to analyze the precursors of the understanding of the mind and, subsequently, to review the development of the Theory of Mind, which can be defined as the ability to understand the knowledge, intentions, emotions and beliefs of other people and, thus, predict their behavior (**Figure 1**).

We could speak of the following skills as precursors to the ability to mentalize:

Joint attention.

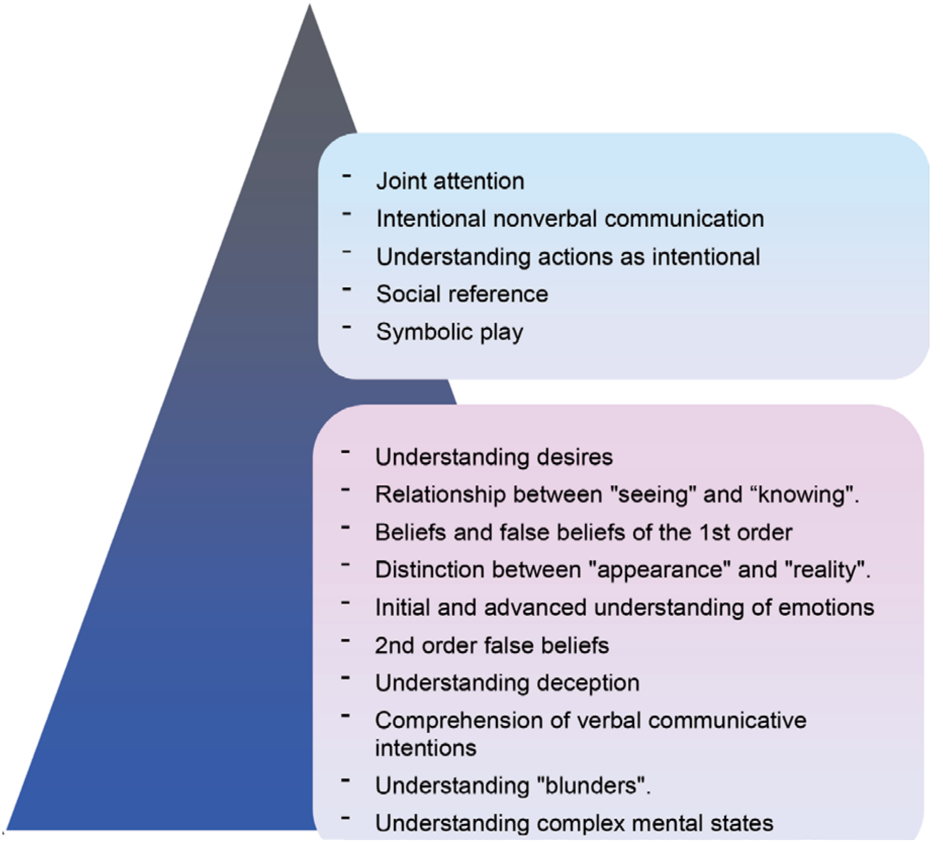

Figure 1.
Precursors and development of the theory of mind.

It is one of the key milestones in the development of infant understanding of the mind. It is not until 9 months when joint attention emerges [29, 30], before that the infant is not able to pay simultaneous attention to the object and the adult.

The development of joint attention is considered an important change in cognitive and social development, along with the ability to alternate gaze between a person and an object, follow the direction of gaze or the use of gestures to indicate or point. From this point on, the interactions established by the infant will change significantly and contribute to the later development of social-cognitive and linguistic skills [31].

Intentional non-verbal communication.

Towards the end of the first year of life, the child begins to use gestures with a communicative intentionality, to direct the adult’s attention to an event or object. Signaling begins as proto-imperative, with the aim of directing the other’s attention to a specific object, and also proto-declarative, to share interest and attention with another person. This declarative function is considered a precursor of Theory of Mind, as it implies that the child conceives of other people as intentional beings with psychological and mental states distinct from his or her own [32].

Understanding actions as intentional.

The ability to differentiate people from objects develops during the first year of life and, during the first months, infants begin to show a greater interest in social stimuli such as faces, voices or human movements [33].

Later, between 9 and 18 months, children begin to understand that people have intentions and, moreover, these intentions may be different from one's own and do not have to correspond to the actual situation [34].

Social reference.

Social referencing refers to the child's understanding that the reference adult attributes positive or negative qualities to people, objects and situations, and that this information is reflected in his or her emotional reactions. From 12 months onwards, children begin to manifest the acquisition of this social referencing [35], and begin to use the mother's emotional expressions to guide behavior.

Symbolic play or simulation activities.

From the second year of life, between 18 and 24 months, children begin to engage in fictional play and develop it until the age of 4 or 5 years. In symbolic play, real identity and fictional identity are decoupled, and this skill is equivalent to the skill needed to perform false-belief tasks [36].

Use of mental terms in spontaneous speech acts.

From the second year of life onwards, mentalistic terms such as "know", "think" or "wish" begin to be used in conversations. More specifically, at 2 years and 4 months, more than half of the children use verbs related to desires such as want and wish. From the age of 3 years onwards, other verbs related to mental states such as think and know begin to be used [37].

As for the main evolutionary milestones in the development of Theory of Mind, we can talk about:

Understanding desires.

By 18 months, children are able to understand that a person may have desires that are different from their own [38]. Between the ages of 2 and 3 years, they begin to understand the relationship between desires and the emotions they trigger, as well as the relationship between desire and action [39].

Understanding the relationship between seeing and knowing.

Between the ages of 3 and 4, typically developing children begin to understand how knowledge is closely related to experience, i.e., they understand the relationship between seeing and knowing [40].

Understanding beliefs and first-order false beliefs.

The ability to understand the difference between belief and reality is critical in the development of Theory of Mind. Between the ages of 3 and 4, children begin to use information about beliefs, true or false, to explain and predict other people's behavior.

In relation to the development of the Theory of Mind, as seen in Module 1, research has focused on studying mainly false belief [41] by means of location change or location change tasks. In this type of task, character 1 hides an object, leaves the scene and character 2 enters and changes the location of this object; when character 1 re-enters, the question is: Where will "character 1" look for the object he/she hid? It is considered that adequately solving this type of task is a marker of the presence of Theory of Mind, since it is necessary to understand that the character has a false belief and to distinguish it from one's own and, secondly, one has to predict the character's behavior from his belief. One of the emblematic location switching tasks is the "Sally and Anne task" [41].

Another type of tasks used to assess first-order false belief are unexpected content tasks, which involve a lower cognitive demand. In these tasks, they are shown a box, such as a box of "Lacasitos", and are asked what they think will be inside the jar, then they are shown the actual contents of the tube, for example a pencil. Subsequently, they are asked to say what they thought was inside the tube and what another child, who had not seen the contents of the tube, would think was inside the tube.

It is commonly accepted that the understanding of false belief emerges around the age of 4 years [42].

Distinction between appearance and reality.

In relation to children's cognitive development, the distinction between appearance and reality was investigated by Flavell and coworkers [43], who investigated this ability using a sponge that looked like a stone. When asked what the object looked like and what it actually was, children under 4 years of age answered the same on both questions, while 4-year-olds were able to distinguish between appearance and reality. These types of tasks are closely related to false belief tasks and have therefore been used on occasion to assess this ability.

Initial understanding of emotions.

The expression and understanding of emotions is crucial to make sense of the social context and to perform coherently and is closely related to the understanding of false beliefs [44].

Its development emerges very early during infant development. Infants at 4 weeks react with a smile when smiled at, by the end of the first year they begin to use the facial expressions of their caregivers to guide their behavior, and at about 2 years of age they begin to use emotional terms such as sad or angry in their conversations [35]. Between the ages of 3 and 4 years, children turn to wishes to explain the emotions of others, so they begin to understand the relationship between satisfying or not satisfying a wish and being happy or sad about it. Between 5 and 6 years of age, children are already able to understand the relationship between beliefs and desires and emotions [45].

Advanced understanding of emotions.

The understanding of more complex emotions such as disappointment or fear, in relation to other mental states, appears between 7 and 8 years of age. The understanding of secondary emotions such as pride, shame or guilt, in which aspects of self-worth are involved, also appears later.

As for experiencing two emotions simultaneously, between 7 and 8 years of age children are able to understand that this can happen with two emotions of the same valence (both positive or both negative), and it is not until about 10 years of age that they are able to conceive that the same person can experience two emotions of opposite valence at the same time.

On the other hand, the ability to distinguish between real emotions and feigned emotions is acquired gradually between 6 and 11 years of age [46].

Understanding second-order false beliefs.

Perner and Wimmer [47] began to study second-order false beliefs, which are those that include a propositional attitude of another person to a first-order belief. An example would be "Mary thinks that John thinks that chocolate is in the refrigerator."

Comprehension of these tasks does not begin to be appreciated until 5 or 6 years of age and is refined over subsequent years [48].

Understanding deception.

In the acts of deception, desires and emotions play an important role; it is a manipulation of information that aims to generate a false belief in another person. This capacity begins to be acquired from the age of 3–4 years, and is definitively acquired from the age of 6 or 7 years [49].

Understanding of verbal communicative intentions.

Both indirect speech acts and figurative language are closely related to the development of Theory of Mind. The most studied aspects have been the understanding of lies and irony. Comprehension of non-literal meanings is acquired around adolescence and figurative language from the age of 8 [50]. As for the comprehension of white lies, it occurs between 5 and 7 years of age and is perfected in later years. Finally, comprehension of ironic messages begins to occur between the ages of 5 and 6 years and improves over time [51].

Typical development		**Development in ASD**	
Months	**Social interaction**	**Months**	**Social interaction**
2	Turns head and eyes in the direction of the source of the sound. Social smile.		
3	They begin to use the "prolonged mutual gaze" as an acceptance of eye dialog.	3	They tend not to use "mutual gaze" to initiate eye dialog.
6	Extends arms in anticipation of being picked up. Repeats actions when imitated by an adult.	6	Less active and demanding attitude. A minority are extremely irritable. Little eye contact. No anticipatory social responses.
8	Difference between parents and strangers. Plays "give and take" object exchange games with adults. Plays peek-a-boo and similar games with a script. Shows objects to adults. Waves goodbye. Cries and/or crawls after mother.	8	Difficult to calm when restless. Approximately 1/3 are extremely introverted and may reject interaction.
12	Child initiates games more frequently. Assumes active and passive role in turn-taking games. Increased eye contact.	12	Sociability often declines when the child begins to crawl or walk. No distress with separation.
18	Play with other children begins: show, offer, take toys. Solitary or parallel play is still more typical.		
24	Episodes of play with other children are brief and are usually related to gross motor activity (e.g., chase games) rather than sharing toys.	24	Usually differentiates parents from other people, but expresses little affection. May give a hug or kiss as an automatic gesture if asked. Indifferent to adults other than parents. May develop intense fears. Prefers to be alone.
36	Learns to take turns and share with other children. Episodes of prolonged collaborative interaction with other children. Altercations between children are frequent. Enjoys helping parents with household chores. Likes to be noticed to make others laugh. Wants to please parents.	36	Failure to accept other children. Excessive irritability. Failure to understand the meaning of punishment.
48	Negotiates roles with peers in social simulation games. Has preferred playmates. Peers verbally (and sometimes physically) exclude unwelcome children from play.	48	Unable to understand roles in play with other children.
60	More oriented to other children than to adults. Intense interest in making friends. Fighting and name-calling with other children is common. Able to change roles, from leader to follower, in play with other children.	60	More adult-oriented than other children. Often becomes more social, but interactions remain awkward and one-sided.

Table 1.
Development of social–emotional competence in typically developing persons and persons with ASD [54].

Understanding of "blunders".

Detecting a "gaffe" involves differentiating between the knowledge of the speaker and the listener and understanding the emotional impact that the speaker's message may have on the listener. This understanding is closely related to advanced social understanding and begins to develop by age 7, with improvement occurring until age 11 [52].

Understanding of other complex mental states.

The understanding of complex mental states includes perception and interpretation through facial expressions, and especially, through gaze. As for the tasks of emotional understanding through gaze, it is observed how it develops between 6 and 13 years of age [53].

Synthesizing everything seen so far, **Table 1** shows a summary of the development of social–emotional competence in people with typical development and people with ASD.

4. Development of intervention programs in the socioemotional area for people with ASD

> *Like an Everest, snowy, immense, indifferent and distant, autism challenges us. We must do something to be able to accompany in its development the child whom nature seems to have sentenced to a condemnation of inevitable solitude... [55, p. 27].*

When developing intervention programs for people with ASD, several aspects must be taken into account. As we have seen so far, these people have peculiar patterns of thinking, communication and social interaction, so educational strategies must be adapted to these individual differences in order to achieve the goals set. To develop these educational strategies it is necessary to have specialized personnel, adapted environments (visual aids), coordination between professionals and between school and home, and most importantly, not to make the mistake of trying to get the person with ASD to have the same socio-emotional development as ours. We must help them to interpret the social cues starting from their mind and not from ours, discovering their needs and not projecting ours on them.

The results of previous research on social–emotional development in ASD suggest that through a correct selection of stimuli, appropriate stimulation and accompaniment and guidance in the processes of social–emotional perception, people with autism can present adequate and functional brain activation [56]. As a result of these observations, and with the emergence of new tools such as tablets or virtual reality, many applications and programs have been developed in recent years that accompany, to a greater or lesser extent, people with ASD in their socioemotional development.

4.1 Assessment of social-emotional competence in people with ASD

The preamble of any social–emotional intervention program for people with ASD will be a first evaluation process of this competence in the person. In order to do so, it is necessary to see which skills within the social–emotional competence we are interested in assessing.

To assess social–emotional competence and the skills that are compromised, we have several instruments that can be very useful, in addition to traditional diagnostic tests such as the ADI, M-CHAT, ADOS, etc., since these disorders are characterized by the presence of dysfunction in social–emotional development. Some of these assessment instruments are listed below (**Table 2**).

Name (Authors)	**Skills assessed**
The Sally and Anne Experiment [41]	Understanding 1st order false beliefs
Task of the “Smarties” [57]	Understanding 1st order false beliefs
Autism-Spectrum Quotient (AQ) [58]	Social skills (items 1, 11, 13, 15, 15, 22, 36, 44, 45, 47, 48), attentional change, communication, imagination and attention to detail.
Faux Pas Recognition Test [59]	Understanding “blunders”.
Reading the Mind in the Eyes Task (Revised, Adult Version: RME-R) [58]	Understanding complex emotions and states of mind through gaze
Reading the Mind in the Voice (Test-Revised) [60]	Understanding of complex emotions and mental states through the voice
Reading the Mind in the Films Test [61]	Understanding complex emotions and states of mind through videos
Friendship Questionnaire (FQ) [62]	Interpersonal relationships and friendship
Faces Test [63]	Understanding of basic and complex emotions (states of mind) through the face
The EQ [64]	Degree of empathy
Interview on knowledge of interaction strategies with peers with peers (CEIC) [65]	Strategies for interacting with peers
Vineland Adaptive Behavior Scales (VABS) [66]	Communication, daily living skills, socialization, and motor skills.
IDEA [67]	Social relationship, Joint attention, Affective capacity and inference of mental states, Communicative functions, Expressive language, Receptive language, Anticipatory competence, Mental flexibility, Sense of self-activity, Imagination, Imitation, Capacity to create signifiers.
Social Interaction Skills Questionnaire (CHIS) [68]	Basic social, friendship, conversational, emotional, interpersonal problem solving and adult relationship skills.
Facial Discrimination Battery (FDB) [69]	Recognition of emotions through the face
ACACIA [70]	Social and communicative behavior

Table 2.
Socioemotional competence assessment instruments.

In addition to the evaluation instruments already mentioned, this process must be completed with interviews with parents or relatives and observation of the person in natural contexts.

4.2 Development of social-emotional intervention in the person with ASD

The development in social knowledge of people with autism is not achieved, as we have seen, through the means by which others achieve it. The student with autism does not want to learn aspects that have to do with the social world (or that he/she learns it but refuses to express it), it is that he/she does not know or cannot learn it through natural means. Therefore, it is necessary to program the express teaching of this knowledge, avoiding falling into “deficit-centered teaching”.

Intervention programs for people with ASD should create learning environments to prevent behavioral problems and enhance the development of their skills. We must adapt the techniques to the specific needs and learning styles of these individuals. The essential questions to delimit the educational intervention are: what to teach and how to teach?

1. What to teach?

Choosing target behaviors or strategies for teaching. This task is a critical stage in the planning of the educational intervention, where we must determine the moment of development in which we should focus the intervention. Neurotypical developmental psychology is today the most effective basis for finding these objectives. Therefore, the descriptive and explanatory study of how the child builds, in interaction with other people, his social knowledge is a mandatory subject for anyone who has to plan the educational intervention of students with autism. As a guide, **Table 3** shows a brief list of social skills throughout development.

Based on this idea, the milestones of social development will be rescued to determine the areas of socio-emotional intervention, starting at all times from the potential and motivations of the individual.

2. How to teach?

It is necessary to talk about the need for structuring, predictability, coherence and systematization of teaching as something basic for the student with autism to learn. We could say that the intervention has to go from a high degree of structuring, through the use of visual anticipators, to programmed destructuring (depending on the individual's level of development), which is closer to natural social environments (where the cues are, as we will remember, subtle, complex, transient and varied).

Age	Developed areas
Before 3 years of age	• Joint attention • Non-verbal intentional counseling • Understanding actions as intentional • Social referencing • Symbolic play • Use of mental terms in spontaneous speech
3–4 years	• Understanding of desires • Understanding of the relationship between seeing and knowing • Understanding of 1st order beliefs • Distinction between appearance and reality • Initial understanding of emotions
4–14 years	• Advanced understanding of emotions • Understanding of 2nd order beliefs • Understanding of deception • Understanding of "blunders". • Understanding of complex mental states

Table 3.
Development of social skills.

Also to be pursued in any learning process is its functionality, spontaneity in its use, and generalization, and all this in a motivational environment. Therefore, the education of the student with ASD requires the realization of a double task: the skill must be taught, but also its use must be taught, an adequate, functional, spontaneous and generalized use.

Finally, the best learning system for the student with autism is that of learning without error, in which, based on the aids provided, the child successfully completes the tasks presented to him/her. Afterwards, and little by little, it is necessary to achieve the progressive fading of the aids up to the highest possible levels, which will be in relation to the level of cognitive development.

Two key objectives when building educational environments for social–emotional development will be:

- Eliminate the barriers that the person has to interact with other people (just as architectural barriers are demolished we must demolish the social barriers).

- Accompany the person with ASD in the understanding of social acts.

As in any educational context, the aim is to promote and encourage maximum personal development to achieve the highest possible quality of life.

5. Conclusions

People with ASD have a specific socio-emotional profile that forces us to design educational interventions in coherence with their needs. It is often taken for granted that any child will naturally acquire all the skills related to the social world without support, but this is not the case for students with ASD and they must be accompanied in this process.

In order to design quality interventions, it is essential to know the explanatory theories of autism. In relation to the socio-emotional profile, we need to know the development of the Theory of Mind and the capacities involved. This needs to be accompanied by an individualized assessment of the person, which helps us to answer two core questions; what to teach and how to teach it?

Conflict of interest

The author confirm that she has no financial or nonfinancial conflicts of interest.

Author details

Marina Jodra
Complutense University of Madrid, Madrid, Spain

*Address all correspondence to: majodra@ucm.es

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Chapter 21

Stem Cell Therapy for Learning Disability

Alok Sharma, Nandini Gokulchandran, Hemangi Sane, Sakshi Desai, Pooja Kulkarni and Prerna Badhe

Abstract

Learning disabilities (LDs) are caused by genetic and/or neurological factors that alter brain functioning and affect processes related to learning, which include dyslexia, dysgraphia, and dyscalculia. It hinders the child's academic, social, and overall life skills. Current treatments for LD include medication and rehabilitation, focusing on management of symptoms. Thus, there is a need to explore newer treatments which will work at cellular level. Stem cell therapy is an evolving field of regenerative medicine and has shown great potential as a treatment strategy for various neuro-developmental and neurological disorders. It addresses the core underlying pathology and its benefits are enhanced when combined with standard treatments. This chapter focuses on various aspects of stem cell therapy in LD which includes the basics of stem cell therapy, rationale for use of stem cells, mechanism of action, monitoring tools like PET CT scan, and multidisciplinary rehabilitation. We have also enumerated our clinical experience and results of patients who underwent autologous bone marrow mononuclear cell transplantation combined with extensive rehabilitation. These patients showed a positive outcome, without any major adverse events. Nineteen out of 20 patients showed improvement in reading, writing, mathematical skills, attention, memory, problem-solving, comprehension skills, spelling, vocabulary, and overall increased academic performance.

Keywords: stem cell therapy, learning disability, bone marrow-derived mononuclear stem cells

1. Introduction

Learning disability (LD) is an umbrella term that includes *dyscalculia* or difficulty in calculating numbers, *dysgraphia* or difficulty in writing, and *dyslexia* or reading difficulty [1]. Also known as Specific Learning Disabilities (SLD), it causes the inability to read and comprehend, which is a major obstacle to learning and may have long-term educational, social, and economic implications while interfering with children reaching their full potential [2]. SLD results not from a global intellectual deficit, but from impairments in one or more of the specific processes of speech, language, reading, spelling, writing, or arithmetic. This possibly results from cerebral dysfunction [3]. Neurological differences in brain structure and function affect a person's ability to receive, store, process, retrieve, or communicate information. While the specific nature of these brain-based disorders is still not well understood, considerable progress has been made in mapping some of the characteristic difficulties of

LD to specific brain regions and structures [4]. Hypoxia can lead to hypoperfusion of the brain and the reversal of hypoxia may lead to self-repair and neural proliferation, which is observed in many animal models of cerebral ischemia. Chronic cerebral hypoperfusion to a lesser degree is known to cause neurodegeneration over a period of months to years through neuronal apoptosis without acute infarction [5] and individuals with chronic cerebral hypoperfusion usually have cognitive deficits of varying degrees [6].

Currently, all treatments for LD involve medications and rehabilitative techniques that focus on managing the symptoms. Thus, there is a need to explore other treatments which will work at the cellular level. Stem cell therapy is a new evolving field of regenerative medicine and has shown great potential as a treatment strategy for various disorders such as autism, intellectual disability, and cerebral palsy among many neuro-developmental conditions. It addresses the core underlying pathology of LD. In experimental studies, stem cell therapy has been shown to repair the hypoxia-damaged neural networks and restore the lost neuronal connections [7]. Stem cells, when injected, migrate to the target tissue and differentiate into mature cells. Along with regenerating and restoring the neurons and glial cells, they have a neuroprotective effect [8]. Several vertebrates regenerate tissues and organs, like the salamanders, regenerate lost body parts through the de-differentiation of specialized cells into new precursor cells. These de-differentiated cells then proliferate and later form new specialized cells of the regenerated organ. Stem cells or progenitor cells are the common denominators for nearly all types of regeneration [9]. The goal of stem cell therapy is thus to enable the localization of therapeutic cells to impaired/injured regions of the brain, to stimulate tissue repair and maintenance via a paracrine effect, and potentially even to generate new neurons [10]. Therefore, stem cells, through re-perfusion of the damaged brain regions in SLD can lead to improved neurological functions. This can increase academic performance and chances of employability in the future. Stem cell therapy has shown improved brain function and quality of life in similar neurological impairments such as autism spectrum disorder, cerebral palsy, intellectual disability.

This chapter focuses on the Regenerative capacity of Stem Cell Therapy in learning disability. It has a detailed description of what stem cells are, where they are obtained from, how they are injected into the body, and their mechanism of action. Furthermore, it explains how stem cell therapy results in a positive outcome in children with learning disabilities. We have included neuroimaging techniques such as PET CT brain scan as a monitoring tool to study the effect of stem cell therapy.

2. Unmet medical need

With increasing awareness, the prevalence of learning disability has risen considerably. Most often LD is managed with medications and rehabilitative therapies which include behavioral therapy, alternate methods of learning like remedial education, individualized education plan (IEP), and intervention programs. However, these treatment strategies do not address the underlying neuropathology of LD. Hence, there is a need for a treatment that focuses on cellular repair and further addresses the cognitive deficit.

3. About stem cells

Stem cells provide the building blocks for every organ in the body. They have the unique ability to divide asymmetrically and to differentiate into the various cell types of the body. They simultaneously replicate to maintain a stem cell lineage. Stem cells are present in almost every human tissue. In embryos, they differentiate into all the tissues and organs of the body and provide a renewal capacity in most organs in fully developed humans. In neurological disorders wherein the neurons are damaged or defective, stem cell therapy repairs and replaces damaged/lost neurons [10]. Cell therapy is based on allogenic (patient receives stem cells from a healthy donor), or autologous transplantation (patient receives their own stem cells) of cells, with the goal of regenerating the damaged tissue or organ of the patient and replenishing specific stem cell populations [11].

3.1 Type of stem cells

Classification of stem cells depend on major characteristics such as (**Figure 1**):

- *Source* of stem cells
- *Potency*—the ability to differentiate into different cell types

3.1.1 Based on the source of stem cells

i. *Embryonic Stem Cells* **(ESCs)**—These are pluripotent, derived from the inner cell mass of the blastocyst, a stage of the pre-implantation embryo, 5–6 days post-fertilization [12]. Our understanding of stem cells began with embryonic stem

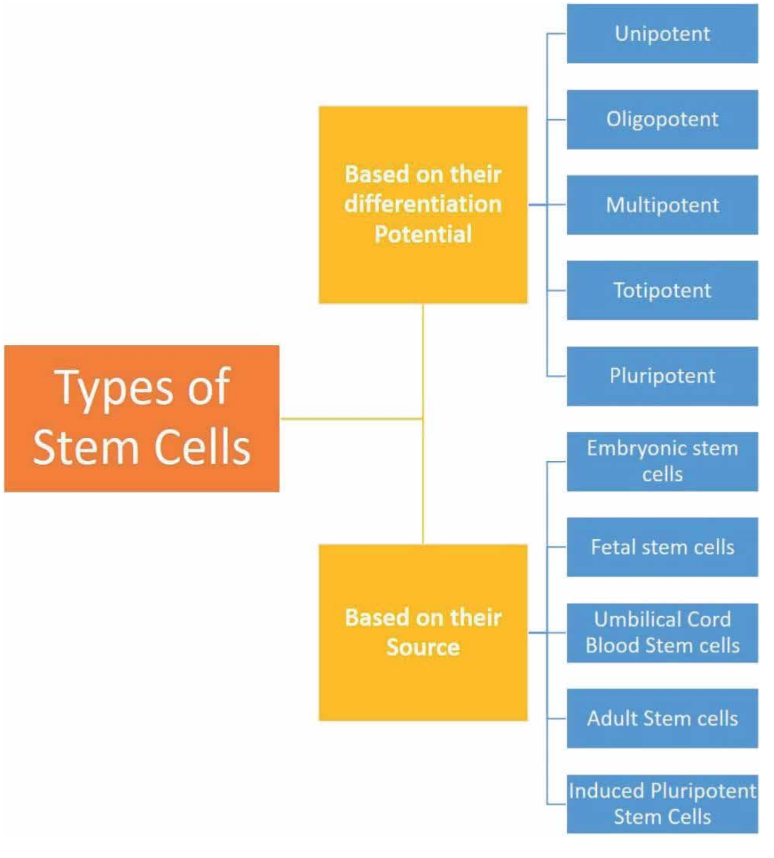

Figure 1.
Types of stem cells based on differentiation potential and source.

cells. They come from a ball of cells called the blastocyst, which forms 5 days after an egg is fertilized and develops into the embryo. In 1998, Professor James Alexander Thomson and his team at the University of Wisconsin-Madison grew the first human embryonic stem cells in a laboratory dish (in vitro). This allowed scientists to learn how the cells function [13]. ES cells have an unmatched capacity for self-renewal and pluripotential. These two factors continue to increase the relative potential of ES cells in cell replacement and regenerative therapies. However, their safety is questionable as they translate into tumors like teratoma and teratocarcinoma *in vivo* which remains the single greatest hurdle to successful ES cell-based therapies. Without rigorous elimination of this possibility, clinical transplantation of Embryonic stem cells will never be safe [14].

ii. *Umbilical Stem Cells*—Human Umbilical cord stem cells have shown the capacity to differentiate into many types of cells in the human body including neurons under appropriate conditions. They have shown the ability to induce the neurorestorative processes of neurogenesis, angiogenesis, and synaptic plasticity that are essential for the recovery of neurological functions [15]. Hematopoietic, endothelial, epithelial, and neural tissues can be derived from umbilical cord blood cells. Thus, transplantation of these stem cells may be a promising therapeutic strategy in neurological disorders.

iii. *Adult Stem Cells-* These are undifferentiated cells derived from adult tissues that divide to replenish dying cells and regenerate damaged tissues. Examples include bone marrow, adipose tissue-derived, neural stem cells among others. These cells have shown to be anti-inflammatory and augment repair in animal models of injury. Mesenchymal Stem Cells which are the most widely present type of cells have the ability of rapid proliferation, differentiation into cell types of endodermal and ectodermal origins, secretions of various trophic factors, and immunomodulatory action, which make them a preferable candidate for cellular therapies [16, 17]. *Bone marrow* is a mixture of various cell types that can be potentially used for regeneration. Bone marrow stem cells can be differentiated into numerous cell types including blood cells and neural cells. These cells act as small biological pumps that secrete cytokines and growth factors with autocrine effects on themselves and paracrine effects on their neighboring resident cells. These actions might stimulate neurogenesis and angiogenesis and may also have a neuroprotective effect [18]. *Adipose*-derived stem cells (ASCs) have become one of the most promising stem cell populations identified so far because they are ubiquitous and can be relatively easily harvested in larger quantities with less donor-site morbidity [19]. Functional experiments indicate that intravenous application of AD-MSCs improves hindlimb motor function through activation of angiogenesis along with upregulation of upstream kinase protein activity, such as ERK1/2 and Akt, in turn promoting cellular survival pathways and tissue-repair mechanisms [20].

iv. *Dental Pulp Stem Cells*—DPSCs are a mesenchymal types of stem cell present inside dental pulp which has osteogenic and chondrogenic potential in vitro and can differentiate into dentin, in vivo [21]. They can proliferate and give rise to identical cells and further differentiate to various cell types such as neuro and adipose cells [22]. In these cells, there is easier surgical access to the collection site, very low morbidity and moreover, can be cryopreserved. DPSCs possess immuno-privilege (able to tolerate the introduction of antigens without eliciting an inflammatory immune response) and anti-inflammatory properties [23]. However, their oncogenic potential is yet to be determined in long-term studies. Research in this area has been mainly confined to animal models and their extensive clinical application is yet to be tested. These stem cells have other limitations such as difficulty in identifying, purifying, and growing them consistently in labs [24].

v. *Fetal Stem Cells*—These can be obtained from cadaveric fetuses following spontaneous abortion, stillbirth, or surgery due to ectopic pregnancy in obstetrics and gynecology hospitals. In addition, such tissue may be derived from elective abortions. The obtained fetal tissue is ordinarily processed and used for grafts in the form of a cell suspension, which is usually intravenously or intraperitoneally injected or, otherwise, transplanted into predefined implant sites during surgery [25]. However, their ability to differentiate is far from proven and the number of FS cells that can be generated is even less than that of Adult Stem cells which hinders their wide-scale applicability to regenerative medicine [14].

vi. *Induced Pluripotent Stem Cells*—iPSCs are the cells that are reprogrammed from somatic cells using different transcription factors. They possess properties of self-renewal and differentiation to many types of cell lineage. Due to this reason, and the absence of any ethical issues, iPSCs could replace the use of embryonic stem cells in research and clinics. In addition, iPSCs are used in various disease conditions for the production of patient-specific cells which can be transplanted to the site of injury or the site of tissue degeneration. The use of iPSCs may eliminate the chances of immune rejection as patient-specific cells may be used for transplantation in various engraftment processes. These stem cells were generated by using a combination of 4 reprogramming factors, including Oct4 (octamer binding transcription factor-4), Sox2 (sex determining region Y)-box 2, Klf4 (Kruppel like factor-4), and c-Myc, and were demonstrated both self-renewing and differentiating like ESCs. Their use offers a good approach for treatments in regenerative medicine as the cells that will be transplanted to the patient's body will be differentiated from the repaired iPSCs generated from the somatic cells from the patient's own body. However, limitations to the use of iPSCs do exist like safe delivery, post-treatment adverse effects, and standardization of protocols to generate large amounts of pure good quality cells. Generation of iPSCs make use of retroviral or lentiviral systems, so, it needs to be studied whether viral systems get incorporated with the host genome. The genetic material inserted via retroviral vectors may randomly integrate into the genome of the host which can cause genetic aberration and teratoma formation [26]. Given the 4 reprogramming factors of iPSCs, the overexpression of Oct4 may lead to epithelial cell dysplasia [27]. The expression of Sox2 has been reported to cause mucinous colon carcinoma [28]. Klf4 has a role in the formation of breast tumors [29]. c-Myc plays an important role in the formation of around 70% of human cancers [30].

3.1.2 Based on potency

i. *Totipotent stem cells* divide and differentiate into cells of the whole organism. Totipotency has the highest differentiation potential. One example of a totipotent cell is a zygote.

ii. *Pluripotent stem cells* (PSCs) that form cells of all germ layers but not extraembryonic structures, such as the placenta. Embryonic stem cells (ESCs) are an example.

iii. *Multipotent stem cells* have a narrower spectrum of differentiation than PSCs, but they can specialize in discrete cells of specific cell lineages. One example is a hematopoietic stem cell.

iv. *Oligopotent stem cells* can differentiate into several cell types. A myeloid stem cell is an example.

v. *Unipotent stem cells* are characterized by the narrowest differentiation capabilities and special property of dividing repeatedly. Their latter feature makes them a promising candidate for therapeutic e.g. dermatocytes [31].

3.1.3 Routes of administration

i. *Intrathecal injection* has a unique feature that allows stem cells to directly migrate to the lesion site in patients with central nervous system (CNS) diseases and for the treatment of neurological diseases is safe and feasible while having good clinical application prospects [32]. The intrathecal route enhances the possibility of a maximal number of transplanted cells “homing” onto damaged sites [33].

ii. *Intravenous injection* is a simple and minimally invasive approach that is ideal, given broad biodistribution and easy access. However, data show that following intravenous infusion, MSCs are trapped within the pulmonary capillaries, causing pulmonary and hemodynamic alterations, and preventing the intended access to other organs [34].

iii. *Intracranial*—The direct stereotactic implantation of stem cells would offer a highly focused delivery vehicle that could potentially enhance engraftment levels [35]. Initial in vivo investigation into the intracerebral implantation of MSCs has shown migration and engraftment at the site of injury, increased endogenous cellular proliferation, and functional improvement up to 8 days after injury [36, 37]. On the other hand, direct implantation into the CNS can cause tissue damage and exacerbated inflammatory response in the events of repeated transplantation [35].

iv. Intra-arterial—Cell delivery involves endovascular infusion of progenitor cells directly in the artery perfusing the ischemic tissue. This route of cell delivery bypasses the peripheral filtering organs, thereby increasing cell delivery. It is less invasive than intracerebral transplantation, it is repeatable, it would allow for a systemic biological effect, and could lead to a widespread distribution in the affected brain regions [38]. Bioluminescent Imaging has shown that intra-arterial injected neural cells engraft in the hypoxia/ischemia-injured brain and engraftment efficiency for intra-arterial injection was 12× higher compared with intravenous delivery [39]. However, it is an invasive procedure with an increased risk of complications.

3.2 Mechanism of action of stem cells

Stem cells have a unique property of homing and targeting specific damaged areas on administration. The homing mechanism is attributed to the expression of growth factors, chemokine, and extracellular matrix receptors on the surface of cells. On administration, they survive, migrate, proliferate, and differentiate into the required cell types [40]. They not only replace the damaged cells but also carry out the repair process via paracrine mechanisms [41]. Transplanted stem cells

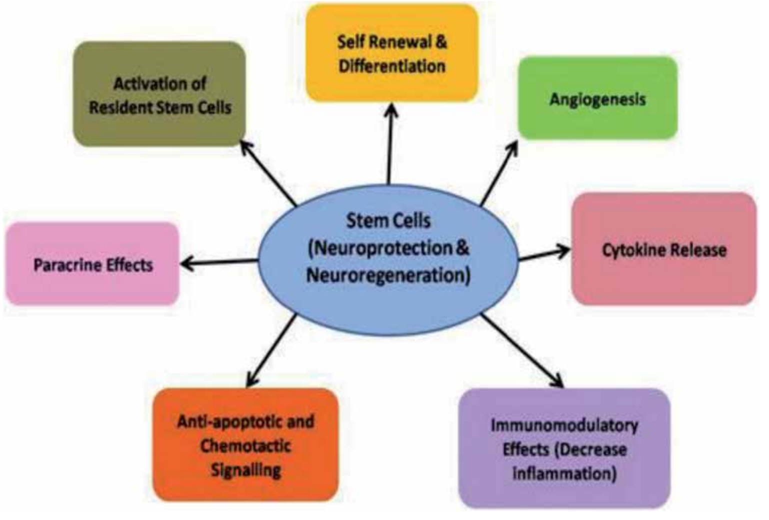

Figure 2.
Mechanism of action of stem cells.

express paracrine signaling factors including cytokines and other growth factors, which are involved in the repair process through neuroprotection, increasing angiogenesis, decreasing inflammation, preventing apoptosis, activation of resident/satellite cells, etc. (**Figure 2**).

3.2.1 Neuroprotection

Stem cells secrete a vast array of neuroprotective growth factors including BDNF, nerve growth factor (NGF), neurotrophin-3 (NT-3), glial cell line-derived neurotrophic factor (GDNF), fibroblast growth factor-2, and insulin-like growth factor type 1. These growth factors activate signaling pathways, enhance the differentiation, survival of neurons and maintain neuronal functions [42].

3.2.2 Increased angiogenesis

Stem cells secrete signaling molecules like vascular endothelial growth factor (VEGF), hepatocyte growth factor (HGF), and basic fibroblast growth factor (FGF2) resulting in improved perfusion, regional blood flow, enhanced angiogenesis, and oxygenation [43].

3.2.3 Immunomodulation

Stem cells impart an immunomodulatory effect as they reduce the levels of pro-inflammatory molecules TNF-α, IL-1β, IL-1α, IL-6 and increase levels of anti-inflammatory molecules such as IL-10 therefore, enhancing endogenous brain repair [44].

3.2.4 Activation of neighboring resident stem cells

The resident stem cells may possess growth factor receptors that can be activated to induce their migration and proliferation and promote both the restoration of dead tissue and the improved function in damaged tissue. Transplanted cells stimulate these endogenous cells to carry out the repair process [45].

4. Published literature

To our knowledge, there are no clinical studies of stem cell therapy in learning disability. However, it has been greatly explored in various pediatric neurological disorders such as autism, cerebral palsy, and intellectual disability [46].

Sharma et al. have established the safety and efficacy of bone marrow-derived mononuclear cells in autism and intellectual disability. In 254 cases of autism spectrum disorder, 95.27% of patients showed an improved score on CARS while 94.48% of cases showed improvement in ISAA. Symptomatic improvements were observed in eye contact, attention and concentration, hyperactivity, sitting tolerance, social interaction, stereotypical behavior, aggressiveness, communication, speech, command following, and self-stimulatory behavior. Eighty six patients who underwent a repeat PET CT scan showed improved brain metabolism after intervention in areas that correlated to the symptomatic changes [47].

In intellectual disability, the outcome of 29 patients of the intervention group was compared to that of 29 patients from only the rehabilitation group and it was found that all patients in the intervention group showed improvement while there was no improvement in 20.69% of patients from only the rehabilitation group. Improvement was noted in cognition, memory, problem-solving, understanding of relationships, social inhibitions, toilet training, command-following, eye contact, aggressive behavior, and attention and concentration. Comparative PET-CT scan study in patients of the intervention group showed improved metabolism in the frontal, parietal cortex, thalamus, mesial temporal structures, and cerebellum. No serious adverse events were recorded [48].

5. Clinical data

We have studied the outcome of autologous bone marrow-derived mononuclear cells in 20 individuals diagnosed with learning disability.

5.1 Demographic data of study population

Demographically, 14 male and 6 female patients were included, where 6 patients were within ages 1–10 years, 13 within 11–20 years, and 1 patient in the 21–30 years age range. Symptomatically, these patients presented with dysfunctions in academic performance, attention and concentration, reading, writing and mathematical skills, spelling, comprehension and recognizing words, problem-solving, and memory issues. Their functional capacity was measured by functional independence measure (FIM) and intelligence and/or social quotient through various tests such as BKT and VSMS measures.

5.2 Procedure

For the procedure of stem cell transplantation, autologous bone marrow mononuclear stem cells (BMMNCs) were selected as they were easily obtainable, safe, and did not involve any ethical issues. Intrathecal route of administration is a minimally invasive, safe, and effective procedure as compared to other routes. Studies have also shown that a mixture of cells exhibits more benefits as compared to a single subfraction of cells [49]. Hence, intrathecal autologous BMMNC transplantation was carried out in our study.

The patients were administered Granulocyte Colony Stimulating Factor (GCSF) before the harvest and transplantation of BMMNCs. On the day of the transplantation, 80–100 ml bone marrow was aspirated using a bone marrow aspiration needle from the right anterior superior iliac spine. This was collected in heparinized tubes and transported to the laboratory. Thereafter, in the culture laboratory, MNCs were separated by the density gradient technique. CD34 counts were performed and transported back to the operation theater in a cool sterile container. With the patient in a left lateral position, using a spinal needle, the thecal sac was punctured at L4-L5 space and the cells were injected through that spinal needle. Following this, Methylprednisolone 500 ml isolyte P was given intravenously, and the patient was observed for any adverse events.

After the stem cell transplantation, all patients underwent specialized rehabilitation such as special education, occupational and physical therapy, psychological counseling, and speech therapy.

6. Result

No major procedure-related adverse events were recorded. One patient reported a slight increase in absence seizures, which was controlled with medications. On an average follow-up of 26 months, 94.7% patients showed an improved clinical status. Reading skills improved in 75% patients, writing skills in 88% patients and mathematical skills improved in 70% affected patients, attention increased in 94% patients, memory skills in 78.5% patients, problem-solving skills improved in 69% patients, and comprehension skills in 72.7% patients. Spelling and vocabulary skills improved in 75% and 60% patients respectively. Overall increased academic performance was reported in 70% patients (**Figure 3**).

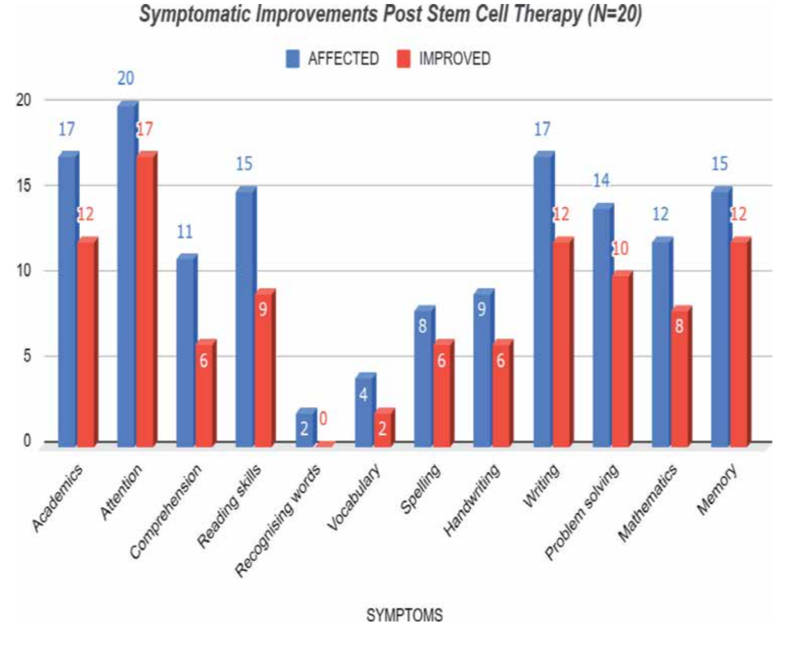

Figure 3.
Improvements were seen in various areas in 20 patients with learning disability post stem cell transplantation.

7. Role of rehabilitation in combination with cellular therapy

Evidence suggests that exercise induces mobility in the injected stem cells, thereby helping in the migration of the cells and helping upregulate neural plasticity [50]. Exercise also improves oxygenation and blood supply to the brain. Hence, the synergistic effect of stem cell therapy and neurorehabilitation brings about maximum functional recovery. Post stem cell therapy, the aim of rehabilitation in individuals with LD is to address the specific deficits that impair their ability to learn through sensory integration therapy, context-specific training, psychological counseling, and vocational training. Occupational therapy interventions use sensory integration methods to enhance sensory processing skills such as understanding, attention, sitting tolerance, and memory skills along with higher cognitive skills like judgment and problem-solving skills. Focusing on fine motor hand functions, handwriting grip, and writing skills are facilitated. Making use of visual schedules and timers to enhance time organization. Some studies showed direct instruction and modeling of letter formation, combined with memory retrieval, self-evaluation, fluency, and/or orthographic coding activities, led to improvements in students' legibility and writing fluency in the studies [51–53], and improvements in correct word sequences [54]. Speech therapists may collaborate with instructors to incorporate instruction that involves multiple modalities to facilitate connections between letters and sounds, as well as between written and oral language that incorporates visual and auditory cues. Students with LD benefit from explicit and systematic instruction that is closely related to their area of instructional need [55]. Special education differs from general education for students with LD when it is more explicit, intensive, and supportive [49]. Some ways of facilitating improved academic performance and life skills are through controlling task difficulty, teaching students in small, interactive groups, modeling and teaching strategies for generating questions and thinking aloud while reading, writing, or working on a scientific or mathematical problem, direct and explicit instructional practices, higher-order processing skills and problem-solving along with learning when, where, and how to apply strategies, ongoing progress monitoring of specific skills, teaching the building blocks of reading and writing like phonemic awareness, writing speed, the process of writing and the organizational and mechanical aspects of writing [56–60]. These strategies enhance the specific skills of reading, writing, arithmetic and inculcate generalization of strategies in life. Alternatively, Art therapy can be used in people with SLD who have difficulties in expressing themselves. It is a form of psychotherapy using art media as its primary mode of communication. Making artwork can facilitate expression and communication for people who find it difficult to express their thoughts and feelings verbally, and it is an accessible approach for children and adults with learning disabilities [61].

8. Radiological imaging

Brain tissue requires glucose for functional activity. The PET-CT scan records brain metabolism by using fluorodeoxyglucose (FDG) uptake. The active neural tissue absorbs glucose in direct proportion to its function. In turn, FDG uptake measures glucose metabolism and detects neuronal activity, which is the level of brain function. It is a promising technology to detect cellular effects of neurorestoration [62, 63]. In our study, a PET-CT scan was performed for all patients prior to cell transplantation to determine the dysfunctions in the brain. In the patients who underwent a repeat stem cell transplantation, PET images were compared to study the changes in brain metabolism after cell therapy. The images prior to stem cell therapy revealed hypo-metabolism in bilateral cerebellar hemispheres, medial temporal lobe, anterior

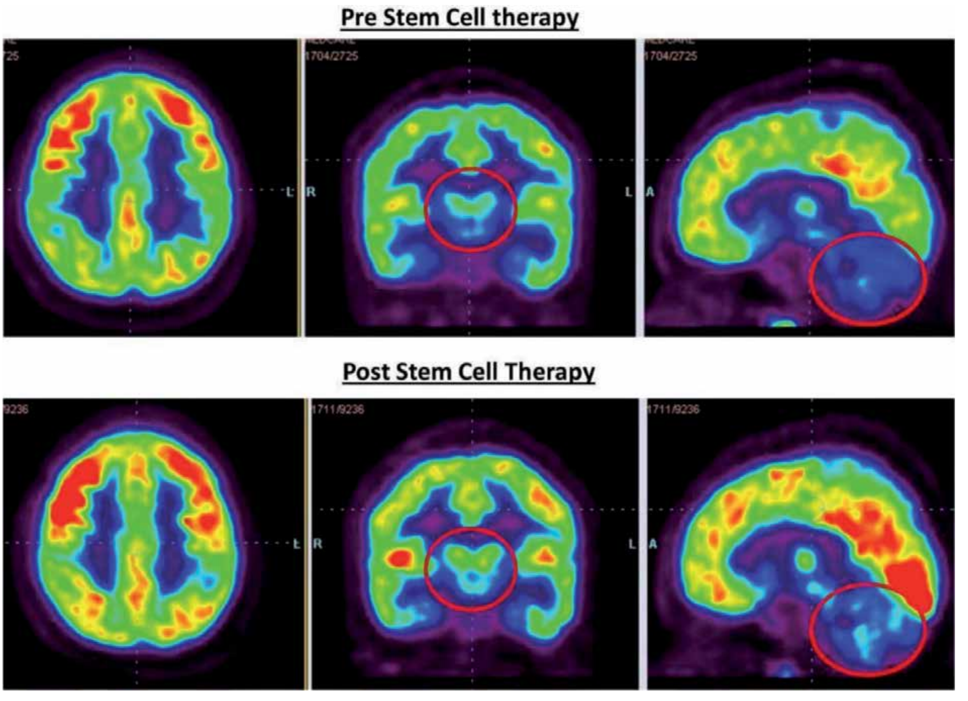

Figure 4.
Improvements were seen in reduced hypometabolism in areas of cerebellum and basal ganglia 12 months post stem cell therapy (the blue hypometabolic areas turn green post cellular therapy).

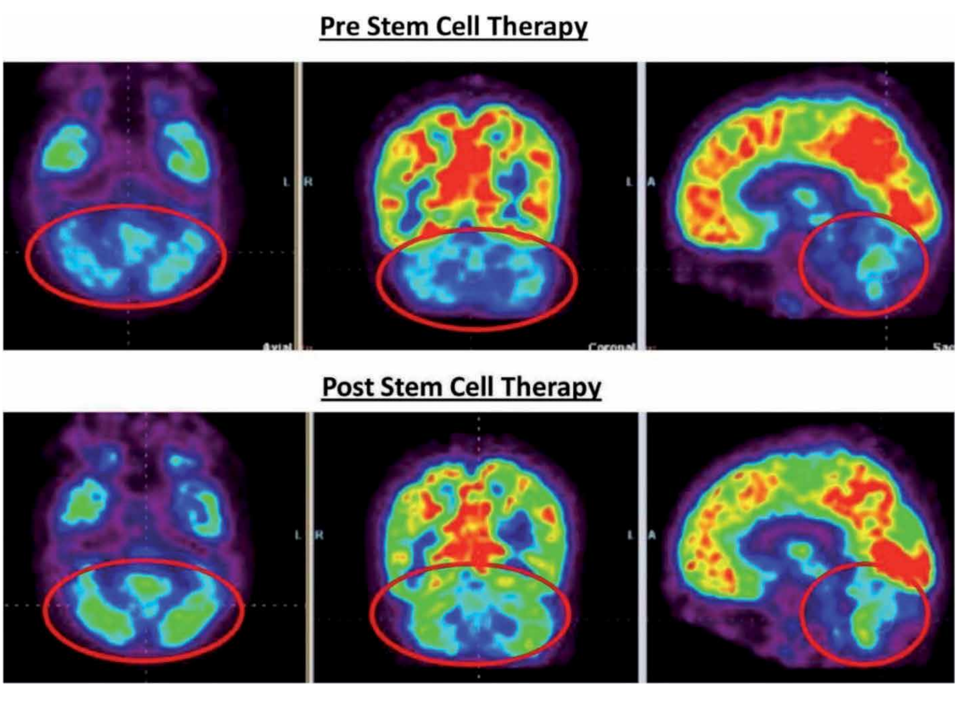

Figure 5.
Improvements were seen in reduced hypometabolism in areas of the cerebellum, temporal and parietal lobes 8 months post stem cell therapy.

and posterior cingulate gyri, and bilateral thalami with basal ganglia involvement, whereas hyper-metabolism was seen in the prefrontal cortex in many cases. These areas showed improved metabolism after cell therapy (**Figures 4** and **5**).

9. Conclusion

Stem cell therapy in combination with standard treatment and rehabilitation is a novel therapeutic option for learning disability. Its safety and efficacy have already been established in other incurable pediatric conditions such as autism, cerebral palsy, intellectual disability. Likewise, the results of our study conducted on patients with a learning disability have demonstrated a positive outcome and is an excellent foundation upon which future research can be advanced. Future studies should focus on analyzing the benefits of different cell types, the number of cells, and the route of administration for optimal use of cell therapy in learning disability.

Author details

Alok Sharma[1], Nandini Gokulchandran[1], Hemangi Sane[2], Sakshi Desai[2,3]*, Pooja Kulkarni[2] and Prerna Badhe[4]

1 Department of Medical Services and Clinical Research, NeuroGen Brain and Spine Institute, India

2 Department of Research and Development, NeuroGen Brain and Spine Institute, India

3 Department of Neurorehabilitation, NeuroGen Brain and Spine Institute, India

4 Department of Regenerative Laboratory Services, NeuroGen Brain and Spine Institute, India

*Address all correspondence to: sakshidesai.work@gmail.com

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Learning disabilities are a heterogeneous group of disorders characterized by failure to acquire, retrieve, and use information competently. These disorders have a multifactorial aetiology and are most common and severe in children, especially when comorbid with other chronic health conditions.

This book provides current and comprehensive information about learning disorders, including information on neurobiology, assessment, clinical features, and treatment. Chapters cover such topics as historical research and hypotheses of learning disorders, neuropsychological assessment and counselling, characteristics of specific disorders such as autism and ADHD, evidence-based treatment strategies and assistive technologies, and much more.

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