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Behavior Analysis

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BEHAVIOR ANALYSIS

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Notice

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Meet the editors

Prof. Huei-Tse Hou is a distinguished professor of the National Taiwan University of Science and Technology and the director of e-Learning Research Center and Mini-Educational Game Development Group of NTUST. His research interests include learning behavioral pattern analysis and game-based learning. He specializes in integrating and applying multidimensional analysis to students' learning behavioral patterns. Dr. Hou has published more than 100 research papers. He serves as the editorial board member or reviewer for more than 20 international educational journals and he received the Outstanding Researcher Award from the Ministry of Science and Technology of Taiwan in 2017. Dr. Hou published more than 20 SSCI journal papers related to the empirical studies of learning behavioral patterns, thus being internationally influential in this field.

Dr. Carolyn Ryan is a licensed psychologist, licensed behavior analyst, and board certified behavior analyst (doctoral). Dr. Ryan has served the field of behavior analysis, including the areas of experimental and applied behavior analysis, service delivery, direct instruction, staff training, counseling, cognitive behavior therapy, college and graduate instruction, autism, learning and developmental disabilities, and in areas of many disorders and disabilities for over 25 years. Dr. Ryan earned her PhD, as well as her undergraduate and two master's degrees, at Queens College and the Graduate Center of the City University of New York (CUNY). She owns her own company and has consulted through a variety of private and public situations while serving others. She is the author and coauthor of several research articles, book chapters and books in behavior analysis. She recently edited the text published through IntechOpen *Learning Disabilities: An International Perspective*. Her articles appear in *Journal of Applied Behavior Analysis*, *Research in Autism Spectrum Disorders*, *The Behavior Analyst Today*, *The Psychological Record*, *Journal of Autism and Developmental Disorders*, *Behavioral Intervention*, *and Perceptual and Motor Skills.* Dr. Ryan made numerous presentations at local, invited addresses and state, national, and international conferences. She has served others by designing and directing programs, providing trainings, designing curriculum for students, supporting staff and students in educational and home settings, teaching undergraduate- and graduate-level coursework, supervising those pursuing the BCBA, assisting on boards, volunteering in the field, and providing behavior analytic services.

Contents

Preface

The current text combines the areas of applied behavior analysis and the more broadly used term of behavior analysis. Applied behavior analysis is the specialization in psychology that relates to the direct alignment and application of behavioral principles to affect socially important behavior change. One chapter relates to the professionalization and credentialing processes related to service delivery for service providers in applied behavior analysis.

The other area of the text targets the more broadly used term of behavior analysis or behavioral pattern analysis. Innovative methods are used to analyze different human behaviors as well as to understand behavioral patterns. These methods may serve as theoretical methods and strategies to assist in understanding behavior. The following relevant research fields using behavior analysis may include education, human-mechanism interaction, learning science, psychology, sociology, guidance and counseling, and marketing and management. The research outcomes and analysis methods assist readers in better understanding the theories and practices of behavioral pattern analysis.

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Section 1

Introduction: Trend and Applications in Behavior Analysis

Chapter 1

Introductory Chapter: The Research Trend and Applications in Behavior Analysis

Huei-Tse Hou

Additional information is available at the end of the chapter

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1. The applications in behavior analysis

As the era of big data and artificial intelligence has come, many research fields are heading toward more precise process analyses. In particular, using innovative methods to analyze different human behaviors as well as to understand specific behavioral patterns help exploring the structures and contexts in all kinds of human behaviors, which can serve as theoretical innovation and strategies to solve human problems. So far, behavior analysis is gradually emphasized in many research fields, including education, human-mechanism interaction, learning science, psychology, sociology, guidance and counseling, marketing and management, etc.

Many research methods have different characteristics in exploring the unknown; for instance, experiment research emphasizes the foundation of positivism. The author believes that behavior analysis focuses on the exploration in latent structures of human behaviors and interactions, which should be based on structuralism. Simon Blackburn suggests that the structuralism is "the belief that phenomena of human life are not intelligible except through their interrelations. These relations constitute a structure, and behind local variations in the surface phenomena there are constant laws of abstract culture" [1]. Based on this philosophy, behavior analysis research, exploring the potential structure in human behaviors, helps connect human behavioral structure and their basic physiological and cognitive structures, which further helps investigate how these behaviors influence social interactions, and even the structure of social organization interactions.

More and more analysis techniques are applied in integrating qualitative and quantitative analysis methods to analyze behavioral process based on structures, including sequential analysis [2], progressive sequential analysis [3], quantitative content analysis [4, 5],

cluster analysis or data mining [6], social network analysis [7], etc. Many other studies also keep developing innovative analysis techniques to integrate multi-dimensional research methods and overcome challenging research difficulties, such as self-report-based sequential analysis (SRSA), exploring behavioral structures in learners' self-reports from their learning behavioral sequential patterns [8]. This technique can further explore the causes of learners' specific learning behaviors and sequences. On the other hand, this innovative analysis method can be applied in all types of research issues across disciplines.

2. Example: Studies of learning behavior analysis

Take learning science, for example, many studies in education discipline have applied sequential analysis and content analysis to understand learners' behavioral patterns in learning and interaction (e.g., [9]–[11]). Behavior analysis is applied in many research topics, such as learners' discussion process or content analysis in computer-supported collaborative learning, CSCL [10], users' operation behaviors, and discussion behaviors in game-based learning activities [5, 9]. Overall, behavior analysis research in education discipline includes two dimensions.

The first type is exploring the potential structure of human behaviors in specific fields (e.g., [9, 12]).

The second type is developing innovative behavior analysis techniques or coding systems to analyze complex human behaviors (e.g., [3, 8, 13]).

The former type belongs to the deeper exploratory research, which does not have statistical presumptions about research hypothesis but discovers new patterns by collecting a large amount of data for behavior analysis and exploring all the possible structures. The latter type is more about the innovation in research methods and instruments. These two research types that the author categorizes above can also be applied in the behavior analysis research of other disciplines. These two research types need to work together to improve research method innovation and the quality of latent structure analysis. These studies are expected to contribute in exploring all kinds of behavioral structures that have not been discovered. Especially in the era of big data, techniques and speed of calculations keep improving, which has an important meaning in the development of behavior analysis. More precise behavior analysis research can help us explain the structures/patterns in big data and discover more complex but important issues with solutions. On the other hand, less precise behavior analysis research or the one without progress may negatively influence our lives because our decisions or judgments will be automatically processed through inaccurate behavior analysis in the era of artificial intelligence.

This book collects the latest behavior analysis research in different disciplines, including some methods or analysis examples as references for the readers, who are interested. These research outcomes and analysis methods help the readers better understand the theories and practices of behavioral pattern analysis.

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Section 2

Cases and Studies of Behavior Analysis

Chapter 2

Applied Behaviour Analysis and Autism: Science, Profession, and Practice

Brian Fennell and Karola Dillenburger

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Abstract

Applied Behaviour Analysis (ABA) is recognised as the scientific basis of effective interventions in many educational, social, and medical fields, including autism. In this chapter, the basic tenets of ABA are described and briefly reviewed. Autism aetiology, diagnosis and prevalence are sketched out and the remainder of the chapter focuses on ABA-based interventions for children with autism. The chapter concludes with an examination of internationally recognised training standards for behaviour analysts.

Keywords: applied behaviour analysis (ABA), autism spectrum disorder (ASD), international perspectives, Europe, United States of America (USA), dissemination, Behaviour Analyst Certification Board (BACB), Board Certified Behaviour Analyst (BCBA)

1. Introduction

Procedures based on the science of behaviour analysis have been used successfully to address socially important behaviours at home, in communities, clinics, classrooms, and businesses [1, 2]. Common goals include improving social skills and academic attainments or the reduction of disruptive behaviours. Many of these methods have been used successfully to support individuals on the autism spectrum [3]. In this chapter, behaviour analysis is described first, then autism aetiology, diagnosis, and prevalence are briefly explicated. The focus then moves onto specific procedures that are particularly effective in supporting children with autism and, finally, professional certification for behaviour analysts is described.

2. Behaviour analysis

The experimental analysis of behaviour has a long history, starting with pioneering work in Thorndike's puzzle boxes and Watson's and Pavlov's work on respondent conditioning, exploring involuntary behaviours that resulted from the presentation of a variety of stimuli. Skinner built on this work with explorations and discoveries related to voluntary operant behaviours, focusing on the effect of consequences on responses [4].

Behavioural pioneers rejected the prevailing mentalistic approach of mainstream psychology, that promulgates a dichotomy between body and mind on the premise that behaviour is caused by an inner state or 'the mind' and coined the term 'radical behaviourism' (from the Greek [rædɪkᵊl] adj. 'arising from or going to a root or source') to describe the underlying philosophy of behaviourism. By categorizing thoughts and feelings as inner/private behaviour shaped by the same behavioural principles as publicly observable behaviour, radical behaviourism offers a holistic, non-dualistic approach to human behaviour [5].

Applied Behaviour Analysis (ABA), i.e., the application of behavioural knowledge to socially significant behaviours, is a distinct discipline with dedicated journals (Journal of Applied Behaviour Analysis; Behaviour Analysis in Practice), large membership associations (Association for Behaviour Analysis-International, ABAI; European Association for Behaviour Analysis, EABA; Association of Professional Behaviour Analysts, APBA), and professional certification (Behaviour Analyst Certification Board, BACB) recognised as a licenced profession.

ABA employs and expands knowledge gained from the experimental analysis of behaviour for the benefit of socially or clinical important behaviours. Social validity is measured through assessments of social appropriateness and significance of target behaviour, intervention, and outcome [1]. Applied behaviour analytic interventions satisfy seven dimensions. They have to be

- Applied (focus on socially significant behaviours)
- Behavioural (targeting measurable behaviours)
- Analytical (decisions are based on data)
- Technological (procedures are replicable)
- Conceptual (clearly based on behaviour analysis)
- Effective (positive impact on the target behaviour)
- Generalizable (behaviour occurs in general, not only where/when/how it was taught) [1].

ABA provides the tools for behaviour change across many human affairs, e.g., seat belt use, littering, sports, language acquisition, health and exercise, emotional behavioural difficulties (EBD), social validity, and staff training [6, 7].

Recognition of the effectiveness of behaviour analytic interventions was enshrined in an amendment to the Individuals with Disabilities Education Act of 1997:

> *In the case of a child whose behavior impedes his or her learning or that of others, consider, when appropriate, strategies, including positive behavioral interventions, strategies, and supports to address that behavior (Sect.614 (d)(3)(B)(i)).*

This legislation requires behavioural intervention plans to be based on a functional behavioural assessment (FBA) [8] and therefore constitute a significant step in the recognition of ABA-based procedures for a wide group of students, including children with autism in the United States of America (USA). In contrast, in the United Kingdom (UK), reports and guidelines, such as those from the National Institute for Clinical Excellence [9], miscategorised 'ABA' as one specific intervention for autism and do not recommend their use in general, although specific ABA-based procedures, such as functional behavioural assessments are recommended.

Functional behavioural assessments (FBA) identify the environmental factors of which the targeted behaviour is a function and thereby are the cornerstone of effective behaviour analytic interventions. FBAs include descriptive methods (e.g., record reviews and service user and/or caregiver interviews), direct behavioural observations, as well as functional analysis in which experimental procedures are used to establish the causal relationship between the dependent and independent variables. After ruling out medical reasons for enduring challenging behaviours, a thorough FBA increases the likelihood of intervention success.

For situations where the function of a behaviour is difficult to determine by descriptive means alone, several experimental functional analysis conditions have been developed. Iwata and colleagues [10] were the first to explore functional analysis of self-injurious behaviour (SIB). They used four experimental conditions: (1) social disapproval or reprimands; (2) academic demand; (3) alone; and (4) unstructured play/enriched environment.

1. The social disapproval condition was used to assess if the SIB was positively reinforced. The researcher engaged in an unrelated activity (e.g., reading papers) without interacting with the child, while the child engaged in an activity that was not overly demanding for them. If the child engaged in the challenging target behaviour, the researcher interacted with the child by delivering a reprimand (e.g., 'Don't do that'; 'That's not nice').
2. The academic demand condition was used to assess if the behaviour in question was negatively reinforced through escape from demand. The child engaged in an activity that was novel, appropriate, and somewhat demanding (e.g., table-top picture matching). As a consequence of SIB, the task demand was discontinued.
3. The alone condition was used to assess if the SIB had a self-stimulatory function. The child was left in a room on his/her own without toys or other materials. This condition was included only if the SIB was not considered dangerous.
4. The unstructured play/enriched environment condition was used to assess the potential of social reinforcement for alternative behaviours. It consisted of the child sitting in close proximity to the researcher who responded with praise and social interaction in the absence of the target behaviour. Inappropriate/challenging behaviours were ignored in this condition.

The functional analysis procedures originally detailed by Iwata and colleagues form the basis of good ABA practice and have been adopted widely and successfully to address many different behaviours, including core indicators of autism.

3. Autism: Aetiology, diagnosis and prevalence

The term 'autism' has been attributed to the Austrian-American psychiatrist Kanner in the early 1940s, although individual cases had been described well before that time. While Kanner's work was written in English and has been recognised widely, his predecessor, the Swiss psychiatrist Bleuler, who coined the term 'autism', and his contemporary, the Austrian paediatrician Asperger, both writing in German, were virtually ignored. Asperger was eventually recognised when his writings were translated into English posthumously. Subsequently, the body of research grew until the diagnostic classification was formalised for the first time in 1980 in the Diagnostic and Statistical Manual of Mental Disorders (DSM-III) [11].

The diagnostic category changed over time, from 'Pervasive Developmental Disorders' that including autistic disorder, Rhett's disorder, childhood disintegrative disorder, Asperger's disorder, and pervasive developmental disorder – not otherwise specified (PDD-NOS) in the DSM-IV-TR [12] to the single category 'Autism Spectrum Disorders (ASD)' in the DSM-5 [13]. The diagnosis of ASD is based on two symptom domains, i.e., impaired social/communication and restricted, repetitive behaviours, and three levels of support needs. Autism was recognised as a heterogeneous condition with many presentations, i.e., each person with autism affected in different ways.

The exact causes of autism are unknown and are likely to concern genetic vulnerabilities coupled with environmental risk factors. It is likely that there are a variety of aetiologies that lead to a variety of 'autisms' [14].

Rising rates of autism are associated with increased costs to society and quality-of-life for individuals and their families. Autism prevalence rates in children in the USA have risen from 1 per 110 (0.90%) to 1:50 [15] and even higher prevalence rates have been reported in South Korea (2.64%) [16] and the United Kingdom (3.5%) [17]. The individual lifetime support cost for someone with autism is estimated between USA$1.4 and USA$2.4 million (UK£0.9-UK£1.5 million) depending on the level of support needs. Assuming a prevalence of 60% co-occurring intellectual disability, 'the total annual costs are £3.4 billion (USA $5 billion) per year in the United Kingdom and $66 billion per year in the United States' [18]. Effective interventions can do much to ameliorate the situation for individuals with autism and their families.

4. ABA-based interventions for children with autism

Behavioural interventions were first used to support individuals with mental illness or intellectual disabilities in state care in the late nineteenth century. For example, Fuller showed that

physical movement (e.g., movement of the right arm) could be introduced to a previously totally non-responsive patient by contingent use of a positive reinforcer (e.g., sweetened milk) [19].

Fester [20] and Oppenheim [21] were among the first to utilise behavioural principles to teach new skills to individuals with autism; however, it was not until Lovaas utilised intensive behavioural interventions, mainly Discrete Trial Training (DTT) with young children with autism, that ABA-based procedures became popularised [22]. A follow-up report of the Lovaas et al. study evidenced the long-term maintenance of the gains that had been achieved with the children [23]. For many not familiar with the science of applied behaviour analysis, Lovaas' name became synonymous with ABA interventions for autism. However, Lovaas' studies have often been misinterpreted as an evaluation of a complete intervention system with little or no recognition of its basis in applied behaviour analysis. This kind of misinformation has led to the erroneous perception that Lovaas Therapy, Lovaas Programme, or Discrete Trial Training (DTT), are the same as the scientific discipline of ABA.

Many ABA-based interventions for children on the autism spectrum are conducted in the home, with parents as active partners [24]. Maurice [25], mother of two children with severe autism, was one of the first to recount how home-based intensive behavioural intervention resulted in her children's ability to be included in mainstream schools without additional supports.

Support groups and social media have played a key role in parental advocacy becoming a grass roots movement for rising autism awareness, demanding ABA-based interventions [26], and attaining relevant autism legislation. In the United States of America, Federal Government and States legislation in almost all states have dramatically improved the funding for behavioural interventions by requiring insurance carriers to provide coverage of ABA-based services. Individual State initiatives have also added to the endorsement, e.g., the State of Maine convened a task force to evaluate the educational interventions for autism as a means of determining appropriate State policy in the area. The task force, citing some of the key features of ABA, such as the use of observable goals, reliable data collection, and programme evaluation based on data evidence, declared behavioural interventions substantiated as effective. Similarly, the New York State Department of Health gave the highest rating to behavioural-based interventions [27]; the Kennedy Krieger Institute of Maryland [28] and Autism Speaks [29] are among many other agencies that promote the use of ABA-based interventions for the people with autism.

A non-exhaustive list of ABA-based interventions with empirical support as efficacious for use with individuals with autism spectrum disorders are briefly described below. For further detail on these and other behavioural methods shown to be effective for children and adults with autism, see the cited research.

ASD is a diagnosis of behaviour deficits in social-communication skills and behaviour excesses in restricted, repetitive behaviours [13]. These behaviours can challenge or disruptive other activities [30, 31], consistently across age groups [32, 33] and over time [33]. ABA-based interventions to support individuals who experience these challenges include functional behaviour assessment (FBA) and behaviour intervention plans (BIP) [34, 35]. Positive Behaviour Support (PBS) is probably the most widely used behaviour analytic, evidence-based intervention package use to support these individuals [36, 37].

Functional communication training (FCT) is an effective method of addressing communication problems [38]. FCT uses shaping procedures to build appropriate communication repertoires, thus reducing the need for non-functional communication efforts [39]. Similarly, picture exchange communication systems (PECS) can improve functional communication in people with autism [40] by using pictorial strategies in an augmentative communication system [41]. Pivotal response training (PRT) is a verbal response prompting methodology for teaching communication to students with autism [42]. Taken together these naturalistic behavioural approaches to the acquisition of verbal and/or vocal communication skills provide powerful interventions for individuals with autism [43].

Precision teaching (PT), focusing on accuracy and speed, i.e., fluency, of behaviour [44, 45], is used very effectively across behavioural and academic curricula as generalisation and maintenance of skills improve with fluency [45]. Other widely used ABA-based procedures include Direct Instruction, using instructional pacing to maintain student motivation, and coral responding, using scripted sequences thus allowing for high frequency of individual responses in large groups to gain and maintain curriculum-based knowledge [46].

With regards to educational interventions for children diagnosed with autism in jurisdictions outside of the USA, the support for ABA-based intervention has not always materialised despite the fact that Research Autism (UK) disseminates research evidence in favour of ABA-based interventions. Noticeably, ABA-based methods of autism support and education have been absent in official reports and, consequently, governments across Europe still support an 'eclectic' approach, rather than demanding scientifically supported interventions [47].

One of the key problems with an eclectic approach to autism interventions is that there is no consistent theoretical framework for the different interventions experienced by the children and thus potentially conflicting messages are propagated, staff training is necessarily inconsistent and training content rather variable, and the interventions are not evidence-based. In fact, Eikeseth and colleagues [48] compared an intensive behavioural programme with an eclectic approach in which both groups received one-to-one instruction for 28 h per week over the course of 1 year. The behavioural treatment group showed significant gains in IQ (i.e., an average of 17 points), language, and adaptive behaviours while the eclectic group showed only an average 4-point gain in IQ. Similarly, Howard and her team [49] reported significant advantages for the behavioural intervention group in the areas of cognitive, non-verbal, and communication measures in comparison to eclectic groups. Clearly, the potential inclusion of unsubstantiated or even hazardous interventions in an eclectic approach is problematical (e.g., facilitated communication and auditory integration training are still used despite evidence of ineffectiveness or even significant harm).

The contradictory reports across different jurisdictions are likely to have adverse effects as teachers and school administrators question the evidence status of different methodologies. Consequently, behavioural interventions may be implemented with less than recommended intensity, low levels of staff training, not at all, or as a part of an eclectic approach. At times it seems that opponents thrive on or even profit from misrepresenting the science [50].

In the absence of coherent and evidence-based guidance, parents educate themselves [51], relying on word of mouth, anecdotes from other parents, celebrity endorsements, and information

provided by autism charities, rather than good quality scientific peer-reviewed journals. Evidently, misinformation about ABA on the internet abounds and this can lead to parents being dissuaded from scientifically validated interventions usually to the detriment of their child [52].

Even if they find accurate information about ABA-based interventions and want to utilise these in support of their child's skills development, implementing home and school programmes requires significant resources. In most of Europe there is no state funding and parents have to pay for ABA-based services themselves, or fight for a little bit of state funding through the tribunal system [53].

In the USA, nearly all States declared ABA-based autism interventions empirically validated and mandate Health Insurances to cover the cost [29]. Yet, although they are not permitted to do so, Health Insurers still try to avoid providing cover by considering autism as a pre-existing condition, a mental illness, or a long-term disability, rather than a neurological disorder. Others try to avoid cover by viewing ABA as 'experimental' or purely educational, rather than medically necessary or pointing to perceived disagreement in the literature, rather than welcoming the large body of evidence supporting ABA-based interventions for autism. At the same time, insurers are right to expect that services they cover are managed by an appropriately qualified professional. Board Certified Behaviour Analysts (BCBA) manage home-based as well as clinic and school-based services in applied behaviour analysis.

5. Behaviour analyst certification

The Behaviour Analyst Certification Board (BACB) [54] verifies behaviour analytic training at Universities and sets the standards and examinations for Board Certified Behaviour Analysts (BCBA) internationally. Thus, it offers a certain level of consumer protection against those who claim to offer applied behaviour analytic interventions without adequate training. In addition, a number of States in the USA have introduced licensure for Board Certified Behaviour Analysts (BCBA) to improve practice standards and ensure insurance coverage.

The BACB is an accredited credentialing body (i.e., the National Commission for Certifying Agencies) and, although the organisation is based in the USA, it has world-wide reach. In fact, the European Association of Behaviour Analysis (EABA) endorses the credentials and offers information about European course sequences through its website. In Ireland, the Division of Behaviour Analysis (DBA) of the Psychological Society of Ireland (PSI) endorse the BACB credentials [55].

The number of BACB verified University programmes across Europe is growing. A full list of courses is available on the BACB webpage. Behaviour analysts are not regulated within European Union laws. The Czech Republic is the only country in Europe to legally regulate the profession of behaviour analysts, based on BACB standards [56].

There are four levels of professional BACB registration or certification, each with course work and supervised practice requirements and examinations. The Registered Behaviour Technician (RBT) is a pre-degree level qualification, while the Board Certified assistant

Behaviour Analyst (BCaBA) requires a verified undergraduate degree. The Board Certified Behaviour Analyst (BCBA) is a master's level qualification and the Board Certified Behaviour Analyst-Doctoral (BCBA-D) is the doctoral level designation.

All certificants must meet entry requirements, complete the required verified behaviour analysis course sequences at University, and fulfil supervised experience requirements before applying for eligibility to take the appropriate extensive examination. In addition to the various levels of certification the BACB has developed a Professional and Ethical Compliance Code that applies to all certificants. The code requires behaviour analysts to practice only in the areas of their training, continue to develop areas of expertise through continued professional development activities, and use and contribute to the evidence-base for behaviour analytic methods. The BACB also developed a good practice guide for autism interventions and publishes translations of BACB resources.

The coursework content of BACB verified course sequences (VCS) includes ethics, functional assessment and functional analysis, interventions and applications, experimental analysis, and conceptual issues. The number of hours for coursework and supervised experience differs depending on the level of certification sought. Supervisors are required to be BCBAs and have completed specified supervisor training.

6. Conclusions

The application of the science of behaviour analysis has provided a range of evidence-based interventions to support individuals on the autism spectrum. Implementation and funding for these interventions differ widely across the world. They are typically home-, school-, or clinic-based, usually starting with a one-to-one therapist-to-child ratio and moving to group work as soon as possible. Outcomes have been very positive and social validity and satisfaction with the outcomes has been high.

This chapter offered a brief description of the scientific discipline of behaviour analysis, summarised the present state of knowledge around autism aetiology, diagnosis and prevalence, and focussed on applied behaviour analysis (ABA)-based interventions for children with autism. Finally, the requirements for professionals working in the field, i.e., Board Certified Behaviour Analysts (BCBA), were described.

Applied behaviour analysis-based interventions for autism clearly have a large evidence-base of effectiveness. The continued failure of governments across Europe to recognise this has left a vacuum, that all too often is filled by fads and fictions [57]. To avoid misinformation and ensure that these interventions are delivered with fidelity, well-trained staff are necessary. Parents of children with autism require and deserve the best information and supports available.

Although policy reform in the USA is still somewhat inconsistent across states and, yet, many are left without financial support, there is reason for optimism that offers a platform from which to lobby for further access to ABA-based interventions for all people with autism who need it.

Conflict of interest

Both authors declare they have no conflict of interest in publication of this chapter.

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Chapter 3

Contingential Analysis: Interbehavioral Methodology for the Applied Field

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Abstract

The main purpose of this chapter is to introduce contingential analysis and to generate interest on this subject. This is an interbehavioral methodology for applied field. Theoretical and philosophical foundations are briefly described at first; this was considered important because this methodology is an alternative and naturalistic way to approach professional work. Its basis is found on the interbehavioral model developed by Kantor such as on the functional taxonomy developed by Ribes and López in 1985. This system has five steps: microcontingential analysis, macrocontingential analysis, behavior origin, solution analysis, and selection, design, and application of intervention strategies; each one is explained in this text. Finally, some effective applications of the methodology are mentioned.

Keywords: contingential analysis, interbehavioral theory, microcontingential problem, macrocontingential analysis, intervention procedures, professional field

1. Introduction

A methodology for the analysis and change of individual humans' behavior in their social environments is presented in this chapter. Despite the fact that methodology is based on the interbehavioral theory created in 1986, it does not have the dissemination it requires. The chapter describes the theoretical framework and categories that support the same. The aim here is to introduce this system for it to be known outside Latin America.

2. Contingential analysis

Contingential analysis is a methodology developed for psychologists' professional work which enables analysis and modification of individual human behavior. It was developed by Ribes et al. [1], based on Ribes and López's [2] work, who developed an interbehavioral theory based on Kantor's work [3]. This theory presents a naturalistic behavior approach which is radically different from the dualistic conceptions that permeate our discipline.

The subject matter of the interbehavioral approach, also known as the field model, is interbehavior, understood as a series of interdependent relationships—of varying degrees of complexity—between specific elements of the environment and of the organism that are built in the ontogenetic history. This approach's specific premises and characteristics make it different from others.

From this perspective and using a functional criterion, all of an individual's interactions with his/her environment comprise different elements that can be grouped into three specific categories: the stimulus-response function, dispositional factors, and the means of contact.

Generally, it is important to mention that the stimulus-response function refers to the response and stimulus segments that make contact. This can take place at different qualitative levels.

Dispositional factors refer to the series of events conducive to certain types of interactions by facilitating or inhibiting the same. Such factors include situational and environmental factors (temperature, objects, places, and organisms, among others), the interbehavioral history (stimulus evolution and reactive biography), and the organism's conditions (diseases, ailments, deprivation fullness, drug effects, or tendencies).

Finally, the physical-chemical, biological, and regulatory means of contact refer to the conditions that enable a specific interaction [2, 3].

These elements constitute the interbehavioral field, which is *a conceptual representation of an interaction segment of the individual organism with its environment* ([2], p. 42). In this field, elements are interrelated synchronously, establishing contingencies between events, in other words, establishing mutual dependencies between them.

Based on this model, Ribes and López [2] developed a taxonomy of the different levels of behavior organization mainly based on two parameters: (1) *mediation*, which is the process by which different factors of a psychological event relate through the critical element, which is the mediating element [2] and (2) the functional *detachment*, which refers to the possibility of an organism to respond in a relatively autonomous manner to the physical-chemical properties of the environment, in other words, its capacity to interact with objects, events, or absent people in the here and now [2].

Thereby, some of this theory's basic characteristics are briefly described hereunder:

a. In a specific context, the relationship between the stimulus and response functions represents the psychological analysis unit.

b. The behavioral approach is naturalistic—the relationships between elements of the person or people with their environment never refer to entities, phenomena, or supernatural

variables. This involves the elimination of: observable/unobservable, public/private, internal/external dichotomies, and, evidently, any mentalist approach.

c. Behavior is conceived as an interdependent relationship between different elements of the person and his/her environment where the different explanatory weights of such relationships can be assigned as an analysis function and not prior to the same.

d. As interbehavior is an abstraction, the relationships that make up behavior are understood as a synchronous event, regardless of their occurrence in real time. A succession of events in time is not assumed.

e. Categories that designate occurrences and dispositions are used. As mentioned, dispositional factors refer to occurrence collections and their function is to make a behavior more or less likely [4].

f. Considering Ribes and López's [2] functional taxonomy, processes with different functional complexity levels that may range from the relationship of an organism with its immediate context in terms of reaction to the same to the relationship that a human being can establish with abstract and conventional products such as mathematical languages are analyzed.

g. The model goes beyond ordinary language with the aim of creating unequivocal terms that enable specific phenomena's precise definition and analysis.

In addition, the existence of different forms of producing knowledge, such as science and technology as part of the interbehavioral model's assumptions, is conceived. The first one has an analytical method and is abstract and general. The second one uses a synthetic method and is concrete and particular if it aims to be scientific. Hence, this approach deems that psychology must be a science and that the creation of technologies or application forms should result from scientific knowledge. Based on this, contingency analysis was developed with the same premises and general conception of the interbehavioral model, with categories and concepts that have a correspondence relationship with the theory in a synthetic language.

This methodology enables analysis and change of individual behavior with different purposes: detection and diagnosis, planning and prevention, development, and intervention and research in different professional practice fields such as organizational, health, sports, educational, and clinical, among others.

Contingential analysis consists of the following five steps to achieve these purposes: (1) identification of the microcontingency relationships, (2) evaluation of the macrocontingential system, (3) origin of problem, (4) solution analysis, and (5) selection, design, application, and evaluation of intervention strategies. Each one of these steps of the contingential analysis methodology is explained as follows.

3. Microcontingential system

The microcontingential system refers to the series of relationships that a person establishes with objects, people, circumstances, or environmental events [5], in which any of these

elements structures the form in which such relationship occurs (mediating element). It is limited according to the conventionally defined situation of interest, family relationship, work relationship, upbringing, and love relationships, among others. It consists of four elements: behavior morphologies, situations, other people's behavior, and effects. Each one is explained herein.

3.1. Behavior morphologies

This first category of the microcontingential system refers to the identification of the ways in which a person, whose behavior is studied, relates to circumstances, objects, or events of his/her environment, as well as with the significant people in that relationship. According to Rodríguez [5], forms of behavior are identified in this paragraph, what a person says, does, thinks, and feels in a specific situation, for example, cry, scream, blackmail, get angry, say something to himself/herself, and drink alcoholic beverages, among others.

Effective morphologies can be identified (those that affect others' or one's own behavior), such as when a person yells at, blackmails or seduces another; or when a person sets his/her alarm clock to get up early the next day; whereas affective morphologies are those without affecting others 'behavior, such as trembling, feeling agitated, nervous, elated or angry.

Likewise, other significant people's behavior morphologies must be included for the behavior of interest, as well as some of these morphologies' parameters (latency, frequency, and intensity), if some are relevant to the analysis [5].

3.2. Situations

Situations are deemed as the set of dispositional physical and social characteristics, of the individual, and his/her environment, which, without belonging to the occurrence category, play a probabilistic role in an interaction, facilitating or inhibiting the same.

Inclusion of dispositional factors in psychology makes it possible to study many phenomena that traditionally have been studied in a dualistic manner, that is, considering them as something "internal", "mental", "unobservable", and those that are generally understood as "causes" of behavior. We are talking about terms such as "emotions", "memory", "imagination", "perception", and "intention", among others.

Based on Ryle's [4] *dispositional* concept, these factors, when they belong to the user, are formed by capabilities and tendencies, whereas when they refer to the environment, they refer to physical and social properties that make up the context in which a relationship takes place. These factors are not occurrences, in other words, specific or discrete variables, but collections of the same. To clarify the latter we give an example of a person who considers himself/herself as jealous which, in psychological terms, refers to a tendency and in this regard to a dispositional factor; the collection of occurrences means that he/she has complained to his/her partner for relating to members of the opposite sex in the past, who makes fidelity demands and pays attention to the way his/her partner observes members of the opposite sex, among others. These ways of behaving make it more likely that in the present situation with

his/her partner, he/she repeats these types of behaviors. To be jealous is a tendency, in other words, a dispositional factor.

The situations that give a context to a relationship comprise different elements with a possible dispositional function. Some of them refer to specific components of the person's interbehavioral history, whereas others refer to certain environmental characteristics. Thereby, the subcategories that correspond to situations are (1) social circumstance, (2) place or places, (3) objects or physical events, (4) socially expected behaviors, (5) competencies and incompetences to carry out what is socially expected, (6) inclinations and propensities, and (7) tendencies [5].

a. Social circumstance: the type of circumstance in this category is identified according to conventional criteria, in which the behavior that is going to be studied is presented. Examples of these circumstances are family circumstances, couple relationships, and work relationships, among others.

b. Place or places: a physical space can have a dispositional function for a certain behavior, for example, a school can facilitate the habit of studying.

c. Objects or physical events: in this category the possible dispositional function of objects or physical events that are part of the physical context is identified. For example, hot weather can facilitate people wearing light clothing or abundant food, for a person to overeat.

d. Socially expected behaviors: in all social circumstances there are tacit or explicit demands for people. These demands have a dispositional function. What a person or a group of people expects from another can make a behavior more or less likely. For example, in a family relationship, children are regularly expected to behave respectfully with their parents, whereas in a peer relationship what can be expected is for peers to bully each other.

e. Competencies or incompetences to do what is socially expected: this category refers to a dispositional factor related to the history of the person whose behavior is studied. It refers to the ability or inability of this person to meet what is expected of him/her in a specific situation. For example, a person is expected to study, pass his/her exams, and do his/her homework in an academic situation. If this person does not have an effective studying method and does not understand the texts, his/her lack of competency is a factor that makes it less likely for him/her to pass his/her exams and get good grades.

f. Inclinations, propensities, and motives: these categories fall within the broadest tendency category, although they have more specific characteristics. Inclinations refer to tastes and preferences; propensities refer to short-term temporary states, particularly states of mind/moods (sadness, happiness, infatuation), to emotional shocks (intense short-term emotions such as rage, elation, anger, fear, etc.), and to biological conditions (such as a headache, drug or alcohol intake, different diseases, sexual deprivation); on the other hand, motives refer to tendencies linked with short-, medium- and long-term possible consequences. It should be noted that these concepts are the ones used the most in a dualistic form as categories that "explain" behavior when from this perspective are a part of the behavior that will be explained. According to the specific analysis of each case, inclinations, propensities, and motives may have a dispositional function and would be a part

of the studied behavior. In some cases, particularly propensities, these may be affective morphologies, that is, affective components of some form of responding; analysis of the case will determine their function. For example, if we are studying a couple's relationship and we realize that she fights with him when she feels sad, due to reasons outside their relationship, her state of mind—sadness—in this case would have a dispositional function of making fights and arguments more likely. But if the person feels sad because her husband tells her that he does not love her anymore, then we would talk about an affective morphology.

g. Tendencies: according to Rodríguez [6], "this concept refers to customs, habits and forms of behavior that have been linked with specific effects in the past and for this reason have a high emission probability under certain circumstances" (p. 94). Those tendencies that make the behavior of interest more or less likely are identified. For example, those kind of behaviors referred in terms such as "irascible", that can make a problem with another person more likely, or an addiction to some drug that may interfere with work, if this is what is being studied.

The described subcategories designate factors that make up a situation; however, not all have a dispositional function for a behavior in particular. In this methodology, it is the psychologist's task to analyze the function of the different factors.

3.3. Other people's behavior

Under this heading the different functions that other people's behavior can exercise and that are significant for the person whose behavior is studied are considered. To analyze the same, the core dimension is the one of *mediating individual/mediated individuals*. The other functions that are conceptually contemplated are dispositional.

- *Mediator* is the behavior that determines (prescribes) the manner in which an interaction takes place; in other words, the contingencies for a specific relationship are predicted/prescribed with this behavior, whether, through instructions, specifying rules of behavior and establishing sanctions, among others. In ordinary language terms, we would think about the behavior that *dominates* other people's behavior.
- *Mediated* is the behavior that is adjusted or regulated by the contingencies prescribed by the mediator's behavior.

The other dispositional functions are:

- Sponsor: this behavior consists of facilitating the conditions for another behavior, without the participation of the person in that interaction. Because of these properties this type of behavior has a dispositional function.
- Propensities and/or inclinations' regulator: there are people whose behavior can modulate tastes, preferences, states of mind/moods, or emotional shocks in another person and this behavior is known as a propensities or inclinations' regulator. As in the sponsor behavior, a relevant regulator behavior does not exist in all of the interactions as in the interaction

under study. It is also important to mention that this regulation does not take place by a prescription of contingencies in such a manner that a person with a mediator function in a relationship cannot have dispositional functions in the same way.

- Tendency regulator: it is similar to the foregoing behavior only that in this case a person's behavior modulates a habit or tendency in another person. For example, if a person's best friend smokes frequently, it is likely that the person in question will smoke too when he/she is with that person.

It is important to bear in mind that people's behaviors do not always have a dispositional function in all studied interactions.

3.4. Effects

The last microcontingential analysis category is the one pertaining to effects. These refer to the consequence relationship that exists between what the user says, does, or thinks and the changes that this can have in the environment, other people's behavior, or one's own behavior [5, 7]. Depending on the type of generated change, the effects are classified in different ways:

On others or on the environment: they refer to the change that one's own behavior generates in other people's behavior or in any environmental physical-chemical property; for example, if a person yells at other people when they interrupt him/her at work, it is very likely that others stop interrupting him/her in that circumstance, as an effect of the person in question's behavior.

On himself/herself: this type of behavior only refers to the one that affects the person that emits the same, producing modifications in what he/she does, thinks, or feels. For example, when a person constantly thinks that thieves are going to break into his/her house and has nightmares and loses his/her appetite, even though this does not occur, his/her behavior has dispositional effects on himself/herself. His/her behavior affects his/her biological and emotional conditions.

Ineffective: a behavior is deemed ineffective when it does not generate changes in the environment or in the person himself/herself, such as some adjustment behaviors.

In summary, the microcontingential system consists of identifying the factors implied in an interaction, its function within the same, and later to determine the explanatory weight of the different components. Each behavior is analyzed in an individual basis, and, as far as morphology does not determine function, every factor is analyzed with functional basis.

4. Macrocontingential system

All human psychological interaction takes place through a means of contact and the regulatory framework is the one that makes our relationships possible [5]. The possibilities of detachment of human behavior regarding the physical-chemical aspects of situations in the here and now

allow a person to behave according to established social conventions by the members of his/her culture that share practices with him/her. This possibility is linked to the language [2], which allows him/her to individualize socially but likewise to socialize to adapt to a culture's practices.

All human interactions thus have a value dimension that depends on the cultural context where they occur [5]. In this regard, behaviors will be rated as moral to the extent that they adjust to the value criteria that regulate the practices in groups of socially ranked individuals [5] and on the contrary, they shall be rated as bad or immoral, when they do not adjust. Due to the fact that there are social hierarchies, individuals' behavior will be assessed differently depending on who emits the same and on who it affects.

It is important to consider that assessments do not occur due to internal or abstract entities or internalizations of cognitions or beliefs. Behavioral assessment is regulated by functional aspects that are not present in an effective manner when such behaviors occur. Ribes [8] mentions that we can only talk about beliefs based on individuals' behavior: *when we talk about believing we do not refer to any uncertain or incomplete knowledge inside our heads. Actually, we refer to the tacit or express acceptance of the adjustment criteria that regulate our actions in a given situation* (p. 84). The possibility of saying that someone believes in something occurs as a result of the observation of an individual's behavior, so we cannot explain beliefs as something different or independent. To say that a person has a belief does not mean that he/she has something inside but rather that he/she will tend to behave in a certain way with people and things [9, 10], in other words, to behave according to certain criteria.

Values, such as actions and beliefs, are acquired before other individuals explicitly impose behavior modes in the "ought to be" manner in a specific social context [5], and these situations, in which one or more people explain the "ought to be" of a relationship, are the ones that regulate individuals' behavior in other situations in which these criteria are tacit. In this manner, *the person acts in a situation which assessment criteria are tacit, as if he/she were in a situation with explicit criteria* ([5], p. 105]).

A person may behave according to the rules established by some of the members of his/her social reference group in a particular situation, which would result in a correspondence between his/her behavior and the behavior that the reference group established as appropriate; in another situation, the person may behave differently from his/her social reference group's forms of behavior in exemplary situations, which would result in a lack of correspondence between his/her behavior and the behavior demands of the social group that should act as the model. This situation would be considered as a moral problem due to that lack of correspondence or adjustment.

Taking the foregoing into consideration, this methodology's second analysis dimension, the *macrocontingential system,* was developed. The said system refers to the psychological analysis of the moral dimension of behavior and, in a simplified manner, consists of an analysis of the correspondences between the valorative practices—such as actions and beliefs—of a person and of the people of his/her reference group.

The way of studying the moral dimension of behavior, from a psychological perspective, is to focus on a person and his/her social environment.

In order to be able to analyze the correspondence between a person's valorative practices and his/her social group and considering that these values were learned in a circumstance where values are explained as the "ought to be" of a type of relationship, two microcontingencies are identified, an exemplary and a situational one [6, 7].

a. Exemplary microcontingency is a microcontingency in which a person or several people explicitly establish or established a behavior mode as the "ought to be" of a certain type of relationship, so to say, it is the relationship that works as an "example".

b. Situational microcontingencies are those microcontingencies that are regulated by the exemplary ones and in which the value/assessment criteria are tacit.

Taking these two microcontingencies into account, the macrocontingential analysis is performed by studying the correspondences between the two dimensions of the assessed behavior. First, correspondences or lack of same between the practices and beliefs in the two types of microcontingencies (exemplary/situational) are analyzed. Then, the correspondence or lack of same between practices and beliefs in each type of microcontingency is analyzed. In both cases the two dimensions of the assessment behavior, the effective practices, in other words, the assessment actions, and the alternative practice of such actions are identified, namely his/her beliefs in relation to those type of actions. This relationship between the two microcontingencies, between doing and believing, and between people in each type of microcontingency, is classified in two types: intrasubject, in which the correspondence or lack of same between what a person does and believes, is related to what he/she does, and inter-subject, which refers to those that can or cannot exist between the different significant people in an interaction [7]. For example, in a clinical context, if a mother complains that she hits her children and says that she cannot avoid it and that she feels very bad afterward, because she is convinced that what she does is an abuse and a sin, as a brief description, we would analyze a lack of intra-subject correspondence in the mother herself in the situational microcontingency. What she believes does not match what she does. It is worth mentioning that this analysis is supplementary to what has been found in the microcontingential analysis.

5. Source of problem

The source of behavior is proposed with a set of categories that can identify relevant aspects in a person's interactive history, considering the functional historical role of the person himself/herself and of the significant people to the behavior under study. The origin/source may have a dispositional function in the currently studied behavior.

Two aspects are evaluated: (1) history of the microcontingency and (2) evaluation of competencies [6]. Each one is described in more detail hereunder.

5.1. Microcontingency history

a. Circumstance in which the behavior started: this refers to the description of specific conventional circumstances in which the studied behavior acquired its particular functionality.

b. Situation in which the current microcontingency started: it refers to how the studied interaction originated in the microcontingential system and how it evolved.

c. Mediating history of behavior: if the studied behavior has had a mediating function/role in the person's past, in other words, if his/her behavior has regulated other people's behavior.

d. Dispositional functions in significant people's past in the present microcontingency: In this part we analyze if the people considered as significant in the interaction in the past have exhibited behaviors that regulate states of mind, shocks, tendencies, or those that have sponsored the studied person's behavior in different situations to the one studied.

5.2. Competencies evaluation

The non-problematic behavior that enables the identification of skills, non-problematic contexts, and resources must also be evaluated in the contingential analysis:

a. Non-problematic exercise of the problem behavior: the situation where the problem behavior is not assessed as such according to the social circumstances and places, the people involved and their role/function, and finally, other behavior morphologies of the user in these situations that must be evaluated.

b. Functionality of behaviors in said contexts: this functionality is evaluated in three ways: (1) as mediating of other people's or the user's own behavior, (2) possible dispositional functionality of behavior, and (3) effectiveness of the problem behavior in these contexts in which it is not assessed as a problem.

c. Availability of potentially functional non-problematic responses in the present microcontingency: here, non-problematic microcontingential relationships, appropriate behavior morphologies in similar contingencies which are assessed as problematic, and user's non-problematic behavior morphologies in relationships with significant people of the problem microcontingency or similar are identified.

From this step on, the following two are the strictly technological components of the contingential analysis and are used when an intervention has to be done and there is an assessed problematic behavior. These two steps are used more in professional fields such as the clinical or health fields. In other professional fields analytical steps are regularly used. In case changes are required in other professional fields, the technological components are carried out adjusting to the nature of the interaction that will be changed (individual/group and type of professional duties that will be performed, among others).

6. Solution analysis

The solution analysis outlines the elements considered for relevant decision-making to change behavior. This step was raised based on breaking with the traditional system where

predetermined problems are classified and thus solutions. From this perspective, each studied interaction is considered unique and if it is necessary to intervene to look for a change, all of the previously analyzed elements must be considered to reach an "ideal" solution. Possible solutions or changes in the behavior of interest are raised to begin with. After this, an analysis of each one of the outlined solutions is carried out considering different criteria, for example, their feasibility, the possible short-, medium- and long-term effects, the necessary and available resources, and the possible emotional cost, among others. When a solution analysis is performed in clinical cases, the user must actively participate in this stage. Once the analysis has been carried out, the most appropriate solution or solutions are selected and are identified in **Table 1**.

The horizontal axis in **Table 1** represents the macrocontingential dimension where there are two options: macrocontingential maintenance or macrocontingential change. If the detected problem is macrocontingential, in other words, when the decisive factor is a lack of correspondence between a person's behavior and his/her reference group's behavior, the macrocontingential change column is chosen; however, when the problem does not have anything to do with a moral evaluation, then the macrocontingential maintenance column is chosen. It is worth mentioning that the type of microcontingential change is specified in the lines and even though a change may be required to achieve correspondence between a person's and his/her group's assessment practices, or of a member of his/her group, this cannot be done without altering any aspect in the microcontingential order. The main direction of the chosen solution is selected in the table.

As indicated, the specific type of foreseen change as a solution is found in the lines.

- Microcontingential maintenance: in this heading there are solutions that must be carried out at a macrocontingential level and that are usually related to a person's change of beliefs, in the direction of his/her substitutive behavior.
- Change other people's behavior: the aim is to change other significant people's behavior in the interaction.
- Change one's own behavior: the possible solution is found in the user's behavior change in terms of its function, with the objective of developing competencies/skills, reducing or eliminating conflicting responses, and thus altering its effects.

	Macrocontingential change	**Macrocontingential maintenance**
Microcontingential maintenance		
Change other people's behavior		
Change one's own behavior		
Options due to new microcontingencies		
Other functional options of the same behavior		

Table 1. Solution analysis table.

- New microcontingencies options: in this option the user leaves the problem microcontingency and moves on to a new one.
- Other functional options of the same behavior: they consist of the modification of the microcontingency, taking advantage of the user's resources.

This step of the methodology gives rise to setting specific intervention objectives.

7. Selection, design, application, and evaluation of the intervention procedures

The selection, design, implementation, and evaluation of the intervention program are the last steps of the methodology and arise from the analysis performed in the previous steps. The emphasis at this point is to design or select strategies based on functional criteria consistent with the functional nature of the studied behavior, the type of procedure according to its effects, and the roles that the psychologist must perform.

Considering that each behavior of interest is unique and therefore there are no "ad hoc" techniques to solve some or to make changes, a selection or individualized design that may consider the use of already established behavioral techniques or of non-standardized procedures is required [11].

According to the foregoing, Díaz-González et al. [12] propose that the design and selection of the intervention must be based on the identification or performed analysis in the first three steps, as well as in the chosen solution. Subsequently, the type of intervention is selected or designed considering the following functional criteria: (1) nature of the therapeutic interaction, (2) type of procedure in terms of its effects, and (3) counselor's roles.

7.1. Nature of the therapeutic interaction

This first section considers the studied interaction's characteristics, as well as the specific characteristics of the behavior to which the technique or procedure is addressed. For this, there are five categories that account for the interaction's functional nature [1].

a. Opportunity: when the behavior is not properly evaluated because it is emitted under circumstances and places in which it must not be emitted.

b. Accuracy: when the behavior of interest is not emitted with the appropriate accuracy.

c. Tendency: when a historically frequent behavior is important for change and therefore, chances that some will be emitted when the current interactions are high.

d. Effect ratio: when the critical factor for the assessment of a behavior as a problem is related to the consequences of the same.

e. Acquisition: as its name implies, a behavior is assessed as a problem because the person lacks some skill and therefore the aim is for the behavior to acquire a new functionality.

7.2. Types of procedure in terms of its effects

For this second set of criteria the expected effect after the application of a given technique or procedure must be taken into account. Four categories are proposed for this:

a. Procedures to change dispositions are those aimed at changing properties of objects or environmental aspects, inclinations, propensities, tendencies, or moving available skills through the user's behavior.

b. Procedures to change other people's behavior are those aimed at changing the function of other significant people's behavior in relationships.

c. Procedures to change one's own behavior imply changing the function of the user's behavior by either creating or changing skills, establishing behaviors that change dispositional or certain effects.

d. The procedures to change macrocontingential practices have the effect of changing beliefs or assessment practices to adjust to those of their reference group or change practices or assessment beliefs of the reference group itself [1].

7.3. Counselor's roles

Great importance is placed on the psychologist-user relationship in contingential analysis. The counselor or psychologist's behavior is deemed to have effects on user's behavior when he/she is in his/her environment and that this is something that cannot be overlooked. Other authors have already talked about this relationship; for example, Ruiz-Sancho [13] performed an analysis of counselor-user language interactions because they consider that the counselor or psychologist's verbalizations shape the user's behavior and in turn, the user's verbalizations shape the counselor's behavior [14]. They conducted research in the clinical context using recordings of clinical sessions and identified four functionally different verbal behaviors throughout the sessions:

1. Evaluate: identify the problem behavior and understand the organism's interaction as a whole in its physical-chemical, biological, and social environment.

2. Explain: present the hypothesis on the learning processes that explain the acquisition and maintenance of the problem behavior to the client.

3. Treat: explain the treatment plan based on the functional analysis that has been explained previously.

4. Maintain: maintain the behavioral changes achieved during the therapy session.

Functionally speaking, these authors claim that evaluating has a discriminatory function, explaining an informative function, treating an instructional function, and maintaining a reinforcing function.

On the other hand, the authors mention that every type of counselor's/psychologist's verbal behavior leads to a type of user's verbal behavior. They classified them in three:

1. Pro-therapeutic verbalizations are verbalizations related to the clinical change in a positive way (achievement, well-being, and follow-up of instructions outside the session, among others).
2. Anti-therapeutic verbalizations are verbalizations related to the clinical change in a negative way (failure, distress, or discomfort, no follow-up of instructions outside the session, among others).
3. Neutral verbalizations are verbalizations related to the clinical change in an impartial or neutral way (request information, provide information, show disagreement, etc.).

A preliminary classification of the counselor's/psychologist's possible roles is proposed in the contingential analysis:

1. To sponsor: this refers to creating the necessary conditions for an interaction to take place between certain people but without being a direct part in this interaction. This is a dispositional function.
2. To inform: it is characterized because the psychologist describes the circumstances, factors, and effects that are related to an interaction taking place or not.
3. To regulate: the psychologist establishes the times and morphological factors affecting the behavior that should be involved in certain forms of behavior.
4. To incite: this is related to the psychologist persuading the user to behave in a certain manner.
5. To train: this consists of exercising the ways a patient must behave.
6. To instruct: this is related to explaining the specific type of behavior that a particular interaction requires.
7. To participate: this refers to the psychologist taking part in the interaction.

It is important to say that the mean difference on this stage is the criteria used to select procedures. Instead of thinking about problems with morphological basis, such as anxiety or depression, the psychologist must consider procedures in terms of their effects and plan his/her own behavior, as part of the intervention stage. For instance, if a microcontingential problem is identified, such as the fear of one mother to establish limits with their children, and it is analyzed that the main explanatory element for this behavior is a propensity, because she has the required competence but she is afraid that children could leave home, intervention should be directed to this propensity. The counselor could select behavioral procedures to change this fear, but it is important he/she should incite and inform about the risks or benefits of the establishment of limits and perform the required changes.

In many cases behavioral techniques are selected, especially if the counselor has to train behaviors, because the microcontingential problem is mainly due to a lack of competences. Modeling, behavioral rehearsal, contingencies' management training, and social skills training are all useful procedures when the nature of the problem relates to acquisition, opportunity, accuracy, among others.

	Used procedure	Type of observed change
I. Problem definition		
II. Solution analysis		
III. Change procedures		
IV. Follow-up		

Table 2. Changes' assessment.

When a macrocontingential problem is identified, there are no standard techniques to be used, but the purpose is to change beliefs, as substitutive behavior. Counselor's behavior is very important on these kinds of cases, because he/she has to use all the required information to change beliefs in a very inciting way. He/she needs to discuss the implications of certain beliefs and to contrast one type with another.

Finally, every time this methodology is used, the changes generated throughout its different stages are evaluated [1]. For this purpose, the change evaluation guide which is a functional classification of the user's changes at different times is used for this (**Table 2**).

7.4. Change evaluation guide (GEC by its acronym in Spanish)

As shown in **Table 2**, the vertical axis of the guide (GEC) comprises each one of the stages the psychologist gets involved with and in which a change can be observed. On the other hand, the used procedure and the user's change at that time must be registered in the horizontal axis.

To register the type of change that may occur, 17 categories gathered in the following five groups are used:

a. dispositional alteration is the alteration of dispositional factors that give the problem behavior a context

(1) properties of objects and physical events

(2) competencies displacement

(3) inclinations

(4) tendencies

(5) one's own behavior with dispositional effects on oneself

(6) interaction strategies

b. Alteration of other people's behavior: this category covers changes in other people's behavior according to their function/role.

(7) sponsors' behavior

(8) propensity and inclination regulators' behavior

(9) tendency regulators' behavior

(10) mediators' behavior

c. Alteration of one's own behavior includes user's changes according to his/her own behavior.

(11) effects of one's own behavior on oneself

(12) one's own mediating behavior

(13) development of competencies/skills

(14) establishment of behaviors that alter the effects of other behaviors

d. Alteration of macrocontingential practices consists of the possible changes of the user's assessment practice.

(15) own behavior that alters others' assessment practices

(16) own behavior to be adjusted to others' assessment practices

(17) another person's behavior that changes one's own and/or others' assessment practices

e. Without change: this is the last category that refers to a lack of change by the user.

8. Final comments

A general description of the contingential analysis was made in this chapter, trying to generate reader's interest in the topic. It overpasses our purpose to illustrate the full application of the analysis, but we recommend reading more about it. This methodology has been successfully applied in a clinical context with different main complaints such as parent-child relationships, fear to walk among elder people, violent familiar relationships, and couples' problems, among many others [15–18]; in a health context where with the basis of the psychological model of biological health and contingential analysis, several researches had been made to understand and change diabetes risk behaviors and HIV risk behaviors, among others [19–25]; in an education context, assessing instructional models to teach contingential analysis, analyzing therapeutic relationships, or developing educative educational workshops for diabetic patients [26–29]; and in a work context developing models and tools to assess laboral competences [30–32].

Considering the fact that the methodology results from an interbehavioral theory, that is, a general human behavior theory, it enables to approach behavior in different professional contexts, in a coherent manner with a scientific position and giving clarity, coherence, and relevance to the application of scientific knowledge; in this regard, this methodology constitutes an alternative to professional psychology. Also, the heuristic value of this approach and the link with basic science must be considered. If we go for a scientific psychology, we need to consider that the adjective *applied* refers to basic and scientific knowledge.

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Chapter 4

Initial Condition and Behavior Patterns in Learning Dynamics: Study of Complexity and Sustainability from Time Series

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Additional information is available at the end of the chapter

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Abstract

Learning is an essential part of human life. In it, our sensory organs and neural networks participate and integrate emotional behaviors, indagative and persuasive abilities, along with the ability to selectively acquire information, to mention a fraction of the media used in learning, converge to it. This study presents the results of the observational monitoring of behaviors, displayed by teams of students in learning processes, their interactions, representing them as series of time. These time series contain the dynamics of learning: weak, average, and chaotic, differentiated by the control parameter (connectivity) that is increasing respectively. The exponents of Lyapunov, the entropy of Kolmogorov, the complexity, the loss of information for each series, and the projection horizon of the processes are calculated for each series. The results, approximate, show that the chaotic dynamics propitiate the learning, given that there is an increase of connectivity within the teams breaking patterns or behavioral stereotypes. The entropic character of connectivity allows estimating the complexity of this human activity, exposing its sustainability, which brings irreversible conflicts with nature, given that the universe of nonequilibrium is a connected universe. Finally, the analysis model developed is historically contextualized, in first approximation, in some ancient civilizations.

Keywords: learnings, time series, Lyapunov coefficients, entropy, sustainability

1. Introduction

When confronting the diverse experiences of daily life, the human being concludes on the ways of acting that are adequate to get away from unpleasant situations and that place him

in conditions of greater well-being and joy. The emotions are numerous and very complex that command the different ways of reacting. Thus, for example, when faced with an event or element that bothers us or that does not give us pleasure, we can react by moving away or try to find a solution or other strategies that translate into behaviors, which will change the situation that face. Of those diverse experiences and circumstances that a person has gone through, of the dissimilar emotions that have produced him and of the multitude of decisions that a person has taken, some left in the person more profound mark than others [1]. And it is by that experience and how we have reacted before it is that it becomes the basis of reference for multiple decisions in the future, and therefore, they go on to form the baggage of a person's behavior pattern. From the above, it is clear that emotions have an enormous influence on learning [2, 3]. Emotion plays an important cognitive role [4–6]: the knowledge of life and the universe is not only intellectual, since the subtle nuances of it are provided by emotion. In effect, emotions enrich human knowledge by broadening the background, too rigorous and symmetrical, of purely intellectual concepts. Emotions are the other way of knowing about the world and themselves [6].

The learning process should give value to facts, people, and situations, shaping the initial contextualized condition, according to its influence on emotionality, given its natural impact on the learning of people. This value assignment manifests itself, neurobiologically, in attentional and perceptual selection [7, 8]; in the selection that is remembered by long-term memory and in the perception that dispositions and attitudes are "felt" as more appropriate [9, 10]. The value assignment makes learning sustainable over time. Thus arises the question that, to some extent, gives the pattern to the title of this chapter:

Is it possible to construct mathematical indicators, appropriate to be measured, that inform about the sustainability [11] of a learning process and that consider the influence of emotions in the induction of behavior patterns?

2. About the study sample

To investigate an answer to this question, we considered a sample of students who take the course of Classical Mechanics Laboratory parallel to the theoretic class of Classical Mechanics. These subjects are dictated by a higher education institution for students of the Common Plan of the Engineering area. The sample is constituted by 240 students distributed in five theoretical courses, with an average of 40 students.

The collaborative learning process that is analyzed relates to the Classical Mechanical Laboratory courses whose content base of 12 experimental activities, each of 90 minutes, programmed during a semester. A "typical" laboratory course was formed by 12 students, which grouped into four teams of three students each. The creation of teams of only women, only men, and mixed were encouraged to study, also, the relationship between gender and learning in science. The selection of the courses is made without any other a priori criteria (notes, social origin, and others). The achievement of significant learning is examined through laboratory reports developed and delivered periodically by the teams of students for each activity plus two cumulative tests with questions about alternatives and development.

The students correspond to their vast majority (90%) to the first family generation in entering higher education.

3. Initial condition: Facing stereotypes

3.1. The search for feeling good

The abandonment of chaotic behavior is at the beginning of human life (and can be translated as loss of entropy), but chaos is inherent to the environment (in life itself), which interprets as the physiopathologic loss of the adaptive possibilities in the neuronal system. This abandonment is an aspect that is not considered or considered irrelevant in a development framework, human and institutional, symmetric or homogeneous, that assumes the predictability of the processes (according to a linear approach) as a norm [12]. From the perspective of human activity, the reduction, in the short term, of anguish, anxiety, stress, and the wear and tear of unpredictable events is positive.

Modern society has turned this search into a pattern, in which it pigeonholes everything it deems necessary and too often regardless of its falsity or truth. This imperative of linearity and symmetry, which seeks to minimize the costs associated with risks, informs us and shapes the meaning of the world [12] by skewing learning. It makes us see, in a noncommutative world, commutativity in events, in the manner of algebra and linear physics. Thus, life experience and teaching associate the built order with "feeling good" [12], encouraging and stimulating behaviors. It follows then that the uncertainty bias permeates all relational forms [13, 14]. The connectivity carried by this road will have stability in relatively short periods of time, collapsing due to unresolved tensions that are incubated in its interior (truth and falsehood). The prolongation in time of relational forms will necessarily require the intervention of elements either internal or external, which can interpret as the basis of mythical, mystical conceptions [15] and of certain justifications that they misuse religion.

3.2. The history of personal experiences in the development of behavior patterns

Based on the experiences and how it reacted previously, experiences become the basis of reference for various future decisions: they constitute the stock of behavior patterns of a person. The construction and use of the contextualized initial condition seek to place these "certainties" in interdiction. Since everything life accepts and creates a bond, it will always be dependent. Two people who apparently do not need anything from each other could not form a relationship.

The way in which the human being reacts, either his way of acting, feeling, or acting, is governed by a series of external guidelines, which society accepts. Much of the behavior of human beings is learned, that is, acquired through interaction with the community in which it grows and develops [16, 17]. This means that the various groups in which he has been interacting have transmitted his guidelines and behaviors to react to the stimuli he receives from the environment.

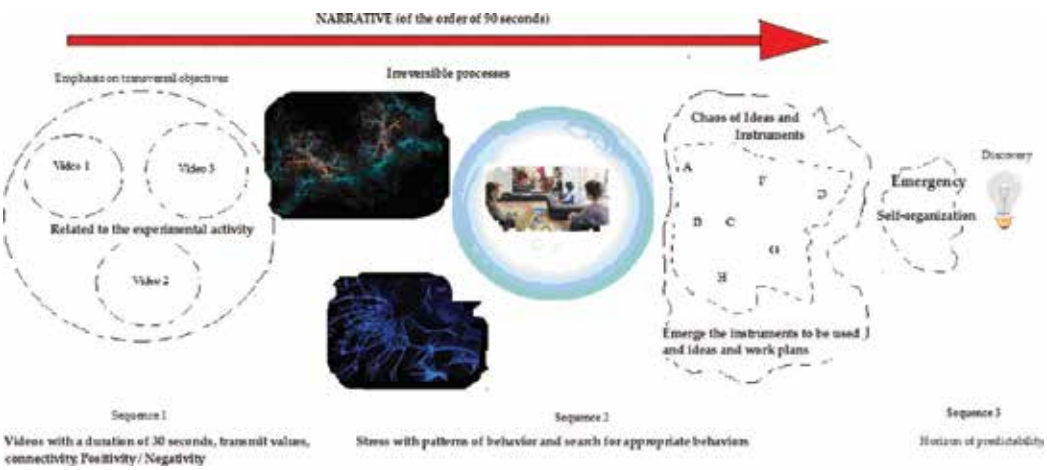
In the United States in the decade of the 1990, Chaos Theory was essentially used to solve or at least canalized racial and social conflicts that expressed in the form of school violence in schools that correspond to marginal environments, such as immigrant communities. It developed a

particular interest in the problems of educational organization and administration in these contexts. Thus, some authors [18, 19] carried out a nascent pedagogy of chaos from the theory of the same name and have used it in the resolution of determining problems of school organization and administration in unstable, violent, and conflicting educational system.

The close relationships between behavior patterns and ideas and attitudes are what have motivated anthropology to study how culture influences the development of personality. From the perspective of the chaotic model applied to the study of learning [20], the stimulus is a contextualized initial condition (CIC). The stimulus (CIC) is susceptible to construction and appeals to the history of past – present – future experience of a sample of individuals with similar life experiences. The narrative to be constructed can be in the form of a short demonstration experiment, short length videos, interaction between the teacher and the student teams through questions that emphasize unexpected relationship events, and so on. The achievement of identity with the contextualized initial condition favors the development of positive or negative emotions propitiating adaptive behaviors.

3.3. Visual narrative: A way to approach the breaking of stereotypes

The visual narrative used is explained in the outline below. This appears divided into three fundamental sequences, as shown in the diagram:



For the first phase on the left-hand side, three or four different or nonhilarious videos presented by the experimental activity will be carried out (each of no more than 10–15 seconds), which has the purpose of presenting transversal objectives such as respect for others (my actions bring consequences to other people and the environment). A question session (student–teacher) held regarding the connectivity of the events was witnessed. It seeks to stimulate curiosity but stressing the ideal of the world in which we believe we live. A predictable world manufactured in the technique to which we associate states of emotional hope.

In the middle of the picture is the real world, of irreversible processes, dominated by nonlinear dynamics, that is, chaos or fractal nature is the world of nonlinearity. Our version of life floats in that sea of irreversibility. This version means a low horizon of predictability.

Given this, our behavior patterns lead us to the illusion that the problems do not touch us or that they will resolve themselves, which is impossible. The collapse between what is learned and what is needed to face situations of high uncertainty manifested in behaviors of anger, crying, denial, impotence, stupor in the face of disaster, frustration, avoidance of error, indifference, etc., all emotions that do not contribute to solve the problem.

A convenient approach to this world is to arrange the measuring instruments being used in the experience chaotically, in such a way that through self-organization and the emergency originates an order that leads us to a possible solution in the form of discovery. Once again, the questions (student–teacher) regarding what you want to measure and how to dispose of the instruments should be the guide to the solution (in a playful way).

Finally, the final section of the video exposes a logical sequence of the disposition of the equipment to reach the objective of the activity.

The proposed sequence modifies the standard way in which the system promotes learning, given that as Albert Einstein said: "It is impossible for us to solve problems using the same procedures that generated them." The contribution of new generations, living the prevailing complexity, with a new understanding of sustainability based on connectivity is fundamental. All activity carried out by the human being entails, irremediably, error. These errors range from measuring instruments (scale of measurement, calibration, seniority, etc.), user expertise, treatment of significant figures, statistical analysis of measured values, and interpretation of measurements to the relationships between them. Therefore, this procedure is inherent to any experimental activity, and in general, we should say of any human activity. Performing activities that are keeping with the way our brain works reduces anxiety, tension, frustration, and fear.

4. Chaos and learning

The fundamental idea underlying this approach to meaningful learning is that chaos makes life and intelligence possible, since the brain is a nonlinear product of a nonlinear evolution on a nonlinear planet [21]. The brain is an unstable system that nevertheless leads and achieves the formation of new orders, as well as chaotic actions [21]. The brain has evolved to become so unstable that at the smallest stimulus, external or internal signal, it can encourage behaviors that represent a healthy break with historical behavior patterns favoring the emergence of an innovative and creative order [22].

A pattern of behavior emerges, once a narrative is recognized in a context. It allows us to optimize our human resources such as physiological, emotional, and rational, by freeing our attention and focusing on those events that burst without us having a collection of proven answers. The irruption of events in scenarios of high complexity [23, 24], created by human activity and progressively intensifies, exposes the weaker side of the human condition: the reserve of learning reactions is shown to be inoperative or too small.

Paradoxically, the built society model is fundamentally reductionist since the fundamental parameter of control is the economic one, a variable that has unleashed a form of economic "complexity" that has the planet as a great dump of the waste of human activity and technology,

garbage. This event is an irremediable "consequence" of all actions, transforming itself, its growth and treatment, and it is a process of very high complexity that very few assumed. At present, propitiate learning, regardless of how connected and globalized they are, from this petty perspective based on consumption without any responsibility to the planet, generates entropy or progressive disorder in nature, stretching it to its limits.

5. Construction of an approach to a chaotic learning model

5.1. Variables to observe

The "typical" performance matrix per student team is divided into small time intervals until the 90-minute class is completed. The observation focuses on the behaviors displayed by students in the process, for which six fields of generic behaviors were typified: Inquiry (IND), Persuasion (PER), Positivity (POS), Negativity (NEG), Internal Information (II), and External Information (IE). Each field contains a set of 13 behaviors, which assigned a numerical range from −6 to +6, as shown by the scheme N°1 for example of Positivity and Inquiry [25–27]:

This hierarchy determines a total of 78 behaviors for the six behavioral fields to observe during the 90-minute session.

To consider the interactive behavior of the team's constituent students, a time of 5 seconds was granted, which gives a total of 1080 rows of data divided into two columns. A column is the time input at intervals of 5 seconds to complete 5400 seconds, and the other is the numerical coding according to the observed behavior displayed by the team.

To construct the proportions X = IND/PER, Y = POS/NEG, and Z = II/IE, the data are divided locker by locker, for the same time, between the Inquiry and Persuasion, Positivity and Negativity, and Internal Information and External Information, using the six different value tables built (**Table 1**).

	Codification
6	Interprets
5	Group in tables of values
4	To size
3	Calibrate a measuring instrument
2	Characterize measurements variables
1	Explore
0	Neutro
-1	Do not explore
-2	Not characterize measurement variables
-3	Not calibrate a measuring instrument
-4	Do not measure
-5	It does not group in tables of values
-6	Does not interpret

t (min)	Inquiry behavior
0	
9	
18	
27	
36	
45	
54	
63	
72	
81	
90	

Table 1. Illustration of a table with the inquiry behavior and its coding taxonomy.

5.2. Experimental procedure

Two laboratory classrooms were used to record the observations, with two video cameras located in each one. Each camera records sound and image by storing the information on external hard drives. The cameras were positioned at the height of 1.8 m fixed to the wall and in such a way as to completely cover the student teams. Previously, a document was created that requested the student's authorization for the filming, which had to be signed by each one of them. Noted that during the filming process, the behavior of the students did not alter the presence of the cameras. In one room, the experimental group to which the initial condition was applied, while in another room, the control group develops its activities with no initial condition. At the end of the lecture session, the collected information is saved indicating the date, time, actively developed, and course.

5.3. Team to collect the information recorded in the videos

Any measurement or data collection instrument must collect two essential requirements: validity and reliability. In general terms, validity refers to the degree to which an instrument measures the variable it intends to measure. Validity is a concept from which different types of evidence have related [28, 29]. This evidence is the content (the degree to which an instrument reflects a specific implicit domain that is measured), criterion (validity of an instrument of measurement compared with an external judgment), and construct (quality of measurement related consistently with other measurements according to hypotheses derived theoretically and that concern the measured concept).

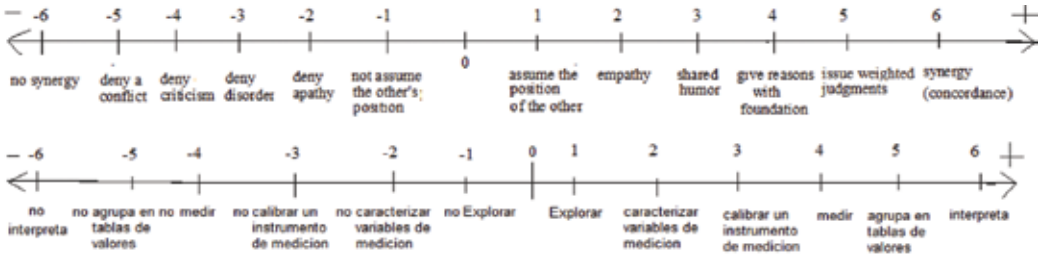
The reliability of the instrument is the degree to which its repeated application to the same subject or object produces the same results. If the correlation between the results of the different appliances is highly positive, the instrument is considered reliable (in psychometrics, Cronbach's alpha [30] is a coefficient used to measure the reliability of a measurement scale).

Applying the Hypothesis Testing (or dokimasia) to the tables of measurements of each one of the variables under observation, we could know if the measurement instrument calibrates from the accuracy.

The procedure for extracting information from the videos of the sessions was divided into two parts: Theory and Praxis.

From the theoretical point of view, the observers trained in the graduation of behaviors for the fields defined in this research: Inquiry, Persuasion, Positivity, Negativity, Internal Information, and External Information. This graduation of the behaviors for Positivity and Inquiry is illustrated in **Scheme 1**. Is it possible to do a finer gradation? Obviously, it is. Similarly, it noted that a specific exploration of facial gestures was not performed (frowning, opening or closing the eyes too much, changing the line of the mouth, and so on and so forth) [31–33]. It is a subject that opens a future work.

From practice, each component of the team in charge of registration, consisting of four people, gives independently the same scene (image and sound) of some of the videos captured of the activity carried out by the students. This brief scene, of the order of 10 minutes, is numerically

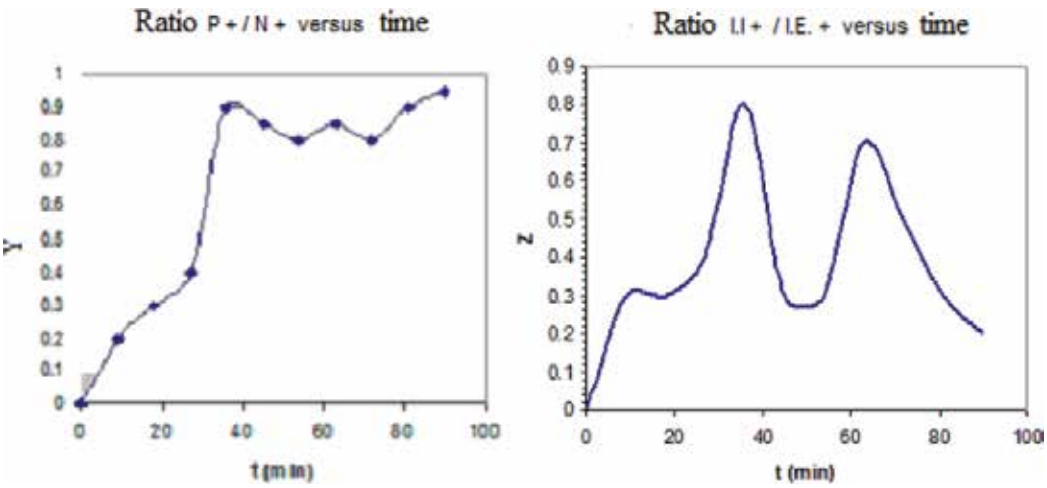


Scheme 1. It indicates the domain of double polarity and the coding scale, in its dual polarity, of Positivity and Inquiry, with its 13 associated behaviors.

coded according to the behaviors observed in the same field. In general, the coding tables have 1080 rows, separated by intervals of 5 seconds. Once this process is finished, the four tables generated are analyzed by the psychologist and a statistician who study the convergences and divergences between the measures: the guideline, in the form of feedback, given to the observers is to identify the actions that promote relationships within the team. Gradually, the times of study of scenes are extended, until covering the session of complete learning about 90 minutes. The comparative analysis of the measures is the one that indicates if the instruments (the observers) present similarity in their registers [27]. After a work period of about 1 month, it was possible to certify that the observers were calibrated and reliable "instruments" (results illustrated in Section 5.5 between the control and experimental team).

5.4. Time series

The proportions X = IND/PER, Y = POS/NEG, and Z = II/IE constructed constitute numerical series of 1080 data that are called time series. After applying the initial condition with emphasis on emotions at 30 minutes, some of the graphs of the moving averages in time are below (**Graph 1**):



Graph 1. Represents the variation over time of the Time Series of the Quantities Positivity/Negativity (= Y) and of the ratio Internal Information/External Information (= Z).

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5.5. Reliability and validity of measuring instruments

Illustration with the Dimension Y = POS/NEG in time using moving averages.

A STUDENT TEAM (COURSE 1)

t (min)	Y_1	Y_1 -0.63	$(Y_1 - 0.63)^2$
0	0	-0.63	0.3969
9	0.2	-0.43	0.1849
18	0.3	-0.33	0.1089
27	0.4	-0.23	0.0529
36	0.9	0.27	0.0729
45	0.85	0.22	0.0484
54	0.8	0.17	0.0289
63	0.85	0.22	0.0484
72	0.8	0.17	0.0289
81	0.9	0.27	0.0729
90	0.95	0.32	0.1024
N =11	Sum =	6.95	Sum = 1.1464
	Sum / 11 =	6.95 / 11	VAR1 = 1.1464 / 11
	Average	= 0.63	= 0.104

A STUDENT TEAM (COURSE 2)

T(min)	Y_2	$Y_2 - 0.75$	$(Y_2 - 0.75)^2$
0	-1	-1.75	3.0625
9	-0.5	-1.25	1.5625
18	1.5	0.75	0.5625
27	0.8	0.05	0.0025
36	1	0.25	0.0625
45	1	0.25	0.0625
54	1	0.25	0.0625
63	0.8	0.05	0.0025
72	1.25	0.5	0.25
81	1.2	0.45	0.2025
90	1.2	0.45	0.2025
N =11	Sum =	8.25	Sum = 6.035
	Sum / 11 =	8.25 / 11	VAR2 = 6.035 / 11
	Average	= 0.75	= 0.5486

where:

$(Y_1-0.55)*(Y_2-0.66)$
1.1025
0.5375
-0.2475
0.0115
0.0675
0.055
0.0425
0.011
0.085
0.1215
0.144
1.9305

Pearson's Sample Correlation Coefficient [34] for the fundamental dimension, Y, referring to two items from two different courses:

$$r = \cos(\alpha) = \frac{\sum_{i=1}^{N}(y_{1i} - \bar{y}_1)(y_{2i} - \bar{y}_2)}{\sqrt{\sum_{i=1}^{N}(y_{1i} - \bar{y}_{1i})^2}\sqrt{\sum_{i=1}^{N}(y_{2i} - \bar{y}_2)^2}} \approx \frac{1.9305}{\sqrt{1.07}\sqrt{2.456}} \approx 0.75 \approx p \quad (1)$$

Cronbach's alpha coefficient [30]:

Confidence interval

$$\bar{Y} \pm t_{n-1;1-\frac{\alpha}{2}} \frac{S}{\sqrt{n}} \quad (2)$$

with $\bar{Y} = 0.63$, $S = 0.322$, α at level 0.05, $r = n - 1 = 11 - 1 = 10$ = degrees of freedom where n is the number of measurements.

$$t_{n-1;1\,1-\frac{\alpha}{2}} = t_{10-1;1-\frac{0.05}{2}} = t_{9;0.975} = 2.228 \text{ (for } \textit{Distribution } t\text{-Student)}.$$
$$\text{confidence interval} = 0.63 \pm 2.228^{*}\frac{0.322}{\sqrt{11}} = \begin{cases} 0.41 & \text{(minimum)} \\ 0.85 & \text{(maximum)} \end{cases} \quad (3)$$

Finally, we want to know if the measuring instrument calibrated for accuracy.

Hypothesis test: defined H_0 = Null Hypothesis and H_1 = Alternative hypothesis [35].

Process:

H0: $\mu = 0.56$, the instrument is calibrated for accuracy.

H1: $\mu \neq 0.56$, the instrument is not calibrated. There is a systematic error.

$$t = \frac{\bar{Y} - \mu}{\frac{S}{\sqrt{n}}} = \frac{0.63 - 0.56}{\frac{0.322}{\sqrt{11}}} \approx 0.72 \quad (4)$$

where $\bar{Y} = 0.63$, $\mu = 0.56$ is a control team (calibrated with valid procedures).

Different observational monitoring teams were employed to perform the measurements and obtain μ

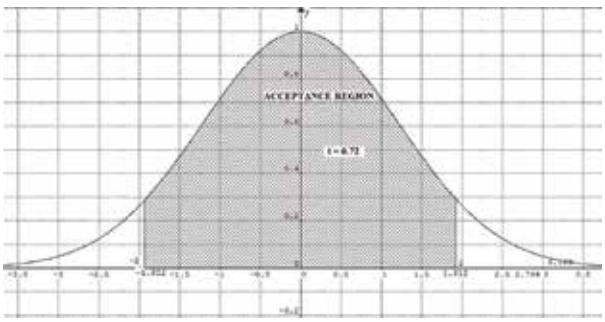
r = n − 1 = 11–1 = 10

$$t_{n-1;;1-\frac{\alpha}{2}} = \left\{ t_{10;0.95} = 1.812; \quad t_{10;0.99} = 2.764; \quad t_{10;0.999} = 3.169 \right.$$

The numerical values of t extracted from [34].

Graph 2 represents the Normal Distribution of the indicators t.

The accuracy calibrated instrument hypothesis is accepted.



Graph 2. Normal distribution of the indicators t.

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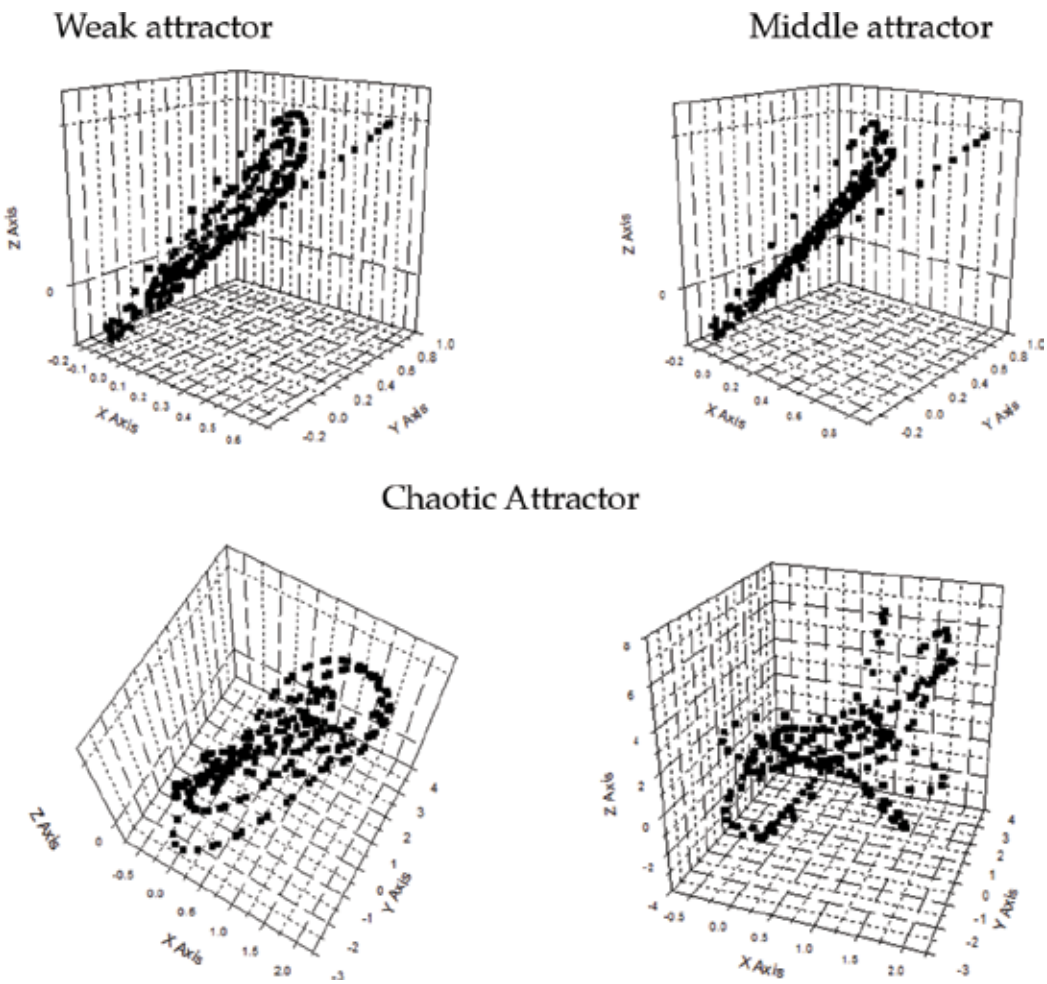
6. Dynamics

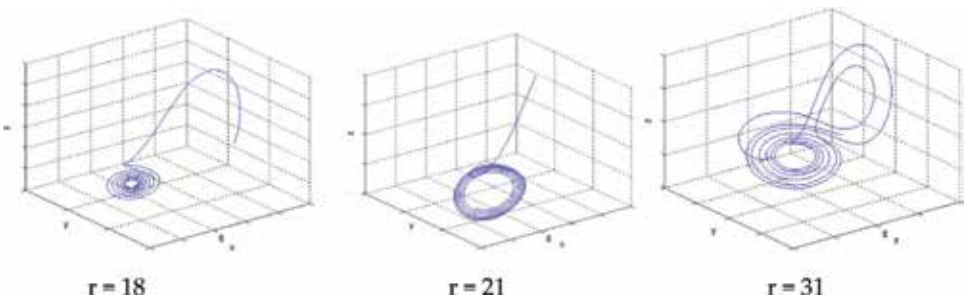
From the time series of X (t), Y (t), and Z (t), the discretized column vectors are constructed (observed that although vectors with a minimum of 1000 elements allow making good estimations, the ideal is that contain over 5000 components for the stability of the Lyapunov coefficients). According to the significant learning of the team of students, the graphs of the time series in the phased space acquire such forms:



The time series and the graph obtained are those that allow incorporating elements of chaos theory in their study. They satisfy two fundamental conditions of this theory: sensitivity to initial conditions and the existence of Lyapunov exponents greater than zero. Applying to the experimental data, the Lorenz equations [36, 37] modified according to the fourth order Runge Kutta numerical method, the dynamics classified from the control parameter

(also called connectivity). Its values deliver the performance of the teams that make up the Experimental Group: Low (r = 16.5, weak attractor), Medium (r = 20.5, medium attractor), and High (r = 28.7, chaotic attractor).

These values compared with those that arise from theoretical iterative cycles (using, for example, adjustment by Fourier Time Series) for X (t), Y (t), and Z (t), based on the range of their experimental domains. Programming in MatLab (software for numerical calculation and scientific analysis) the modified Lorenz equations [28, 33] (also possible by Neural Networks [38] or Cellular Automata [39]), the graphs are obtained as shown:



These graphics are classified according to the values of the theoretic control parameter, r, which roughly matches with the values of r for weak, medium and chaotic attractor, respectively, emerging from the experimental Time Series.

It was observed that the contrast between the performance of the experimental groups (selecting a team with chaotic dynamics) and the control groups (traditional courses without initial condition: choosing a good performance team) is carried out through cross-correlation. The cross-correlations by group according to the influence exerted by the variable of emotions Y (= Positivity/Negativity) on the variable X (= Inquiry/Persuasion) [20–25] is observed in **Table 2**.

The experimental group treated with contextualized initial conditions, which promote high connectivity within each team, shows that the balanced presence of positivity/negativity in their relationships exerts an influence 1.7 ~ 2, approximately, on the variable X, which is inquiry/persuasion (the most rational part of the team's work). Thus, the team leads more efficiently and safely toward the achievement of meaningful learning. This influence translated into connectivity and emotional field evolution reflected in the value that students give to learning and in its achievements. These achievements range from the experience of collaborative work, each component is determined in the learning process, to the formal evaluation procedures applied ranging from the weekly reports, entrance test at the beginning of the teaching session, tests, oral interrogation of any component of the team whose performance is extended to the whole team, etc.

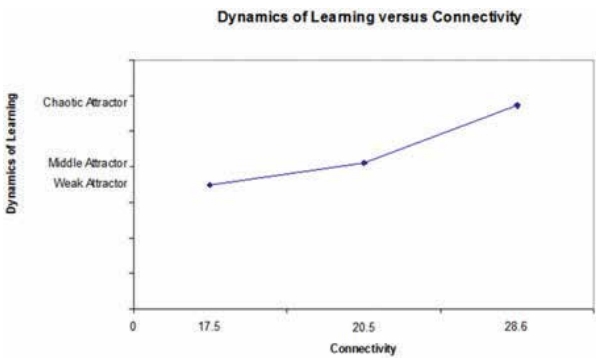
Group	Control	Experimental	Comparison: experimental/control
Cross-correlation	0.3	0.5	1.7

Table 2. Comparison between cross-correlation according to the Control and Experimental Teams.

7. Connectivity

The control parameter r (connectivity [40]) gives the transition between the different dynamics that favor meaningful learning. Connectivity defined as the capacity shown by the components of a system to expand the actions of others by their actions and to expand their actions from the actions of others [41, 42]. This definition is a glimpse into an underlying referential framework, inherent in all things, sustained by the complex intervariable interferences that characterize them, in a first approximation.

These interferences induce clutter dynamics that create an intelligent collective order, but temporary, which makes it imperative to incorporate them in learning. Teams with high connectivity and high POS/NEG quotients (greater than or equal to: 2.5 [43], 4.3 [44], and 5 [17]) are sustained over time and achieve the objectives of the activity [24, 45]. When observing **Graph 3**, we can see a growth in connectivity, as we approach the chaotic or complex dynamics:



Graph 3. Dynamics of learning versus connectivity.

What does this increasing behavior of connectivity (entropic connectivity) mean for learning? Is it possible to calculate it? How is it related to the complexity of the learning process under study?

Answering these questions, different numerical procedures were applied to the time series [46], which allow determining the Lyapunov coefficients [47], the Kolmogorov entropy (S_K) [48, 49], the complexity [50], and finally, the uncertainty in information [51].

8. Irreversibility and the sustainability of learning

The position of Ilya Prigogine [52, 53] on irreversibility and entropy varies that of traditional physics. In his lecture The Birth of Time (Rome, 1987), Prigogine argued:

"Entropy always contains two dialectical elements: a creator element of disorder, but also a creative element of order. (…) We see, then, that instability, fluctuations, and irreversibility

play a role at all levels of nature: chemical, ecological, climatological, biological - with the formation of biomolecules - and finally cosmological".

In this way, it was observed that the phenomenon of irreversibility for Prigogine is constructive, highlighting the "creative role of time," which, at least at a macroscopic level, supposes a kind of antientropy: "*the universe of non-equilibrium is a connected universe.*".

According to Wackernagel et al. [11]:

"Sustainability requires that life is within the regeneration capacity of the biosphere. In an attempt to measure the degree to which humanity satisfies this requirement, existing data have been used to translate human demand on the environment in the area required for the production of food and other goods, as well as in the absorption of waste. Numerical estimates indicate that human demand may well have outgrown the regenerative capacities of the biosphere since the 1980s. According to this preliminary and exploratory evaluation, the carrying capacity of humanity corresponds to 70% of that of the world biosphere in 1961, growing up to 120% in 1999".

All processes are irreversible because they are connected entropically making the complexity increases. Human activity is not exempt from this principle.

Chaotic systems consume considerable energy and information to maintain their level of complexity while being very sensitive to environmental fluctuations [54].

9. Some general mathematical concepts

9.1. The coefficient of Lyapunov

The standard procedure of determining whether or not a system is chaotic is through the exponents of Lyapunov represented by λ. When considering two nearest points in a stage n, x_n and $x_n + d\,x_n$, in the next temporal stage, they will diverge, particularly at x_{n+1} and $x_{n+1} + d\,x_{n+1}$. It is this average ratio of divergence (or convergence) that the exponents of Lyapunov capture. Another way of thinking about the exponents of Lyapunov is as a proportion in which the information about the initial conditions lashes. There are so many exponents of Lyapunov as a dimension of phase space.

The signs of the Lyapunov exponents, λ, provide a qualitative picture of a system's dynamics. One-dimensional maps are characterized by a single Lyapunov exponent.

If the exponent of Lyapunov is positive, $\lambda > 0$, then the system is chaotic and unstable [55, 56]. Next points will diverge regardless of how close they are. Although there is no order, the system is still deterministic. The magnitude of Lyapunov exponents is a measure of sensitivity to initial conditions, the primary characteristic of a chaotic system.

If $\lambda < 0$, then the system is attracted to a fixed point or stable periodic orbit [55]. The absolute value of the exponents indicates the degree of stability.

If $\lambda = 0$, the system is in a marginally stable orbit [55].

In a three-dimensional continuous dissipative dynamical system, the only possible spectra, and the attractors they describe, are as follows: (+,0,−), a strange attractor; (0,0,−), a two-torus; (0,−,−), a limit cycle; and (−,−,−), a fixed point [55].

The equation that allows calculating the coefficient of Lyapunov is given by:

$$\lambda = \lim_{T\to\infty} \frac{1}{T} \sum_{n=1}^{L} \ln \left| \frac{d x_{n+1}}{d x_n} \right| \tag{5}$$

9.2. The exponent of Hurst, H

H is used as a measure of long-term memory of time series. It refers to the autocorrelations of the time series, and the speed at which they decrease as the gap between pairs of values increases. The inverse of the Hurst exponent is equal to the fractal dimension of a time series. H takes values between 0 and 1:

H ≈ 0.5 indicates the absence of long-term dependence [57].

0.5 < H < 1, it is a persistent series, graphically presents a smooth appearance. H ≈ 1 indicates that the degree of persistence or long-term dependence holds.

H < 0.5, corresponds to anti-persistence, contrary to long-range dependency (LRD), indicates a strong negative correlation of the process that fluctuates violently.

0 < H < 0.5 indicates that the time series, in the long term, change high and low values of adjacent pairs of data; this tendency remains to fluctuate for a long time [57–59].

H is an index for the categorization of complexity, quantifies the chaotic dynamics, and is directly related to the fractal dimension, D, where 1 < D < 2, such that D = 2–H.

9.3. Embedding dimension

The Embedding Theorem serves to remake from the observed or measured time series, the evolution of the states in the phase space, where the exponents of Lyapunov and the fractal dimension can be calculated (for example). It uses the method of delayed coordinates (reconstruction with delays). If we have the data series $x_1, x_2, x_3, x_4 \ldots x_n$, we can form the set of points $(x_1, x_2 \ldots, x_p)$, $(x_2, x_3 \ldots, x_{p+1})$ …, and $(x_i, x_{i+1} \ldots, x_{p+i})$. These points determine a trajectory in the space R^p. The dynamics of the empirical system represented by the "minimum" dynamics (in a dimensional sense) of this set of points:

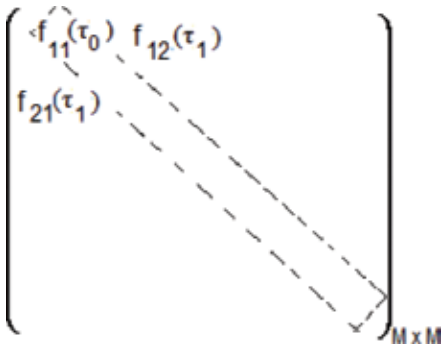
If the system is random, the fractal dimension grows, as the dimension of the embedding space increases, that is, p.

If the system is periodic, the fractal dimension grows to a value k and then remains constant and whole (it is not fractal).

If the system is chaotic, the fractal dimension stabilizes for a certain embedding dimension p. Also, at least one exponent of Lyapunov will be positive.

9.4. Matrix and correlation dimension

The decomposition of time series into main analysis components gives rise to the correlation matrix. This matrix is two-dimensional (M × M) constructed by placing the values of the correlation function for $\tau = 0$ along the main diagonal. Then, the values for $\tau = 1$ put to the right and left of the diagonal, following with $\tau = 2$ and so on until completing the matrix, which can be as large as 16 × 16 [37, 60].



The number of significant eigenvalues of the correlation matrix, of the order of the correlation dimension, is a measure of the complexity of the system [37]. A procedure of these characteristics was applied the time series of X (t), Y (t), and Z (t).

9.5. The entropy of Kolmogorov and its relation to the loss of information

Following Farmer [61, 62], one of the essential differences between chaotic and predictable behavior is that chaotic trajectories continuously generate new information, while predictable trajectories do not. Metric entropy makes this notion more rigorous. In addition to providing a good definition of "chaos," metric entropy provides a quantitative way to describe "how chaotic" a dynamic system is.

The entropy of Kolmogorov [48, 49] is the average information loss [51, 63], when "l" (cell side in units of information) and τ (time) become infinitesimal:

$$S_K = -\lim_{\tau\to 0}\lim_{l\to 0}\lim_{n\to\infty}\frac{l}{n\tau}\sum_{0\ldots n} P_{o\ldots n}\log P_{0\ldots n} \quad \text{(Kolmogorov entropy)} \tag{6}$$

Expressed in information bits/sec or bits/orbits for a continuous system and bits/iteration for a discrete system.

The entropy difference of Kolmogorov (ΔS_K) between one cell and another ($S_{K\,n+1} - S_{K\,n}$) represents the additional information needed to know, in which cell (i_{n+1}) system will be found in the future. Therefore, the difference ($S_{K\,n+1} - S_{K\,n}$) measures the loss of system information over time.

In conclusion, the calculation of the entropy of Kolmogorov:

1. Check if the entropy of Kolmogorov is between zero and infinity ($0 < S_K < \infty$), which allows verifying the presence of chaotic behavior. If the Kolmogorov entropy is equal to 0, no information loss, and the system is regular and predictable. If $S_K = \infty$, the system is entirely random and it is impossible to make any prediction.
2. Determine the amount of information needed to predict the future behavior of a system, in this case, a learning process.
3. Calculate the speed with which the system loses (or downgrade information over time).
4. To establish the maximum horizon of temporal predictability of the system, from which no prediction can make, nor elaboration of scenarios.

9.6. Determination of information loss

There is a relationship between the entropy of Kolmogorov and the characteristic parameter of chaos, the exponent of Lyapunov, λ, which shows that it is proportional to the loss of information, $< \Delta I >$ [51]:

$$\langle \Delta I \rangle_i \log 2 = -\lambda_i \Rightarrow \langle \Delta I \rangle_i = \frac{-\lambda_i}{\log 2}, \quad i = X, Y, Z \tag{7}$$

The coefficients of Lyapunov λ_x, $\lambda_{y,}$ and λ_z are associated with the time series of the Inquiry/Persuasion (X (t)), Positivity/Negativity (Y (t)), and Internal Information/External Information (Z (t)) coefficients obtained according to learning dynamics.

The expressions for $<\Delta I>_i$ are in bits/time and show the relationship between the entropy of Kolmogorov and the exponent of Lyapunov, λ.

If $\lambda < 0$, the movement is not chaotic, information does not lose, because the prediction is accurate. (It is the main idea of the current educational paradigm).

If $\lambda > 0$, the movement is chaotic, the prediction is less accurate and, therefore, the loss of information is greater [51, 64].

10. Experimental results: Application of the chaos data analyzer software (CDA) to the experimental time series

In chaos theory, the calculation of the Lyapunov coefficients is fundamental because it allows studying the effect of the initial condition, the irreversibility of the processes, the entropy, the time of predictability, the complexity, and, based on these parameters, to characterize the sustainability of a learning process.

In the cases of weak attractor dynamics and middle attractor dynamics, chaos theory does not apply, since they are predictable or deterministic systems.

10.1. Chaotic attractor dynamics

For the analysis of the time series, the CDA Software, Chaos Data Analyzer Programs [37, 60], and the Golden Surfer Software were used to fill incomplete time series [65].

Notation:

λ: Exponent of Lyapunov (bits/units of time) [37, 47, 66].

D: Encrusting dimension [37].

n: is the number of sample intervals over which each pair of points followed before a new pair is selected.

A: is the relative accuracy of the data before the expected noise begins to dominate.

H: Exponent of Hurst is related to the smoothness of the curve and the dimension fractal, according to Mandelbrot [67–69], $0 \leq H \leq 1$. To $0.5 \leq H \leq 1.0$ indicates persistence (the past tends to persist in the future).

S = Correlation entropy [37–60] for each variable (measured in bits/units of time) (**Table 3**):

Variable	Λ	D	N	A	H	Correlation dimension	S_K
X	1.150 ± 0.099	1	2	0.0001	0.925	0.719 ± 0.247	1.027
Y	0.723 ± 0.084	1	2	0.0001	0.919	0.728 ± 0.245	0.477
Z	1.469 ± 0.105	1	2	0.0001	0.89	0.737 ± 0.251	0.728

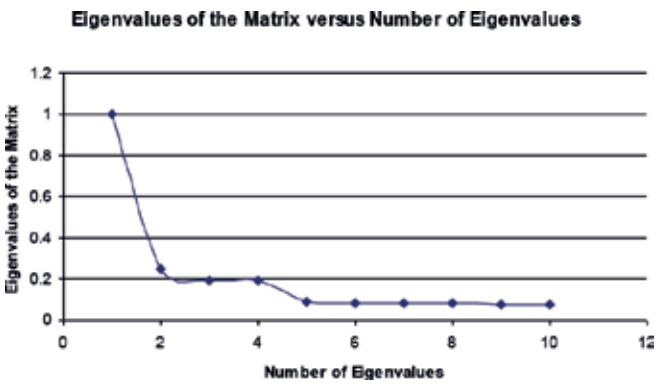
Table 3. The correlation entropy, S_K, is the entropy of Kolmogorov, and its reciprocal delivers the time for which the prediction is significant.

Applying the calculation of the correlation matrix to the time series X (t) of the chaotic attractor, the number of eigenvalues, of the order of the correlation dimension, is a measure of the complexity of the system [37]. In this case, two significant eigenvalues were determined (not zero) (**Graph 4**):

The time series of Y (t) and Z (t) treated in a similar way present the same number of eigenvalues. So, we conclude that given the number of eigenvalues, the series represent a complex system.

According to the López-Corona approach [50] for complexity, with normalized S_k (**Table 3**) $\rightarrow S_{K_{obs}}$:

$$C_i(t) = aS_{K_{obs,i}}\left(1 - S_{K_{obs,i}}\right) > 0, \quad i = X, Y, Z \tag{8}$$



Graph 4. Eigenvalues of the matrix versus number eigenvalues.

The values of C(t) for time series give results greater than zero for the three time series (X(t), Y (t), and Z (t)), which would characterize a complex system and is coincident with the result of the matrix of correlation.

In the learning process studied, applying Chaos Theory to time series arising from characteristic variables that are common to all learning processes, three particularities revealed entropic connectivity, irreversibility, and complexity. In the same way, the sustainability of the process is due to the quotient of the POS/NEG emotions, when positive influence exists (POS) in the case of the Chaotic Attractor Dynamics, which is the one that presents the highest achievement in meaningful learning (rudely indicated as performance). These learnings lead to the consequent formation of patterns of "desired" behavior. Increasing connectivity is increasing entropy, which to maintain the "beloved" order, entropy (negentropy) must be transferred to the environment (to the planet), is quantifiable evidence of such process, the increase of garbage and pollution. This corollary demonstrates the irreversibility of the process in the current narrative. Is it possible to modify this plot? Within the current narrative, it seems unlikely. A new form of relationship between ourselves and with nature must build. (Chaos theory does not admit complexity for the weak and middle attractor, i.e., it does not apply).

11. The future in the past? Ancient civilizations

The considerable cognitive requirements of life in complex societies have resulted in many primate species having larger and more expensive brains [70], with all that this implies in connectivity. The human immersed in evolution has historically transferred the cost of learning the complexity of nature, and there is ample evidence.

11.1. Mesopotamia

In the interior of ancient Mesopotamia, agriculture and livestock farming were imposed as the primary economic activity between 6000 and 5000 BC. Due to unfavorable natural conditions

for this practice in large part of this territory, men built and used canals to transport water from distant sources and thus obtain good harvests. Because of these facilities, they were able to achieve very high performances. On the absence of excavations in rural areas, the knowledge of ancient Mesopotamian agriculture is based mainly on old texts, including the numerous records of the practice of field sales. Exploitation contracts or loans for farmers, as well as the abundant documentation, were found in the administrative buildings of the palaces and temples of the cities of Mesopotamia.

The irrigation technology in the fields implemented implied the risk of soil salinization. The evaporation of water causes the minerals it contains to rise, and if the soil salt content is too high, the field can no longer be cultivated and the water must be drained off the field to replenish the soil. This problem affected many lands in southern Mesopotamia, which became uncultivable and abandoned after intensive exploitation. In contrast, palm trees grow very well in salinized grounds, which explains their growth in the oldest Mesopotamia.

11.2. The Mayans

The collapse of the Mayan civilization was because of the destruction of the environment caused by it due to the mismanagement of resources, indicated the American archeologist Richard D. Hansen [71, 72], one of the principal researchers of that old culture. "The Mayans themselves damaged their environment. They destroyed it. The impact of the damage (to the environment) was so strong that they caused the collapse of civilization," says Hansen.

In the Cuenca Mirador, the expert explained, the Mayans developed "the first economic state in the Americas." "In the pre-Classic period (in the year 1500 BC), they formed the first political State, almost an empire, where there was a development with strong economic management and large populations," but due to a strategic error "of government," the same Mayas caused its collapse.

Starting in 150 AC, "due to multifactors" associated with the environment such as diseases, drought, and deforestation, "people started to leave the area." "But it was not a case of abandonment in which people leave, but come back. Here they left and did not return. The collapse of the Mayas was a total abandonment "due to the lack of resources, Hansen stressed. The Mayans "were human" and as such "made mistakes," "abused the resources they had at their disposal." They fell into "conspicuous consumption." Preferring to build great palaces "without thinking about the needs of the people, without feeding them, until they finished everything, "he said.

11.3. Roman Empire

In the year 100 BC, the Roman Empire was spread along the Mediterranean. The Romans could have stayed in this area, near the sea, but the explorations gave good results, and they were encouraged to continue their territorial expansion by increasing connectivity. However, transportation by land was slow and expensive, unlike maritime transport, so the increase in the connectivity became expensive.

According to Joseph Tainter [73, 74], professor of environment and society at Utah State University, one of the most important lessons of the fall of Rome is that complexity comes at a cost. In the third century, Rome added more and more new elements: a considerable

army, cavalry, and subdivided provinces (each with its bureaucracies, courts, and defenses), all components necessary to maintain the cohesion of its almost 60 million inhabitants of the more varied races. Eventually, it could not, to the eaves of knowledge and technique of the time that already left their trace of disorder in the environment, continue to sustain that growing complexity entering a long collapse and fragmentation.

12. Conclusion

The mathematical theory of chaos when applied to experimental time series of learning processes is shown to be efficient and rigorous in revealing properties that underlie the interior of those, such as irreversibility and entropic connectivity. Similarly, when categorizing the performance of learning according to the dynamics (weak, medium, chaotic), it exhibits the behavioral patterns produced by each dynamic. Learning, as a human activity perennial in time, induces behavior patterns, an order associated with emotions, exporting entropy to the biosphere: "order wins" wanted "exporting disorder" not wanted. This learning reveals an overestimation, historical, and cultural, of the regenerative capacities of the environment and planet Earth, especially concerning one of the forms of the disorder ("unwanted"), more characteristic of modern human activity: garbage and pollution, which we leave in charge of the planet. At present, we can perceive these regenerative limits in the form of depletion of croplands and productive demands on agricultural land through increasingly powerful fertilizers with unexpected consequences, consumption of drinking water, acidification and desertification of the oceans, atmospheric pollution, climate change, and so on. Would we expect another result? As we say about the time series, we face the increasing, and the frenetic entropy connectivity of the learning (much of trial and error) overstimulated by a POS/NEG ratio exacerbated toward positivity. On the other hand, an economic-technological system that essentially seeks to optimize profit as a synonym of well-being and, by extension, an illusion of happiness. Given the current state of the biosphere [75–77], would we expect another result? The complexity of this disjunctive is that nothing is more proper to human nature than its willingness to learn. Civilization, from its inception, has shown that an essential evolutionary characteristic of its learning is to adapt the environment to its utilities and needs, which will always be influenced by the certainties and uncertainties of knowledge and its transforming polarity. Innovating patterns of behavior, which have given us confidence in our possibilities by feeling exclusive of species on a planet with supposedly infinite resources, are complex. It means accepting limits. It recognizes in human activities not only its load of positivity, but also negativity, which broadens its meaning. There is no more provocative word for freewill than the idea of limits to what we want and can do. It is necessary to face that in all the processes that they want to carry out, the existence of limits will play an essential role. A predicament that is not new, and always proclaimed—and most of the time, interestingly overlooked—by the most varied forms and themes of reflection: complex systems, entropy, science, emotions, the human brain, religion, and more.

It is probable that the revenge for the untied man (restless Nietzsche would say), of today, is the irruption of the "contemplative man" that Nietzsche would point us out of tomorrow. The challenge is greater, as indicated, because it requires us to explore new forms of

relationship between ourselves and with nature [58], of which we are a part, and of the planet Earth in particular. Our viability of species is in interdiction, even expanding our environment of space, and this is a medium, even extremely hostile to human life [59].

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Chapter 5

Assessing Perspective-Taking in Children through Different Formats of Deictic Framing Protocol

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Additional information is available at the end of the chapter

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Abstract

The modern behavioral account of human language and cognition known as Relational Frame Theory (RFT) has argued that deictic relations are key repertoires underlying the development of the ability to take the perspective of another individual. Several studies have employed a deictic framing-based test protocol as an assessment of perspective-taking. In recent years, the format of the protocol has been modified in different studies. However, no empirical investigations have compared the original protocol with the new formats. The present chapter reports two studies that investigated whether a deictic relational protocol based on modification from recent research demonstrated better performance versus traditional deictic relations measured, with typically developing children. Results of Study 1 showed that variability in the scenarios proposed by recent research could be the best option, although a series of modifications should be made for the target population. Results of Study 2 showed that a combination of both original and new protocols of deictic relations gave a better performance on the perspective-taking task in the sample used. This chapter supports the need to adapt perspective-taking protocol to the work with children.

Keywords: deictic relations, RFT, perspective-taking, children, contextual behavioral science

1. Introduction

Perspective-taking has been defined as the social-cognitive ability to assume another individual's perspective, to infer thoughts, emotions, and motivations [1]. For many years, mainstream developmental psychologists have studied children's development regarding the understanding of thoughts and beliefs of others (for a review see [2]). This cognitive approach,

known as Theory of Mind (ToM) [3], has been an inspiration for psychologists studying typical and atypical development in children. Indeed, a search conducted using the filter "theory of mind" in PsycINFO, returned more than 6400 entries— including theses, books, and journal articles. An interest in these phenomena has also been shown by behavioral psychologists. The recently developed Relational Frame Theory (RFT) [4], which is a modern behavioral approach to the study of language and cognition, considers perspective-taking as generalized operant behavior that can be learned [5–7]. In line with the RFT approach, learning to respond to appropriate questions defined on the base of deictic relations — such as I-YOU, HERE-THERE, and NOW-THEN—, appears to be critical in establishing perspective-taking repertoires [8]. Such relations have been learned from a history of multiple exemplars of asking and responding to questions such as, "What am I doing now?", "What did you eat then?" or "Where were you jumping then?". Each time these questions are answered, the physical properties of environment are different. However, the relational properties of I-you, here-there, and now-then remain constant across all exemplars. That is to say, the so-called deictic relations are an abstraction of an individual's perspective of the world and of others, in other words, deictic relations specify a relation in terms of the perspective of the speaker [4].

The first RFT study on perspective-taking in term of deictic relations was reported by Barnes-Holmes [5]. In this study, a testing and training protocol was developed for establishing the three deictic relations on the three levels of relational complexity (i.e., simple, reversed, and double reversed relational response) in young children. A simple relational response consists of relations in which none of the elements are reversed (e.g., "I-experimenter- am sitting here in a blue chair and you -participant- are sitting there in a black chair. Where are you sitting?"). In a reversed relational response, some of the elements are reversed (e.g., "If I were you and you were me, where would you be sitting?") and a correct response reflects this relational reversal (i.e., the experimenter is sitting in a black chair and the participant is sitting in a blue chair). In a double reversed relational response, two relations are reversed simultaneously (e.g., "If I were you and you were me and if here were there and there were here, where would you be sitting?") and a correct response would appear to require more complex derived relational activity (i.e., the experimenter would be sitting on the blue chair and the participant would be sitting on the black chair).

Many studies have investigated the RFT approach to perspective-taking through the Barnes-Holmes protocol [8–14]. Studies such as those by Heagle and Rehfeldt [15] or Rehfeldt et al. [11] improved perspective-taking skills by means of reinforcement contingencies during the training trials for correct responses on the deictic relational protocol. Others [10, 14] established the relationship between deictic framing and ToM skills. This protocol has also shown that deictic responding can help to understand clinical concepts such as social anhedonia or schizophrenia (e.g. [13, 16, 17]).

In recent years, the format of the original protocol has been modified in different studies. For example, the approach used in Davlin et al. [18] and in Gilroy et al. [19] was an extension of the Barnes-Holmes deictic framing protocol using a story reading context. These authors used more naturalistic story reading procedures from storybook materials, resources readily available to young children. Vilardaga et al. [20] created scenarios systematically developed on the basis of core deictic relations, although different from each other and suited for natural

language contexts. These studies have suggested that deictic relations should be presented in contexts similar to activities of daily life in order to facilitate generalization of perspective-taking ability. However, there is no published study to date that has investigated whether the modifications to the original Barnes-Holmes protocol improve deictic relational responding. McHugh et al. [7] compared four conditions to present the trials in the adult population (in written versus spoken form, and with visual aids versus no visual aids), but all conditions were based on the structure of the original Barnes-Holmes protocol.

The goal of this chapter was to compare different variations of perspective-taking protocol to assess deictic relational responding in children. The purpose of Study 1 was to determine if a protocol involving a set of contextual cues that were systematically different to each other and without necessarily using the exact words I-you, here-there, or now-then, would allow participants to more reliably identify responses based on the underlying deictic relations. If in fact the variability in the scenarios proposed by Vilardaga et al. [20] showed better performance for the Barnes-Holmes protocol, this would allow the development of a specific measure of deictic relation responding for children. The purpose of Study 2 was to analyze whether in fact performance with the Barnes-Holmes protocol improved due to the changes resulting from the previous study. In this last study the features of different conditions from Study 1 would be integrated in order to design a new deictic relational measure developed specifically to fit the childhood population.

2. Study 1

2.1. Participants

Twenty-three participants (14 girls and 9 boys) aged 6–7 years old were selected for participation in the experiment. All of the participants were typically developing students and they were recruited from a primary school. The consent of parents and teachers was sought prior to each child's participation. Criteria for participation included that neither their mainstream schoolteachers nor parents had identified them as having any learning difficulties. All of the children in this study were reported by their teachers to read at grade level, displayed no reading comprehension problems and an absence of disruptive behavior that could interfere with performing the tasks required.

2.2. Setting and material

The experiment was conducted in a quiet room free from distraction, located at the school which children attended. Participants were exposed to the experimental procedures individually in two sessions. Sessions could be terminated upon the child's request at any time (although this never occurred). The perspective-taking tasks consisted of different deictic relations protocols (explained in the Procedure) which included the three types of deictic frames (i.e., I-You, Here-There, and Now-Then) and the three levels of relational complexity (i.e., simple, reversed, and double reversed) used in the Barnes-Holmes protocol.

2.3. Design

A between subjects design was used to assess the effects of different perspective-taking protocol on the percentage of correct responses by both relational complexity and relation-type. The independent variable was made up of different formats of presentation deictic frames and it was made up of three levels (Condition 1–3 explained below). The measurement variables were performance on relational complexity, on relation-type and number of repetitions of trials.

2.4. Procedure

At the beginning of each session, participants were given the following instructions:

> *"I will ask you a number of questions. Your job is to listen to each task and tell me what you think is the correct answer to each question. If you do not understand any question or you need to hear the question once more, feel free to ask for the sentence to be repeated. I cannot tell you when you have answered correctly. So you should pay full attention. Do the best that you can".*

Participants were asked if they understood these instructions and then asked to begin. No participant indicated that they did not understand what was required.

2.4.1. Pretest

To assess the initial level for deictic relations in order to ensure all groups were at the same level, the participants completed a pretest measuring of perspective-taking abilities. The perspective-taking protocol contained a subset of the 18 trials (six per complexity level) used in the Barnes-Holmes protocol. Other studies [10, 14, 21] also used this short version of 18 trials for testing. This pretest protocol contained a random presentation of all three deictic relational frames across all three complexity levels. Each trial consisted of two questions (e.g., "Where am I sitting?/Where are you sitting?"). The actual questions depended on the type of relation being tested. After answering the first question, participants were asked the second question immediately. A correct response to a trial required that the participants answered both questions correctly. No visual aids and no feedback were provided for subjects' responses. The way of proceeding was as follows: the experimenter read all tasks aloud from the perspective-taking protocol, participants responded orally and the experimenter recorded each response. The researcher repeated a question twice, if requested to do so by a participant.

After the pretest sessions, participants were assigned to each of three conditions (five subjects in each condition) ensuring that groups were at the same level for deictic relation responding before the experimental condition was implemented. Although in all conditions the way to proceed was the same as for the pretest, the order of the presentation of the trials was randomized in a different sequence to the pretest protocol. This new sequence was the same for all conditions. If the participant requested, the researcher repeated a question a maximum of two times. Any form of corrective feedback was provided for participants' responses.

2.4.2. Conditions 1-2

Condition 1 and Condition 2 were similar to the protocol used in the pretest procedure, but now a range of visual aids were employed to facilitate responding to all of the tasks contained within the protocol. Nevertheless, the actual locations of the visual aids remain fixed in reversed and double reversed trials. For example, if the experimenter said "I am sitting here on the red sofa and you are sitting there on the white sofa", the experimenter had a picture of a red sofa and the participant had a picture of a white sofa. On other hand, if the experimenter said during a reversed trial "if I were you and you were me", the pictures did not change. These items included; two identically sized, differently colored pencils (one blue and one orange); two pictures of sofas (one red and one white); a picture of a pair of scissors; and a picture of a radio. It should be noted that the items were different to the pretest protocol (i.e., red and white sofas vs. black and blue chair). The purpose was to keep the same format as the Barnes-Holmes protocol, but using other stimuli.

Condition 2 was identical to Condition 1, but the length for Condition 2 was twice that of Condition 1, that is, 18 trials in Conditions 1 and 36 trials in Condition 2. This was done since in Condition 2 the two questions per trial were presented as separate trials. According to Lovett and Rehfeldt [22] and Weil et al. [14], the present study explored the hypothesis that a correct response to the first question in a trial could serve as a discriminative stimulus and facilitate a correct response on the second question of that trial. To control the second response and ensure that participants were responding according to the appropriate deictic relation for all questions, in Condition 2 the questions were presented as separate trials. However, in both Condition 1 and Condition 2 a correct response to a trial required that the participant answered both questions correctly. The sequential order of the last 18 trials in Condition 2 was the same as the first 18 trials. During sessions of Conditions 2, participants were given a break of 5 minutes after each 15 minutes of testing (or earlier if requested).

2.4.3. Condition 3

In contrast to Condition 1 and 2, in the protocol used in Condition 3, most of the trials did not necessarily include the actual words *I-you, here-there*, and *now-then.* An example of trial used in this Condition was as follows: "Last Sunday Julian was buying chewing-gum at the sweet shop and this morning he is cutting figures in the classroom. If this morning was last Sunday and if the classroom was the sweet shop, where would he be this morning?" (Full protocol may be obtained by writing to the principal author). As discussed by different authors [4, 6, 20], the terms *I-you, here-there*, and *now-then* refer to relational frames that must be functionally and not formally defined. Many phrases common in our daily life often include or replace words coordinated with particular individuals, places, and times (e.g., "It is 2 o'clock and I am eating [here and now], and Anne [you] is still in the school" [there and now]) [23]. From an RFT point of view, "Anne" or "she" may be functionally equivalent to "you" and "the school" may be functionally equivalent to "there." Furthermore, according to Vilardaga et al. [20], in Condition 3 not a single trial used the same content as any other trial. In other words, each trial used

names of objects, places, and scenarios that were different to each other. The purpose of this was so that participants were not distracted by the repetition of similar words and to develop a more natural evaluation of the relational responding involved in perspective-taking.

Although each type of trial involved two questions, in line with Vilardaga et al. [20] each question was separated into two equivalent trials. The trials were equivalent because they corresponded to the same deictic relations: simple I-you, simple here-there, simple now-then, reversed I-you, reversed here-there, reversed now-then, double reversed I-you/here-there, and double reversed here-there/now-then. The current protocol consisted of a battery of 36 scenarios, each with a corresponding question. As in the above mentioned Condition 2, the sequential order of the last 18 trials was the same as the first 18 trials.

Another key feature that differentiated this Condition from the Barnes-Holmes protocol was that each reversed and double reversed relation was separated indicating only the part of the reversal of each question. The aim of these modifications was to eliminate fatigue and to facilitate discrimination between reversal cue and double reversal cue. Understanding the difference between the last two levels of complexity of deictic relations requires complex conditional discriminations because the statements are very similar. For example, the sentence "if last Sunday was this morning and this morning was last Sunday" is more like "if last Sunday was this morning and this morning was last Sunday and if the sweet shop was the classroom and the classroom was the sweet shop" than "if last Sunday was this morning" versus "if last Sunday was this morning and if the sweet shop was the classroom". Separating reversal cue becomes more prominent for the differences between reversed and double reversed relations.

In a similar fashion to Vilardaga et al. [20], Condition 3 was presented in written form, although the experimenter also read all tasks aloud. In order to ensure that participants had sufficient reading comprehension skills, they previously read two short texts and answered two questions. The short texts would not be presented in the deictic relational protocol but had a similar format to the questions in Condition 3. Participants who did not answer both questions correctly were excluded (all of the children in the present study read at good level and displayed no reading comprehension problems).

2.5. Results

The percentage of correct responses for each participant in the Deictic Relations Pretest is presented in **Table 1**.

Table 1 shows that some participants made fewer mistakes on double reversed relations than reversed relations. However double relations can be considered to require the most complex form of relational responding from a theoretical point of view. These outcomes are consistent with other studies [11, 18], which suggest that the structure of the double reversed relations is such that a correct response can be given without engaging in relational responding if the participant is not able to detect the reversal cue. In other words, participants who do not discriminate between simple level and a more *complex level* of relational framing or the cue "If…then", can answer correctly both simple and double reversed relations.

	Simple			Reversed			Double Reversed	
Participant	I-YOU	HERE-THERE	NOW-THEN	I-YOU	HERE-THERE	NOW-THEN	I-YOU/HERE-THERE	HERE-THERE/NOW-THEN
1	50	50	100	50	0	100	66.67	66.67
2	100	50	100	50	0	50	66.67	66.67
3	100	50	100	0	0	50	66.67	66.67
4	100	50	50	50	0	0	33.33	100
5	50	100	100	50	0	50	33.33	33.33
6	50	50	0	50	0	0	0	100
7	50	100	50	100	100	50	100	33.33
8	100	0	100	50	100	100	0	33.33
9	100	0	100	0	50	100	66.67	33.33
10	100	100	100	0	0	50	66.67	33.33
11	100	50	100	100	50	100	66.67	33.33
12	100	100	50	0	50	0	66.67	66.67
13	50	100	50	0	0	50	66.67	66.67
14	100	100	50	100	50	50	33.33	66.67
15	100	50	50	50	100	100	33.33	33.33
16	100	100	100	100	100	50	33.33	66.67
17	50	50	50	100	50	0	66.67	33.33
18	100	100	100	100	50	100	33.33	66.67
19	100	50	50	100	100	50	66.67	66.67
20	100	50	100	50	0	0	33.33	33.33
21	100	50	100	100	100	0	66.67	33.33
22	100	50	0	50	0	0	33.33	33.33
23	100	100	100	100	100	50	0	33.33
24	50	100	0	50	0	50	100	0
Total	85.42	66.67	70.83	58.33	41.67	47.92	50.00	50.00

Note: Relations that reached 100% accuracy are shaded.

Table 1. Percentage of correct responses by relation type in pretest protocol.

Participants who demonstrated an overall accuracy rate below 65% across simple trials were removed from the analyses (see **Table 1**). According to this criterion, four participants were removed from the final analysis (they were participants 6, 17, 22, and 24), resulting in a total sample of 20 participants. Vilardaga et al. [20] and Villatte et al. [13] used a similar criterion as a control for participants who were likely to be randomly responding and therefore not engaging in the task.

In order to ensure all groups were at the same level of deictic relational responding before implementing the different conditions, they were formed following a set of specific criteria: (1) participants who exceeded only 65% of correct simple trials; (2) those who exceeded 80% of correct simple trials, but failed 80% of reversed relations; (3) those who exceeded 80% of correct simple and reversed trials, and (4) those who exceeded only 80% of reversed trials. **Table 2** shows the final composition of groups. Due to double reversed relations being considered to require the most complex form of relational responding, and given the age of the participants, this level of complexity was not taken into account for the formation of groups.

The groups 1, 2 and 3 were assigned to Conditions 1, 2 and 3, respectively. The mean percentages of correct response and standard deviations in term of Condition and relational complexity are presented in **Table 3**. With regard to Condition 3, although in the original Vilardaga et al. [20] protocol each trial or scenario only had one question, a correction criterion similar to Condition 2 was additionally adopted to check if variability of scenarios would maintain the results even when separating the questions. For this reason, Condition 3 was marked in two different ways. In the first one, Condition 3a, each question per trial was marked as separate trial. That is to say, each question was taken into consideration independently of the other correct one. Although each type of trial had two questions separated into two different trials, a correct response to a trial did not require that the participant answered both questions correctly. The second one, Condition 3b, was similar to Condition 2. A correct response to a trial required the participant to answer both questions correctly. As such, the two questions were marked as one single trial. In short, Condition 3a was marked as if it had 36 trials, while Condition 3b was marked as if it had 18 trials.

In general, the data indicate that correct answers decrease as a function of relational complexity (see **Table 3**). Particularly, the best performance on the simple and on reversed relations was achieved in Condition 1, however it underwent a sharp decline for the double reversals. The best

Group	Participants	Simple		Reversed		Double Reversed	
		Mean Percentage Correct	Standard Deviation	Mean Percentage Correct	Standard Deviation	Mean Percentage Correct	Standard Deviation
1	1, 5, 12, 16, 7	80	13.94	53.33	29.81	56.67	19.91
2	9, 2, 20, 18, 15	80	13.94	53.33	29.81	46.67	13.95
3	13, 10, 21, 11,19	80	13.94	53.33	34.15	56.67	9.13

Note: The order in which participants of each group are displayed in the table corresponds to the order of specific criteria displayed in the text. For example, participant 1 is equivalent to participants 9 and 13 because they reached the first criterion.

Table 2. Composition of the groups and mean percentage of correct responses by relational complexity in each group.

	Simple		Reversed		Double Reversed	
	Mean Percentage Correct	Standard Deviation	Mean Percentage Correct	Standard Deviation	Mean Percentage Correct	Standard Deviation
Condition 1	90.00	14.90	80.00	13.94	16.67	20.41
Condition 2	70.00	21.73	43.33	22.36	10.00	14.91
Condition 3a	86.67	13.94	71.67	16.24	20.00	7.45
Condition 3b	80.00	21.73	60.00	22.36	10.00	9.13

Note: The best result for each relational complexity is shaded.

Table 3. Means and standard deviations for relational complexity in each condition.

performance for double reversed relations was achieved in Condition 3a. Condition 2 produced the weakest performances for all levels of relational complexity. Both Condition 1 and Condition 3a/b achieved better results on simple and reversed relations than pretest (see **Tables 2** and **3**), but both Conditions performed worse for double reversed than pretest. A possible reason for this may be that the participants were able to detect the reversal cue on double reversed with these Conditions versus pretest procedure, but they did not have sufficient ability to answer in accordance with double reversed. In other words, compared with responding to double relations as if they were simple relations, during Condition 1 and Condition 3a/b the participants responded as if double reversed relations were reversed relations.

Comparison of means between the three conditions was performed using non-parametric tests (Mann-Whitney U). Since the sample size was small and assumption of normality is not met, it was decided to use non-parametric tests. According to relational complexity, the differences between Condition 1 and Condition 2 ($p < 0.02$) as well as Condition 2 and Condition 3a were significant ($p < 0.05$) in reversed relations. For all other comparisons, the differences were non-significant.

With regards to the different ways of marking in Condition 3, when the questions were taken into consideration independently of each other for marking (i.e., Condition 3a), Condition 3 achieved better results than when the two questions per trial were marked as one single trial (Condition 3b). However, the differences were non-significant. Furthermore, Condition 3b achieved better results than Condition 2, which was marked in the same way.

The results for relation type for all Conditions are presented in **Table 4**. The number of correct responses on I-YOU/ HERE-THERE double reversals in Condition 2 was zero. The data indicated that Condition 1 achieved the best performance for all types of simple relations, as well as I-YOU reversed relations and NOW-THEN reversed relations, but on HERE-THERE

	Simple			Reversed			Double Reversed	
	I-YOU	HERE-THERE	NOW-THEN	I-YOU	HERE-THERE	NOW-THEN	I-YOU/ HERE-THERE	HERE-THERE/ NOW-THEN
	M (SD)	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*
Condition 1	100 (0)	90 (22.36)	80 (44.72)	100 (0)	70 (27.39)	70 (27.39)	6.67 (14.9)	26.67 (27.89)
Condition 2	90 (22.36)	80 (27.39)	40 (41.83)	80 (27.39)	30 (27.39)	20 (27.39)	0	20 (29.81)
Condition 3a	100 (0)	90 (13.7)	70 (32.6)	70 (32.6)	90 (13.7)	55 (20.92)	13.33 (13.94)	26.67 (9.13)
Condition 3b	100 (0)	80 (27.39)	60 (41.83)	60 (41.83)	80 (27.39)	40 (22.36)	6.67 (14.9)	13.33 (18.25)

Note: The best result for each relational type is shaded.

Table 4. Means and standard deviations for relational type in each condition.

reversed relations it did not. In this case, Condition 3a achieved the highest score. Regarding to double reversed relations, Condition 3a achieved the best performance for these two types of these relations.

Non-parametric tests (Mann-Whitney U) revealed significant differences between Condition 1 and Condition 2 in NOW-THEN reversed relations (<0.04), between Condition 2 and Condition 3a in HERE-THERE reversed relations (<0.01), and between Condition 2 and Condition 3b in HERE-THERE reversed relations (<0.04).

In connection with the number of trials being repeated per condition, Condition 3 was the only one in which no trial was repeated. Furthermore, in Condition 1 and 2 some participants asked whether the trial had been done before (e.g. "but you have already asked me this question before", "I don't understand why you are asking me again", "Did I make a mistake? Because you are asking me that question again").

The results from Condition 1-3a/b can be discussed as follows. Condition 1 relinquished first position when the two questions per trial were presented as separate trials (see Condition 2 in **Tables 3**, **4**). These findings are consistent with the results of other studies [14, 22], and they confirmed our initial hypothesis that a correct response to the first question of a trial could serve as a discriminative stimulus and facilitate a correct response for the second question of that trial.

Overall, Condition 3 finished in first or second position for the majority of relation types (see **Table 4**). However, it gave the weakest performances on I-YOU reversed relations. It should be recalled that the structure of the I-You relations in Condition 3 can be described as Other-Other relations because the trials enquiring about the perspective of the characters included in the scenario. According to Lovett and Rehfeldt [22], it could be that Other-Other relations are a

more *complex level* of deictic relations because the participant must first change perspective from I to You in order to then change perspective from You to Other. That is to say, I-You frame would be a prerequisite relation in order to be able to respond to an Other-Other relation. The same could happen on NOW-THEN relations. As is the case of Vilardaga et al. [20], this condition used more *complex temporal* relations than today-yesterday (i.e., 3 h ago, this morning, right now, last Sunday, next Summer…). *According to* Hayes et al. [4], *abstracting relational responding along temporal comparatives is a highly verbal action. Hayes, Fox, Gifford, Wilson, Barnes-Holmes and Healy [24] asked how "the future" can be presented, meaning that* time is inherently more abstract. Due to the fact that temporal frames tend to emerge later in development, more *complex temporal concepts could make performance for* temporal deictic relations *worse.* Contrary to the abstraction used in temporal relations, HERE-THERE relations in Condition 3 were represented by specific natural contexts (e.g., Margarita is buying some drinks in the supermarket and Victoria is studying in the English school). According to the outcomes, the HERE-THERE reversed relation (i.e., if here was there) could require a more abstract ability than specific place reversed (i.e., if the supermarket was the classroom). This could be a possible reason for the better results the HERE-THERE reversed relation achieved in Condition 3.

The present study suggests that the variability between scenarios allows for the fact that the participants are not distracted by the repetition of similar words and to facilitate deictic relational responding. These results are consistent with those in Vilardaga et al. [20]. However, although the protocol used in Condition 3 was an adaption developed specifically to fit a child population from Vilardaga et al. [20], Study 1 shows that some scenarios could be too complicated for the sample used. Perhaps the verbal repertoire of this age group was not sufficiently developed to allow deictic relational responding with more complex concepts. For example, the *temporal concepts used may not be suitable for early or middle childhood. The purpose of Study 2 was to adapt the variability on trials to especially fit a childhood population.*

3. Study 2

With regard to the performances observed in Study 1, the current study was designed to determine whether a specific deictic protocol, maintaining the structure of the I-YOU and NOW-THEN relations in Condition 1, but following the variability in scenarios developed by Vilardaga et al. [20], would facilitate the participant's relational performances.

3.1. Participants

Five typically developing children with no known disabilities participated in this study (3 girls and 2 boys). They were carried over from Study 1 and were selected from the pretest procedure in the previous study. Since the participants have been evaluated in the Pretest of the previous study, consent is already available authorizing their participation. The school and the recruitment procedure were the same as Study 1. These children had not participated in any of the conditions of Study 1.

3.2. Setting and material

The setting used in Study 2 was identical to that employed in Study 1. The specific protocol designed for this Study is explained below.

3.3. Design

Similar to Study 1, a between subjects design was used to assess the effects of different perspective-taking protocols on the percentage of correct responses by both relational complexity and relation-type. The comparisons were made between the condition in Study 2 and the conditions in Study 1. The independent variable was the format of presentation in deictic frames. The measurement variables were: performance on relational complexity, on relation-type and number of repetitions of trials.

3.4. Procedure

At the beginning of each session, participants were given the same instructions as Study 1. The experimenter read all tasks aloud from the perspective-taking protocol, the participant responded orally and the experimenter recorded each response. The order of the presentation of the different trials was identical to that employed in all conditions in Study 1. As in previous conditions, no corrective feedback was provided for participants' responses.

This study was in keeping with the philosophy of the Vilardaga et al. [20] study, in which scenarios were created differently to each other. The trials were randomly selected from Condition 3 of Study 1, however the contexts were simplified in order to make it easier to respond under the control of deictic contextual cues (full protocol may be obtained by writing to the principal author). In addition, the exact terms I-You and Now-Then remained constant in line with Condition 1 of the previous study. Another key feature that differentiated this study from Condition 3 in Study 1 was that now a range of visual aids were employed to facilitate responding to all of the tasks contained within the protocol. This protocol was not presented in written form. The visual aids included pictures all different to each other, such as a bicycle, skates, a classroom, a theater and an ice-cream, amongst others. For example, if the experimenter said "I am at a bakery and you are at a sweetshop" the experimenter would have a picture of a bakery and the participant would have a picture of sweetshop. These modifications were made in order to involve the participant in more realistic contextual cues than in Condition 3. Seeing and holding the photos provided a more realistic representation than reading the sentence. In a similar fashion to Condition 1 and Condition 2, the actual locations of the visual aids remain fixed in reversed and double reversed trials.

The length of this protocol was 18 trials, including trials containing all three frames and the three levels of complexity. Due to the differences between Condition 3a and Condition 3b in the previous study being non-significant, each trial of Study 2 consisted of two questions in line with Condition 1, in order to minimize the assessment times. After answering the first question, participants were asked the second question immediately. A correct response to a trial required that the participants answered both questions correctly. In line with Condition 3

in Study 1, in order to discriminate between reversed and double reversed relations, as well as to eliminate fatigue because of sentences being too long, each reversed and double reversed relation was separated, indicating only the part of the reversal of each question (i.e., If the park was the aquarium, where would I be?; If the aquarium was the park, where would you be?).

3.5. Results

In order to ensure the group was at the same level as participants from Study 1, before implementing the Condition, the participants were selected in accordance with the set of specific criteria mentioned above. **Table 5** shows the final composition of the group.

Figure 1 shows the percentage of correct responses in terms of Condition and relational complexity. It can be seen from the figure that participants in Study 2 gave more correct responses than other Conditions in Study 1 on all levels of complexity (M = 100, SD = 0; M = 90, SD = 14.91; M = 26.67 SD = 14.91,on simple, reversed, and double reversed relations, respectively).

Participants	Simple		Reversed		Double Reversed	
	Mean Percentage Correct	Standard Deviation	Mean Percentage Correct	Standard Deviation	Mean Percentage Correct	Standard Deviation
4,3,14,23, 8	80.00	13.94	53.33	34.15	43.33	25.28

Table 5. Means and standard deviations by relational complexity in pretest.

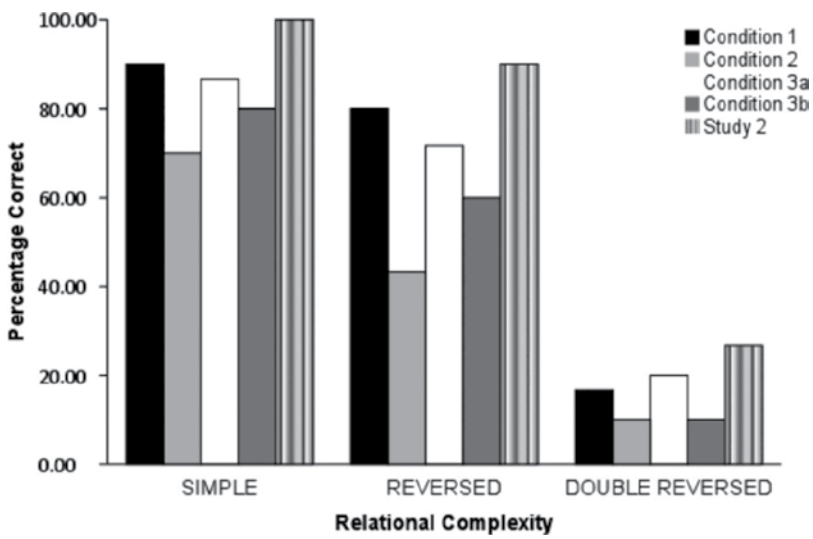

Figure 1. Mean percentage of correct responses for each condition in simple, reversed and double reversed relations.

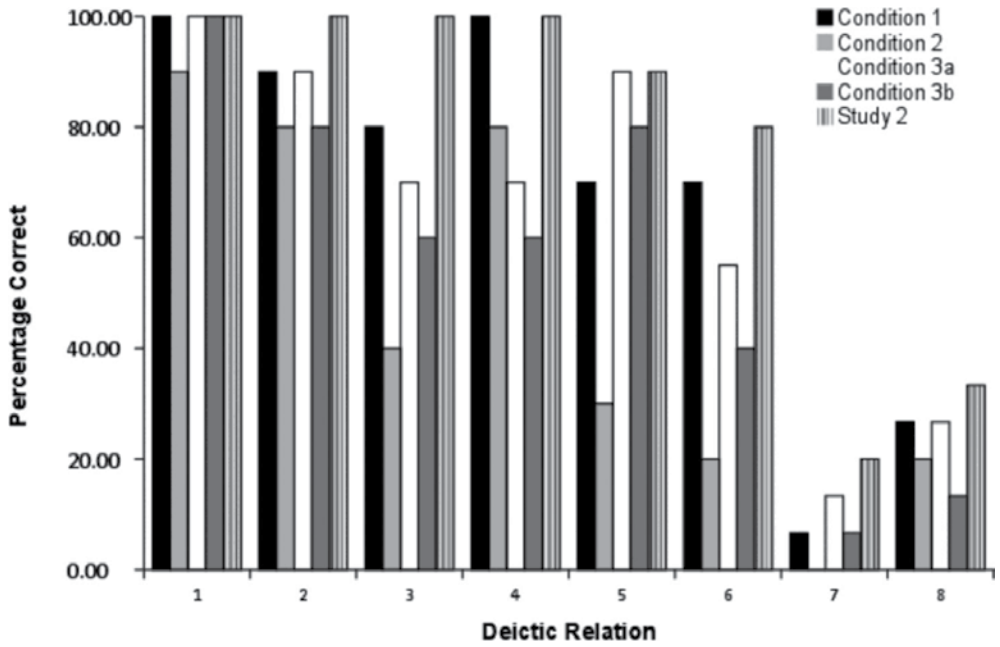

Figure 2. Mean percentage of correct responses for each condition by relation type.

Comparison of means between conditions in Study 1 and the condition in Study 2 were performed using non-parametric tests (Mann-Whitney U). According to relational complexity, the differences between Study 2 versus Condition 2 ($p < 0.02$) and Study 2 versus Condition 3b were significant ($p < 0.05$) in reversed relations. For all other comparisons, the differences were non-significant.

The results for relation type from all Conditions in Study 1 and Study 2 are presented in **Figure 2**. The number of correct responses in I-YOU/ HERE-THERE double reversals in Condition 2 was zero. The data indicated that participants in Study 2 achieved the best results for all relation types compared with Condition 1–3 in Study 1.

Non-parametric tests (Mann-Whitney U) revealed significant differences between Condition 2 and Study 2 in NOW-THEN simple relations (<0.02), in HERE-THERE reversed relations (<0.02) and in NOW-THEN reversed relations (=0.02); and between Condition 3b and Study 2 in NOW-THEN reversed relations (<0.05).

In connection with the number of repetitions of trials, it is also worth emphasizing that it was not necessary to repeat any trials for the condition in Study 2.

4. General discussion

From the RFT account, perspective-taking involves complex patterns of derived relational responding in accordance with the deictic relational frames of I-you, here-there, and now-

then. As noted in the introduction, many studies have investigated the RFT approach to perspective-taking through the Barnes-Holmes protocol and, in recent years, the format of the original protocol has been modified in different studies. However, no published study to date has compared the performance in the original protocol with new perspective-taking protocols. This approach was adopted in the current study with a view to analyzing differences between the original Barnes-Holmes protocol and an adapted protocol which included different scenarios and adaptations of reversal cues.

The results of both Study 1 and Study 2 indicated between-group differences with regard to variations in the format of protocol in terms of performance accuracy. Our ability to draw firm conclusions from these findings is limited because of the small sample size. Nonetheless, some interesting trends were apparent in the data, the most important being the role of stimuli variability between trials in the perspective-taking protocol. The difference in the number of correct responses for both relational complexity and relation type between conditions in Study 1 and Study 2, suggest the repetition of similar words developed by Y. Barnes-Holmes [5] could cause fatigue and lack of interest for the task. After listening to the words *black chair* and *blue chair* many times, participants become confused and lose interest. On the other hand, whereas Condition 3 in Study 1 or our deictic protocol in Study 2 did not need to repeat any trials, the Barnes-Holmes protocol of the Conditions 1–2 required more than 10 repetitions. These differences in number of repetitions requested by participants could be due to the fact that in the Condition 3 and Study 2, each trial presented a new and unique scenario, making the task less cognitively demanding. As mentioned earlier, for Conditions 1 and 2 in Study 1 some participants did not understand why the same trial was being done again. These findings are consistent with recent extensions of deictic teaching procedures which incorporate different and more naturalistic contexts with the purpose of bringing them in line with everyday discourse [18, 19, 22].

Although the findings from both studies are consistent with those of Vilardaga et al. [20] because a set of contextual cues that were systematically different to each other allowed participants to more reliably identify responses based on the underlying deictic relations, different changes were carried out to Study 2 to specifically fit a childhood population. The exact terms I-you and now-then remained constant in line with the original Barnes-Holmes protocol. Consistent with Lovett and Rehfeldt [22], evoking I-you framing response based on different personal deictic cues, required a more complex ability in derived relational responding. On the other hand, as discussed above from a RFT point of view [4], responding to temporal relations implies responding relationally to a situation where the relation is defined not by the physical properties, but by some other feature of the situation. Abstracting the physical dimension of concepts such as yesterday, tomorrow, or next week, requires highly verbal actions. For this reason, temporal frames of deictic protocols should be adapted to the verbal repertoire of children. These results support the need for adaptation of the assessment tools to the population targeted, raising important issues that should be addressed in future research.

Limitations of the current study should also be considered. Sample size and number of trials by protocol are too small to establish strong conclusions. The protocols designed are part of a bigger research project in which children are being trained in perspective-taking via deictic relations. The protocols of the present study should be considered as screening tools, not

training protocols. As previously mentioned, other studies [10, 14, 21] also used a short version of the 18 trials for testing. Future work with larger samples and protocols is needed to clarify this issue. Despite these limitations, the current paper seems to lend support to further elaborations of the protocol originally developed by Y. Barnes- Holmes [5] for the specific target population, i.e. typically developing children. Summarizing the results of present study, variability between scenarios, more natural and familiar contexts, direct interpersonal deictic relations (I-You versus Other-Other), specific locations for spatial relations, and non-complex temporal relations, seem to be key features for improving the children's performances. These findings support the idea of developing measures of perspective-taking from an RFT approach aimed at facilitating generalization towards other tasks or everyday contexts.

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