The Learning of Conceptual Categories for Students with Level 1 Autism Spectrum Disorder

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Abstract: This article presents a study where the overall objective is to measure any changes found as a result of the application of a program to facilitate the development of the semantic memory of people with Level 1 Autism Spectrum Disorder, following the implementation of a specific program to facilitate the creation of conceptual categories.

The study, based on a quasi-experimental design, analyzes the effectiveness of the program designed around four cognitive variables, comparatively observed in three groups of participants (N:19), distributed across one experimental group (N:7) and two control groups (made up of 7 and 5 participants respectively), conducted over three successive measures, 1 pre-test and 2 post-test measures at 6-month intervals. The results, found by repeatedly testing measures of intra-subject effects, show the effectiveness of the designed program, as it has aided in the development of meaningful learning for the members of the experimental group.

Keywords: Autism Spectrum Disorder, semantic memory, concepts, categories.

INTRODUCTION

The processes of memory and learning are circular relationships of reciprocal influence, so that information processing forms an active modular process. In this sense, Brown and William (1982) [1] include four primary factors in learning situations that interact with each other: 1) the activities and methodology used, 2) the learner's personal characteristics, 3) the nature of the learning materials, and 4) the criterion- referenced tasks, that is, the kinds of answers the learners require. Meanwhile, Rains (2002) [2] points out how the memory system itself helps to determine the decisive influence of sensory memory (perception) in attributing relevance to a learning content, which is the first step in giving this information access to the permanent memory and for the permanent memory in turn to redirect the attentional processes towards the perceptual act itself.

In this sense, Barsalou (2008) [3] notes that processing follows a system based on two steps: 1) the modal representations of memory, which take place in the brain systems underlying perception, action and emotion, become active during the experience or learning, and 2) from here, the brain transduces these modal representations into other amodal representations, represented by the categories constructed in the semantic modular memory. For example, modal representations emerge from the concept of a cat, which are then transduced into amodal symbols, which account for these experiences, the cat's meow or fur, and when this information is retrieved, the amodal symbols become representatives of this conceptual category.

Collins & Loftus (1975) [4] also propose a model based on the existence of spreading activation between cognitively interconnected networks or nodes, which they base on research on the analysis of associatively related semantic words. Thus, for example, the presentation of the word "July", would activate the node corresponding to a related word like "August", generating, by approximation, an immediate understanding of the relationship between the concepts.

Posner (1978; 1980) [5-6] notes that there is a clear relationship between encoding processes, related to the action of working memory, and neural cognitive networks, which explains how the central executive develops its functional activation based on the operation of three attentional networks: 1) the posterior attentional network, which coordinates the focus of attention to a place in space where a potentially relevant stimulus appears, 2) the alerting attentional network, responsible for maintaining the general state of arousal that is necessary to control and detect the expected stimulus, and 3) the anterior attentional network, which exercises voluntary control over the processing of information in situations that require executive processes of planning, and the developing of strategies and responses. During the process of the activation of neural networks, the configuration of learning and behaviors is then determined by the continuous processes of activation-inhibition of incoming stimuli depending on whether these are

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E-ISSN: 2292-2598/16

deemed relevant or not in accordance with previously acquired information. If this information is considered relevant, then it will form part of the activation process to begin the sequence; and if not, the information will simply be lost.

Numerous research studies have been published to answer this question [7,8], in which the anterior network is said to play an important role, having the ability to modulate the other two networks through the development of strategies when learning tasks require as such, which proves a high level of functional interrelationship. On the other hand, in regard to the possible relationship between the posterior network and the alerting network, evidence of important connections has also been found, which seem to indicate a dependency between both, with significant correlations on an activation level.

According to these empirical postulates, Simmons & Barsalou (2003) [9] propose a procedural structure that corresponds with five clearly distinct subsystems: 1) the feature maps that facilitate the perception of the stimulus and the encoding of its characteristics, attributes or physical traits, 2) the zones of analytical convergence, which make up the second-order pooling corresponding to the analysis of such features, 3) the holistic convergence zones, which allow the configuration of multiple analytical properties that try to provide a comprehensive conceptual vision of the initially perceived stimulus, 4) the modality convergence zones, which reflect the characteristics assimilated (learned) by the anterior analytical and holistic areas, and 5) the transmodal convergence zones, which are multimodal categories, and facilitate the interrelationship between the concepts of the different modalities.

This procedural proposal demonstrates the principle of neuronal spatial proximity in a convergence zone, which shows the interrelationship that exists between the networks responsible for the learning process, observed in the convergence of analyses between the different zones [10-13].

From a neuropsychological theory point of view, Saffran (2000) [14] believes that deficits in semantic memory are due, above all, to the difficulties encountered in the perception of the attributes of concepts, from both a perceptual (perceived sensory physical characteristics) and functional (interactive level of the applicability of the concept) perspective, which are related to competences for developing relationships, associations and interactions attributed to the concept, such as, for example, where an animal lives and what it eats.

According to these theories, individuals with autism spectrum disorder (ASD) already have difficulties with the initial perceptual process or stimuli input, as they show cognitive peculiarities in conducting a comprehensive analysis of its meaning, which, according to the theory of central cognitive coherence [15,16], occurs on two levels, respectively called conceptual and perceptual coherence levels [17], which relate to: 1) the integration of information at a perceptual level during the process of inputting information, and 2) the integration of information at a conceptual level in order to proceed with the process of encoding the content in the semantic memory. Empirical evidence about these deficits refers to both types of information integration processes, at both a perceptual level and an encoding level, in relation to memory tasks and activities [18,19], and in relation to the performance of actions of interaction processes in a given context [20,21].

However, studies on the deficits found in perceptual-visual integration tasks in individuals with ASD have yielded mixed results, in the sense that some studies show significantly severe difficulties in visual perception processes when compared to results from the control group participants [22-24], while other studies show results that are very similar to those obtained by the participants of the control groups [25-27]. There is however, consensus in regard to processes for the integration of information with global content or gestalt, which shows that there is a tendency for individuals with ASD to focus on parts or details of the stimuli [28-30]. Plaisted (2001) [31] states that it is precisely these difficulties that explain the deficit in the processing of the cognitive categorical attribution or, at the very least, lead to the deficits found in semantic processing.

Objectives

This body of research has the following general objectives:

1. Design and implement a program to facilitate the learning of conceptual categories in people with Level 1 ASD.

2. Analyze the level of semantic development acquired as a result of the application of the program.

3. Determine the effectiveness of the program administered to the experimental group, through the use of comparative studies using the data generated by the members of the control groups.

4. Establish appropriate conclusions based on the comparative results, in relation to the program's proposals.

METHOD

Research Design

Design of the research consisted of a quasi-experimental study, based on the analysis of data from three groups of participants, one experimental group and two control groups, whose results have been monitored by applying three successive or repeated measures (DMR) ANOVA design research, consisting of an analysis of measures pretest- program- posttest (1) - program- posttest (2) [32].

Participants

The study involved a total of 19 students with "Level 1 ASD", diagnosed in accordance with the Diagnostic and Statistical Manual of Mental Disorders Fifth Edition (*DSM-5*) [33], which lists diagnostic criteria ASD 299.00 (84.0): A) persistent deficits in social communication and social interaction, B) restricted, repetitive patterns of behavior, interests, or activities, C) symptoms must present during the early developmental period, D) symptoms cause clinically significant impairment in the social area, E) these disturbances are not better explained by intellectual disabilities. These deficits in social communication and restricted, repetitive behaviours are presented alongside severity levels: Level 1) requiring support, Level 2) requiring substantial support, and Level 3) requiring very substantial support.

Students were divided into three groups: an experimental group, made up of 7 students aged between 6 and 13 years old, and two control groups (1-2), made up of 7 and 5 participants respectively, whose age frequency distribution can be seen in Table **1**.

Variables

For the analysis of the program's effectiveness, we have selected four variables: 1) semantic category or an ability to establish conceptual categories, 2) correct-incorrect, based on the ability to carry out categorical classifications, 3) ambiguous-unambiguous, in relation to the subject's cognitive adaptation ability, and 4) perseverative-not perseverative, or the level of flexibility in relation to previously learned criteria (see Table **2**). Each of these four variables corresponds, in turn, with three measure levels: a pretest, prior to the implementation of the program, and two successive post-tests, following the implementation of the program, making a total of 12 levels for analysis.

Variable 1 (semantic category) was found following the application of the qualitative test addressing the development of conceptual categories, built ad hoc, following the structure of categories developed by Omar (2015) [34], while variables 2, 3 and 4 have been obtained from the use of the Wisconsin card sorting test WCST [35].

Procedure

During the initial phase, an evaluation of the selected variables was undertaken across the three groups using the conceptual categories test and the Wisconsin test. This was followed by the implementation of the designed program, including the appropriate adjustments based on the individual needs of the participants who formed part of the experimental group. Meanwhile, participants from control group 1 followed the implementation of other specific programs related to the development of social and communicative dimensions included in the diagnosis of the disorder, while participants from control group 2 continued with the curricular schedule as set at an institutional level. After three months, the second

Table 1: Assignation of Participants into Groups

		Age				Total
		6-7 y/o	8-9 y/o	10-11 y/o	12-13 y/o	
Group	Experimental	1	2	2	2	7
	Control 1	1	2	2	2	7
	Control 2	0	1	2	2	5
Total		2	5	6	6	19

Table 2: Name of the Selected Variables

Variables	Labels		
	pretest	Posttest1	posttest2
Semantic category	Semantic 1	Semantic 2	Semantic 3
Correct-incorrect	Correction 1	Correction 2	Correction 3
Ambiguous-unambiguous	Ambiguity 1	Ambiguity 2	Ambiguity 3
Perseverative-non-perseverative	Perseveration 1	Perseveration 2	Perseveration 3

measure for the three groups was undertaken, and three months later the third measures of the analysis were carried out.

Data Analysis

The data found across the three measures, corresponding to the three groups of participants, were compared to measure any possible differences in relation to the number of errors made across the four variables, expressed in percentiles, using the statistical program SPSS, version 23, and the multivariate general linear repeated measures test (MR) as well as the post-hoc statistic, indicated for the group variable.

The Program

From a global point of view, the main objectives of the program are: 1) the development of conceptual categories, 2) to encode the conceptual information that has been included, 3) to build links, relationships and signals between new information, 4) to organize and prioritize conceptual information into conceptual categories: 5) to retrieve the hierarchized information within the semantic memory using encoded signals and 6) to build relationships between the new information and previously encoded content. To meet these objectives, the program is structured in 5 phases:

1. Assessment, including: a) assessment of previously acquired skills, b) stimulus presentation (e.g., the terrestrial sphere is round and is made up of continents and oceans)
2. Codification of the stimulus, which is made up of: a) subdivision of the initial stimulus: concept 1: round; concept 2: continents; concept 3: oceans
3. Creation of nodes, which is made up of: a) links and connections to related information: round (concept of known circular objects), continents (concept of land), oceans (concept of water).
4. Motor experience, consisting of the following parts: a) motor experience of the concepts: circular motor movements; b) handling of the earth element; c) handling of the water element.
5. Own construction of the category, which includes: a) self-built model of the terrestrial sphere, following observation of a modelling video; b) composition of a circular sphere; c) composition of reliefs made from clay, and; d) filling of hollow spaces with water.

RESULTS

The MR multivariate analysis, which is based on Mauchly's sphericity, shows that this assumption is not met, that is, that the variance-covariance matrix is nonspherical (sig: 160) (see Table **2**)

It is for this reason that an analysis of the contrast of within-subject effects or univariate approximations were chosen, because these do not require this condition, and because this test is significantly more potent than multivariate contrasts in populations that include few participants, as in our case (see Table **4**).

As shown in the Table above, the contrast shows that both the critical level of the version of the F statistic of the sphericity assumption, uncorrected (sig: .00), and the significance levels of the other corrected measures of the epsilon estimates *Greenhouse-Geisser (sig: 00), Huynh- Feldt (sig: 00) and lower*

Table 3: Mauchly's Sphericity Test (b)

Within- subjects effect	W de Mauchly	Chi-square	gl	Sig.	Epsilon(a)		
					Huynh-Feldt	Lower-limit	Greenhouse-Geisser
Factor1	.00	79.80	65	.16	.50	.88	.09

Table 4: Within-Subject Effects Test

Source		Type III Sum of squares	gl	Root-mean-square	F	Sig.
Factor1	Sphericity assumption	44.03	11	4.0	28.13	.00
	Greenhouse-Geisser	44.03	5.49	8.00	28.13	.00
	Huynh-Feldt	44.03	9.75	4.51	28.13	.00
	Lower-limit	44.03	1.00	44.03	28,13	.00
Factor1* group	Sphericity assumption	24.24	22	1.10	7.74	.00
	Greenhouse-Geisser	24.24	10.99	2.20	7.74	.00
	Huynh-Feldt	24.24	19.51	1.24	7.74	.00
	Lower-limit	24.24	2.00	12.12	7.74	.00
Error (Factor1)	Sphericity assumption	25.04	176	.14		
	Greenhouse-Geisser	25.04	87.97	.28		
	Huynh-Feldt	25.04	156.11	.16		
	Lower-limit	25.04	16.00	1.56		

Limite (sig: 00), have significant levels, which means that there are statistically significant changes in the reduction in the percentage of errors in the study's four variables.

The interaction data regarding the group variable (the group of participants), also show significant critical levels, both in the *sphericity assumption* (sig: .00), and in the other corrected measures (*Greenhouse-Geisser*: .00, *Huynh- Feldt:* .00 and *Lower-limit*: .00), which leads to the conclusion that there are significant differences in the comparative contrasts depending on the group of participants, so that the group variable decisively influences the existence of such changes, in relation to the reduction of the number of errors made across the four variables.

Moreover, the total levels of the intersection, clearly indicating scores other than zero (see Table **5**), allow the inference that these results are conclusive in regard to the importance of the selected variables in order to predict the effectiveness of intervention programs that are specifically tailored to students with ASD.

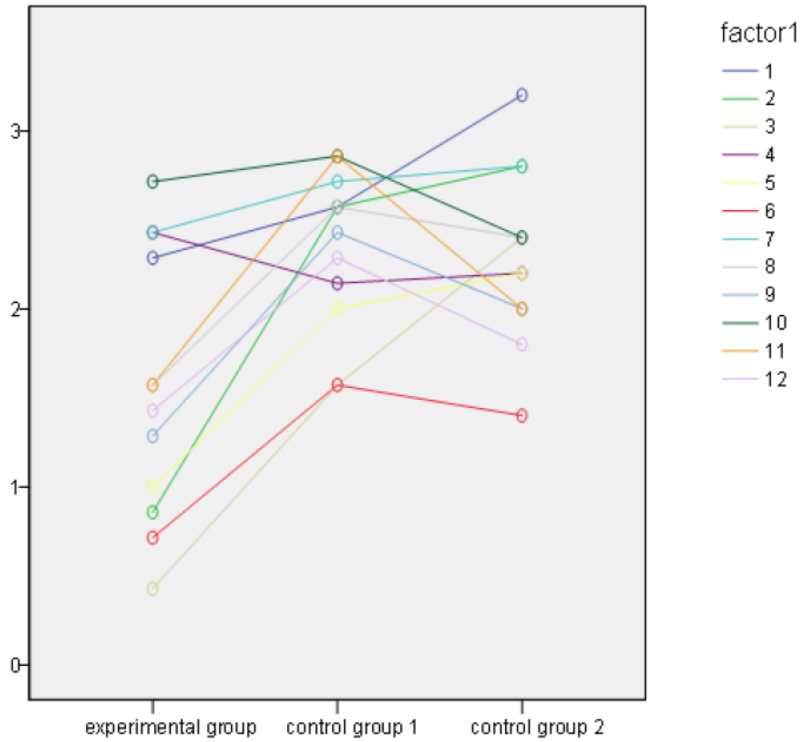
In line with these data, Graph **1** is a graphic representation of how the levels of improvement in reducing the percentage of errors of the participants who make up the experimental group do in fact significantly decrease over the three successive measures related to the four variables of the study, compared with their peers who form part of the two control groups, whose scores remain constant. This is graphically represented by the multiple crossings between the lines, reflecting the evolution of the results.

To analyze the differential data found in relation to the group variable, we proceeded to carry out a comparative post-hoc analysis. Thus, and following the assumption of Levene's test, which indicates equality of the variances (µ of the sig: 0.40), Tukey's post hoc comparison analysis (see Table **6**) was undertaken.

As can be seen, the data of the participants who formed the experimental group differ significantly from the data of participants from both control groups (1-2), so that the experimental group showed a significant differential critical level in relation to control group 1 (sig: .00) and control group 2 (sig: .02). Similarly, neither control group 1 nor 2 show any significant differences from each other (sig: .98), while it is evident that both of them differ significantly from the experimental group (sig: .00).

Table 5: Within-Subject Effects Tests

Source	Type III square sum	gl	Root-mean-square	F	Sig.
Intersection	79.26	1	79.26	459.442	.00
Group	2.60	2	1.30	7.55	.00
Error	2.76	16	.17		



Graph 1: Estimated marginal measures.

Table 6: Tukey's Comparison Test

(I) group	(J) group	Difference between means (I-J)	SE	Sig.	95% confidence interval	
					Lower limit	Upper limit
Experimental group	control1	-.78(*)	.22	.00	-1.35	-.21
	control2	-.74(*)	.24	.02	-1.36	-.11
Control group 1	experimental	.78(*)	.22	.00	.21	1.35
	control2	.04	.24	.98	-.58	.67
Control group 2	experimental	.74(*)	.24	.02	.11	1.36
	control1	-.04	.24	.98	-.67	.58

Based on observed measures.
*Level of .05.

These data clearly distinguish two subsets (see Table **7**): on the one hand, members of the experimental group (subset 1), and on the other, the integrated participants of both control groups (subset 2).

In conclusion, the design and implementation of the program for the development of conceptual categories has led to the obtainment of significant differences in the development capacity of semantic memory through the acquisition of conceptual categories in those

Table 7: Tukey's HDS Subsets

Group	N	Subset	
	1	1	2
Experimental	7	1.55	
Control2	5		2.30
Control1	7		2.34
Sig.		1.00	.98

Alpha = .05.

students with ASD who formed the experimental group compared their peers who were participants in either of the 2 control groups.

DISCUSSION

The implementation of specific programs designed to facilitate perceptual-cognitive development in students with ASD is a topic of the greatest relevance today on an international scale. In fact, the various innovations introduced in this area of work are contrasted throughout this study.

The National Autism Center (2009), the National Research Council (2001) and the National Autism Project (2016) [36-38] among other institutions, have designed plans and projects that provide advice and guidance on the future of scientific research in matters of cognitive-perceptual development, which form the theoretical pillars to facilitate the design of specific programs for the intervention and improvement of semantic memory adapted for individuals with ASD.

The contributions of Hirata *et al*. (2016), Lovell & Wetherell (2016), Normand & Sallafranque (2016) and the National Center for Special Education Research (NCSER) (2015) at the Institute of Education Sciences (IES) (2014) [39-43] propose scientific papers that expose the results found in those programs implemented to facilitate the psycho-social and educational development of people with ASD. Within these results, significant improvements in cognitive development can be observed, especially when perceptive-cognitive factors interact with social factors, and the results also stress the importance of carrying out the implementation of programs in natural and inclusive environments.

The National Center for Special Education Research (2015), much like Ingersoll & Wainer (2013) [44-45], justify their innovations related to the field of the development of social and communication dimensions in students with ASD. In their results they also emphasize the importance, on the one hand, of dimensional interactive work on a cognitive level and, on the other hand, of carrying out the implementation of these within a natural context, carried out by the families or school teachers directly, who are properly trained and advised by specialists.

Similarly, the Early Childhood Program at the Center on the Developing Child at Harvard University (NCSER) (2015) [46] has focused its studies on projects of early intervention in students with ASD, basing the intervention on the interaction of all the elements that make up the cognitive system, providing significant data for the design of effective programs in order to facilitate the improvement of neurobiological development.

Through their projects of psychoeducational innovation, the Center on the Developing Child (2015), the National Scientific Council on the Developing Child and the Council on Children with Disabilities (2010), Frey, Small, Feil & Edward (2015), as well as Shaw & Hatton (2009) [47-50], based their research on the development of the basic psychological processes of an individual with ASD during infancy, carried out across the following phases: 1) early detection of needs, 2) contribution of the resources necessary to facilitate the development of the objectives, 3) promotion of the interaction of the psychological elements during the intervention, and 4) facilitation of the training of families and teachers to carry out its implementation in everyday environments. The results show clear improvements in the cognitive development of students that formed part of the experimental group.

All these contributions provide, in effect, general guidelines for the design of specific programs, with the basic goal of developing learning skills in individuals with ASD.

Thus, Stahmer´s ImPACT Project (Stahmer, 2012) [51], which has been designed to facilitate the training of families and teachers directly involved with children at risk of some form of ASD and aged between 12 and 24 months, has two basic objectives: 1) training for the teaching of early detection strategies for families and teachers, in relation to the most notable signs of the disorder, and 2) providing training in aspects of development, such as reciprocity, contingency, shared control or play development in order to facilitate adaptive development, focusing on participation in shared attention strategies and executive tasks [52].

The projects that form part of the Advanced Social Communication and Play (ASAP) [53], which have been implemented by teams of teachers, pursue the following general objectives: 1) facilitate the development of social and communication skills in people with ASD, and 2) apply programs enabling overall personal development in natural, everyday contexts. The results indicate significant improvements to both dimensions addressed when an assessment of the programs are undertaken prior to the development of the competencies.

The programs implemented by the Enhanced Milieu Teaching [54,55], intend to facilitate the psychosocial development of people with ASD, employing 2-dimensional content: 1) the linguistic dimension within a natural situation, and 2) the interactive development of basic psychological processes, joint, selective and directed perception-attention and the development of symbolic play and the learning of rules-scripts. The results show data that are relevant to facilitating the improvement of such programs.

The Program for Preschoolers and Parents (LEAP) [56,57], which has been designed to facilitate improvement in learning processes and strategies, has been adapted for its inclusion in a classroom environment, and its objectives relate to: 1) facilitating the development of cognition, and 2) enhancing the development of interactive communication. The results are very encouraging, both in relation to the processes of language acquisition and in the development of higher cognitive processes.

Developmentally Appropriate Treatment for Autism [47] is an intervention designed for the education of families and teachers of people with ASD who are aged between 18 and 30 months, and aims to improve the cognitive processes through support practices that include intensive instruction. The results show significant improvements in functional cognitive development as well as in social skills and adaptive behaviors.

Both the projects undertaken by LEAP and the experiments carried out using the Treatment and Education of Autistic and Communication Handicapped Children method (TEACCH) [58,59], conclude their studies with the indication that when interventions are carried out in natural and inclusive environments, are highly structured and contain highly functional components, the results obtained are clearly positive.

Data similar to the data above are found following the application of the Star Program: Strategies for Teaching on Autism Research, implemented by Arick, Loos, Falco & Krug (2004) [60], the Community Adapted Early Start Denver Model [61,62] and the Comprehensive Intervention [64-67], whose objectives are also the cognitive development of people with ASD through interaction of the different basic psychological elements and the natural implementation of the programs.

Currently, all the programs are being included in the technological developments adapted to people with ASD, with the overall objective of facilitating the development of cognitive processes, both at a attentional-perceptual level, and in regard to conceptual and categorical construction, which plays a functional role is a functional applied task that is key to the development of general neuropsychological skills in these individuals [68-72].

In conclusion, in line with our research methods, the different programs cited throughout this study base their design on five key elements: 1) an initial needs assessment [73], 2) providing the necessary support based on the initial assessment carried out, 3) basic incidence of an interrelated development of the intrinsic dimensions of the disorder [74], 4) training for those factors directly involved in the educational process, that is, families and teachers [75,76], 5) designing and implementing programs tailored to the assessed needs within a natural environment, with important functional implications and 5) the promotion of inclusive processes in the implementation of specific programs [77].

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Received on 19-07-2016 Accepted on 25-07-2016 Published on 15-08-2016

DOI: http://dx.doi.org/10.6000/2292-2598.2016.04.02.6