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CONCEPT LEARNING, VERBAL-NONVERBAL TAXONOMY: A STUDY FROM ENGRAM THEORY AND CONCEPTUAL ATOMISM

APRENDIZAJE DE CONCEPTOS, TAXONOMÍA VERBAL-NO VERBAL: UN ESTUDIO DESDE LA TEORÍA DE ENGRAMAS Y EL ATOMISMO CONCEPTUAL

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Concept learning, Verbal-Nonverbal Taxonomy: A Study from Engram Theory and Conceptual Atomism

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ABSTRACT

This article focuses on concept learning, exploring the variability of this process in relation to verbal and nonverbal taxonomy. The theories of concept and memory, particularly conceptual atomism and engram theory, are examined, which provide a solid foundation for understanding learning processes and concept formation. A novel definition of "dynamic concept" is elaborated based on these theories. Considering this, an experiment was designed to measure conceptual learning, finding statistically significant differences in learning between verbal and non-verbal concepts. Non-verbal concepts were recalled more extensively than verbal ones, with a significant effect size, consistent with prior research. Demographically, women and men showed similar learning patterns in verbal concepts, but men exhibited highest number of correct answers during the test in non-verbal concepts.

Keywords*: concept, memory, learning, engrams, conceptual, atomism*

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Aprendizaje de Conceptos, Taxonomía Verbal-No Verbal: Un Estudio desde la Teoría de Engramas y el Atomismo Conceptual

RESUMEN

Este artículo se enfoca en el aprendizaje conceptual, explorando la variabilidad de este proceso en relación con la taxonomía verbal y no verbal. Se examinan las teorías del concepto y la memoria, particularmente el atomismo conceptual y la teoría del engrama, que proporcionan una sólida base para entender los procesos de aprendizaje y formación de conceptos. Se elabora una nueva definición de "concepto dinámico" basada en estas teorías. Considerando esto, se diseñó un experimento para medir el aprendizaje conceptual, encontrando diferencias estadísticamente significativas en el aprendizaje entre conceptos verbales y no verbales. Los conceptos no verbales fueron recordados de manera más extensa que los verbales, con un tamaño de efecto significativo, consistente con investigaciones previas. Demográficamente, las mujeres y los hombres mostraron patrones de aprendizaje similares en conceptos verbales, pero los hombres exhibieron el mayor número de respuestas correctas durante la prueba en conceptos no verbales.

Palabras claves: *concepto, memoria, aprendizaje, engramas, atomismo, conceptual*

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INTRODUCTION

The Concept

Memory plays a crucial role in behavioral sciences and education. The study of memory has been of great relevance, and various theories have been developed to explain its functioning, such as cognitive schemas (Piaget & Warden, 1926) and their relationship with behavior (Beck, 1964, 1967). One notable advancement in this field is the discovery of memory engrams, which explain how information is processed and retrieved in the brain (Liu et al., 2015; Ramirez et al., 2013; Ryan et al., 2015).

However, in the study of engram theory, there is naturally a lack of research in the domain of semantic and declarative memory, as the optogenetics technique used for studying it is not suitable for application in humans. As a result, this aspect of memory has not been studied thus far, despite its importance in our current culture (Eichenbaum, 2016).

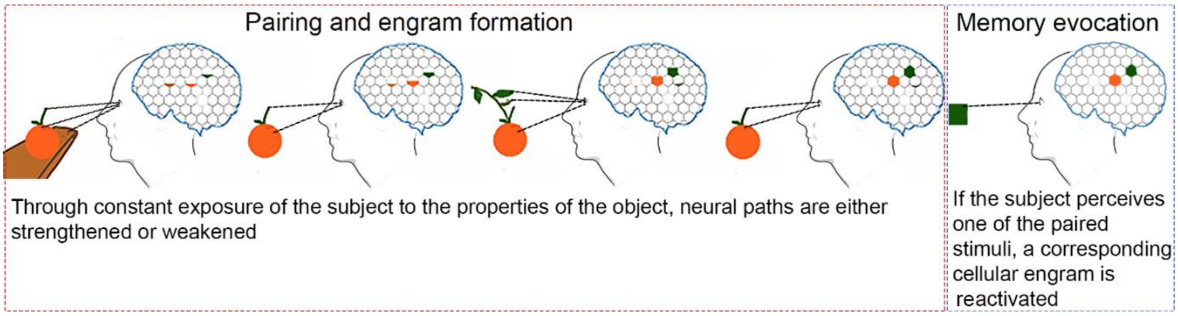
The concept represents the building blocks of thoughts, crucial for psychological processes like memory (Margolis, Eric & Laurence, Stephen, 2019). However, its nature has been the subject of intense debate (Margolis & Laurence, 1999; Margolis & Laurence, 2015). To explain the concept, numerous theories have been developed; with the most common one, that consider concepts as definitions that consist of two components: their reference and their meaning (Fodor & Pylyshyn, 2015), or as a "mental representation associated with a linguistic signifier" (Real Academia Española [RAE], 2022). This semantic variable inherently excludes nonverbal concepts or blocks of information that do not involve semantic or declarative information. This popular view serves as the basis for important situations such as education, where traditionally, only what can be declared is assessed. According to Fodor, cognitive science is mired in areas dependent on this topic (Fodor, as cited in Rodríguez, 2007).

Thus, Fodor proposes conceptual atomism, which suggests a concept without structure where most of them are atomic and determined by nomologically supported informational relationships between the individual and their context (Rodríguez, 2007). In conceptual atomism, the content of a concept depends on its relation to the world, resulting in its psychological variability as a consequence of causal relationships between the subject and the world.

A concept is recalled when the individual experiences an appropriate causal relationship with the property of the world to which the concept refers (Margolis et al., 2019).

Fodor's definition of the concept has an analogical resemblance to the dynamics of memory formation (Figure 1) as discovered in neuroscience by Tonegawa in his reframe of the engram theory. This theory was based on Semon's work (1923) and reformulated as follows: When a subject experiences an event, selected stimuli from the experience activate sets of neurons that produce lasting physical and/or chemical changes (engrams) in those cells and their connections, facilitating memory storage. Later, when a part of the original stimulus returns, these cells connected by the created engram are reactivated to evoke the recall of a memory (Liu et al., 2015).

Figure 1. Learning from engram theory and conceptual atomism



Based on this approach, within this research is proposed a definition of "concept" in accordance with the engram theory (Liu et al., 2015) and conceptual atomism (Fodor, 1975).

The dynamic concept

Based on the analysis of terms used in the engram theory and the conceptual atomism theory, certain terms were chosen to describe the phenomenon of concept formation and evocation (Table 1). The reasons for their use are explained, along with efforts to avoid terms conflicting with the learning theory or others.

Table 1. Main Terms

Term	Description
Property	Characteristics of objects and phenomena in the environment.
Stimulus	Effect of properties on the senses.
Pairing	A relationship established between the stimulus that causes a property of an object or phenomenon with a part of the memory.
Activate	Lasting chemical or physical changes that occur in neural engrams and their connections for the first time, in response to contact between the subject and their environment.
Reactivate	A situation in which a fraction or all of an original stimulus returns and then, reactivates previously paired clusters of neurons or engrams.
Evoke	It causes the phenomenon of remembering.
Remembering or Remembrance	An act of re-experiencing a specific memory.
Storage	Memory formation resulting from the activation of neuronal engrams.

Next, the function of each term adopted for the definition of the dynamic concept proposed in this research is broken down, marking it between < > for its distinction, while conceptual learning is explained from the already established theoretical framework:

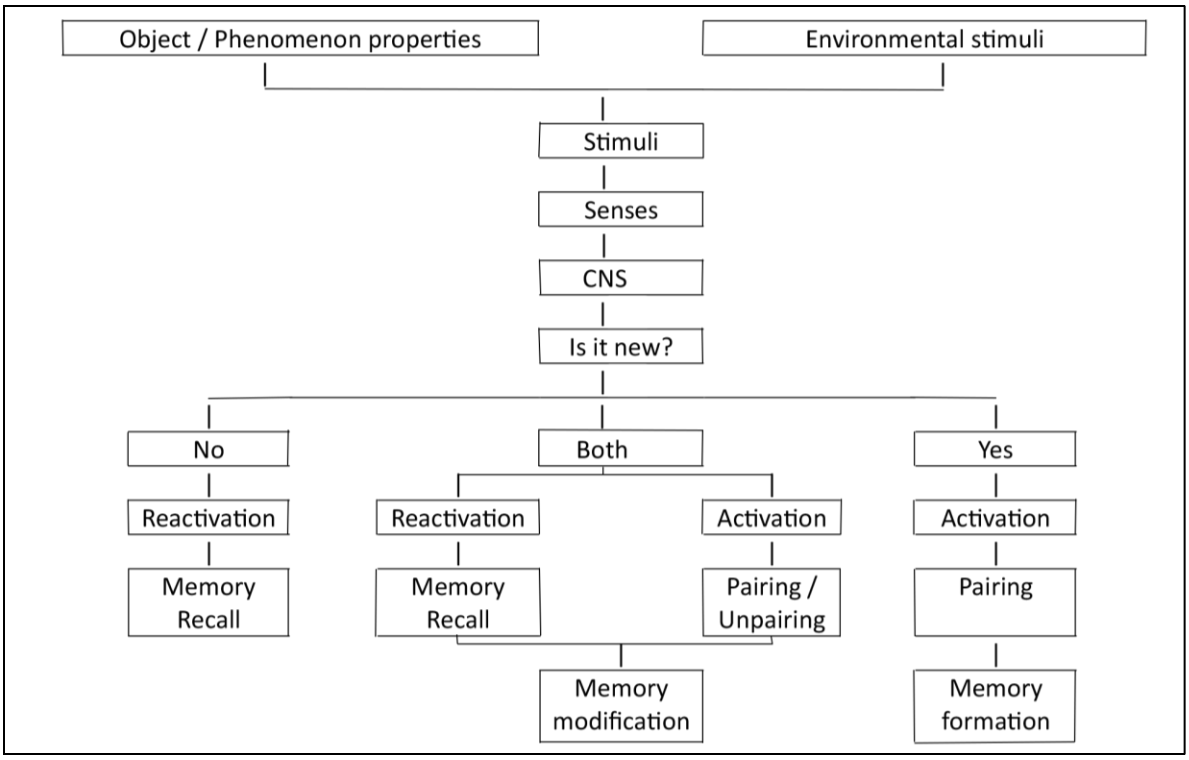
Conceptual learning is crucial for survival, commencing when an individual engages with their environment, where objects and phenomena within it, possess <properties> that distinguish them. These properties <stimulate> the subject's senses; for instance, a flower emits molecules that reach the subject's nose, <stimulating> the sense of smell with the <property> of odor.

Once the sense is stimulated, its connection with the nervous system <activates> <engrams> or clusters of neurons and their connections, associated with the stimulus nature and the subject's perception. It's important to distinguish between <activation> and <reactivation>; activation occurs when something new is learned, while reactivation happens when a previously perceived or learned stimulus is received. In other words, an engram has already been <paired> with the object's property.

Note that the term <pairing> is used here instead of Fodor's (1982) "locking" in conceptual atomism to explain the established connection between an object's property and a part of memory. In neuroscience, this phenomenon is referred to as "association" and/or "consolidation." While "consolidate" might seem preferable, it implies a permanent situation (RAE, 2014). According to Liu et al. (2014), "pairing" can change in certain situations, such as shifts in emotional valence associated with a memory. Thus, <pairing> is used as it aligns with engram theory and encompasses the phenomenon of "unpairing", avoiding in this way permanence, and maintaining memory and concepts as dynamic entities.

From activation or reactivation arise two representative memory phenomena, activation involves the first contact between the subject and an external object is <properties>, leading to lasting chemical or physical changes in cellular engrams and their connections, contributing to <storage> of memory. The term <storage> is widely used in reviewed studies of engram theory (Table 1).

Figure 2. From the stimulus to memory.



Conversely, reactivation is used to describe the situation where a fraction or the entire original stimulus returns and reactivates previously paired cell clusters or engrams, <evoking> the <recall> of a specific <memory> (Figure 2).

In this sense, the term <evoke> is used to explain the triggering of the <remembering> phenomenon that involves, the re-experiencing of a specific memory. It is crucial to note that remembering is <evoked>, and memory is <recalled>.

This circumvents phrases like "bringing to consciousness" or "memory retrieval," which, although used in neuroscience, may be confused with other theories like information theory.

The concept, as addressed in this research, lacks an internal structure (Fodor, 1982), as it is formed by cellular <engrams> dynamically activated or reactivated based on the stimuli received by the subject. Objects and phenomena in the environment have distinguishing properties, analogically learned by the individual in his neuronal engrams, by being activated or reactivated according to the presence of some specific property.

It should be noted that cellular-level storage occurs with the activation of specific neurons, a stimulus activates a cluster of neurons, not just one cell. Thus, although a single property, such as a color, is perceived, it does not imply the activation of a single neuron but rather multiple neurons in a complex manner; reactivation of a cell engram evokes a property.

Based on this analysis on conceptual learning from the conceptual atomism and engram theory, the following definition of a (dynamic) concept is proposed:

The concept is a basic element of thought, crucial to intellectual processes; it lacks structure, becoming dynamic and relative on the experience of each subject. It consists of the evocation of recollections from memory, because of the reactivation of neural engrams and in response to stimulation elicited by properties of previously paired objects or external or internal phenomena by the quantitative or qualitative exposure between them and the subject. This activation caused lasting physical and/or chemical changes between specific neurons, forming engrams.

Table 2. Regularities between theories for the conformation of the concept

Conceptual atomism	Engram Theory	Hebb Theory
Natural properties	External and internal stimuli	
Artificial properties	Internal stimuli	
Evocation	Reactivation	
Mental state	Engram	
Locking	Lasting chemical or physical changes between specific neurons	Plasticity by exposure and/or quality
Exposition	Stimulation	

Analyzing both theories (Table 2) the design of conceptual learning experiment was developed, making possible to analyze learning from this perspective, its relation to verbal and nonverbal taxonomy and the effects of anxiety on the conceptual evocation.

METHOD

The subjects were students who can follow instructions. Individuals with psychological disorders, blindness or visual impairments, and those unable to use the experimental materials were excluded as criteria.

The participants were from different places in Mexico. The sample consisted of 268 individuals with an average age of 17.33 (SD = 1.059), 158 (59%) women, and 109 (40.7%) males. Participants were asked for their informed consent, which involved clarifying the privacy of their data, stating their participation was voluntary, and explaining the purpose of the research, the consent is conducted in electronic format due to the online nature of the experiment.

Based on the primary objective of the research, a hypothesis was formulated for resolution, which justifies the calculation of the sample size (Quispe, 2020):

H0 = There are no statistically significant differences between the mean of accuracy in verbal concept learning and the mean of accuracy in nonverbal concept learning in the experiment.

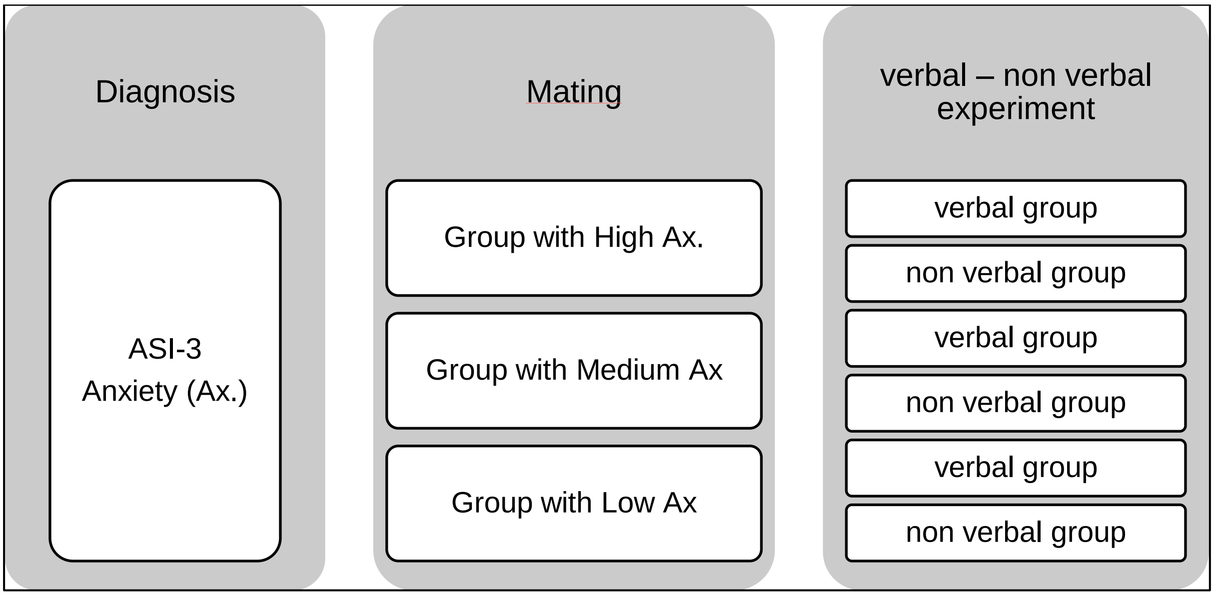
The sampling was probabilistic, to calculate the sample size, RStudio software and the 'pwr' package titled "Basic Functions for Power Analysis" (Champely et al., 2017) were used. This package contains functions for Cohen's statistical power analysis (1988).

The hypothesis involves two means from different populations with two tails, i.e., H0: $\mu 2 = \mu 1$ vs HA: $\mu 2 \neq \mu 1$. To calculate the sample size, the effect size "d" or design effect needs to be obtained using the formula: (μ1 - μ2) / standard deviation. With μ1: 56, μ2: 53.43, and standard deviation: 7.024, the result was d = 0.36588838268792710706150341685649. The command for calculating the sample size for this type of hypothesis in RStudio is as follows:

Sample = pwr.t.test(d = 0.36588838268792710706150341685649, sig.level = 0.05, power = 0.50, type = 'two.sample', alternative = 'two.sided')

This resulted in a requirement of 58 subjects per group. The subjects were matched based on their baseline anxiety, which represents the possibility of a person reacting with anxiety to life situations, since baseline anxiety is a variable that can affect learning (Blumer & Benson, 1975). To reduce confounding factors, the decision was made to match subjects based on this criterion. As a result of the matching process, three groups were obtained: high anxiety, medium anxiety, and low anxiety.,Each group was randomly divided by the software into an experimental group and a control group (Figure 3), where the independent variable is verbal or nonverbal information. The evaluation is performed automatically by the software at the moment that the subject interacts with it.

Figure 3. Research design



Data collection was conducted by the software application used in the experiment. For the assessment of subjects regarding the anxiety variable, the ASI-3 questionnaire was used: New Scale for the Assessment of Anxiety Sensitivity (Hernández-Pozo, Alvarado-Bravo, Espinosa-Luna, et al., 2022). The questionnaire was validated in the Mexican population with a total scale reliability of Cronbach's alpha equal to 0.919.

The data collected by the software were automatically sent to a spreadsheet on the network that captured data from all applications. This approach eliminated errors caused by the researcher's expectations during the experiment evaluation or personal observation.

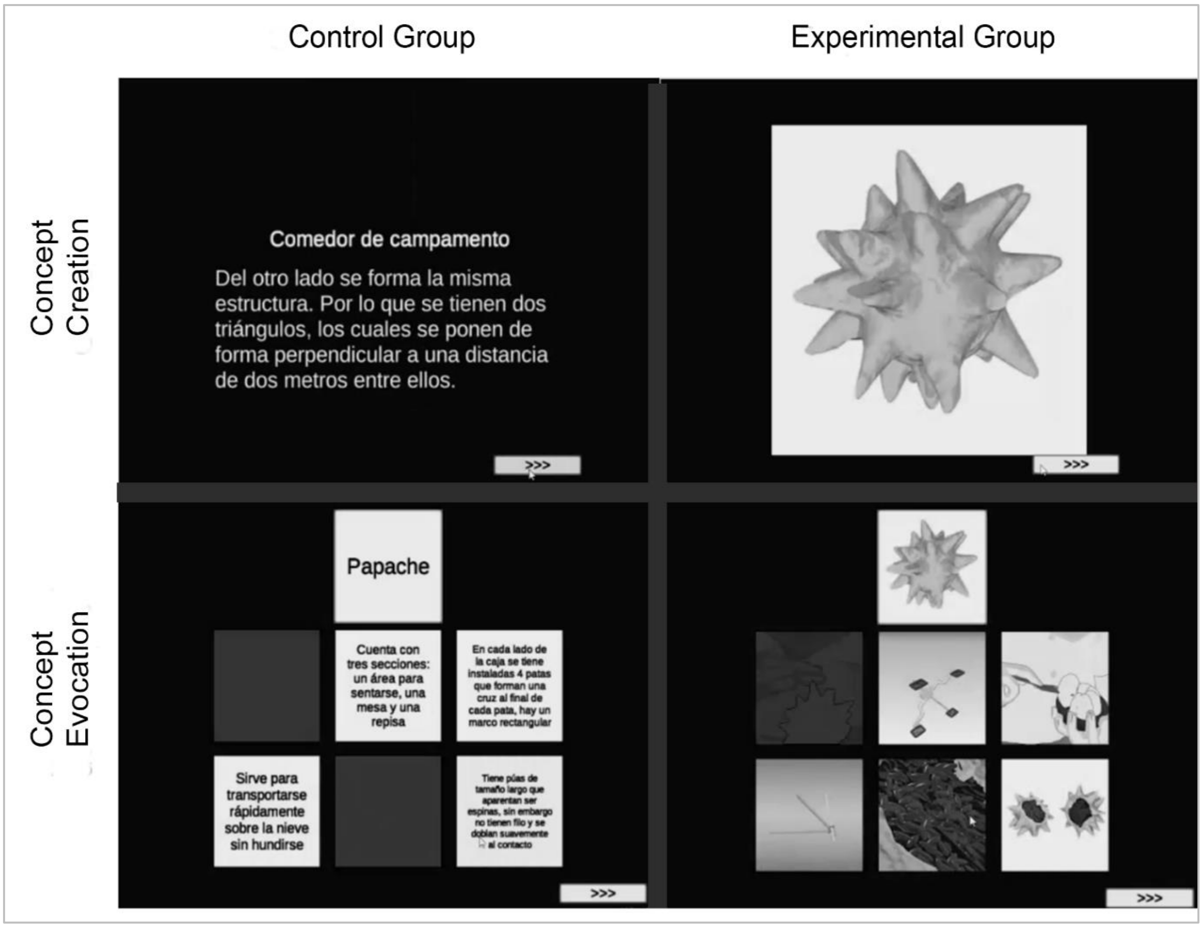
Experiment

The experiments follow a process of discrimination and generalization. Although different concepts were learned, they share a common design. Initially, a situation is created wherein the subject is intended to learn a concept without the use of text. This is achieved through the continuous exposure of the subject to an object or phenomenon, as posited by Hebb's theory, Conceptual Atomism and Engram's theory.

The experiment consisted of two stages. In the first stage, the subjects were repeatedly exposed to a set of related stimuli to create a concept, theoretically pairing the object properties with the subject neuronal engrams. The nature of the stimulus presented changed according to a verbal and nonverbal taxonomy, which defined the control and experimental groups.

After the conceptual creation process, the learning of the concept was verified. This involved the retrieval of information from memory as a second step in the experiment. Without the use of text and considering the engram theory, the subject is presented with only one feature of the entire object or phenomenon. The aim is to determine if, based on that single feature, the subject can discriminate between the features that constitute the concept and those that do not, while also generalizing the characteristics of an object as a consequence.

Figure 4. Comparison of experiments between control and experimental groups



The experiment with the control group aims to create concepts using semantic information. In the second stage, the goal is to retrieve the concepts using words. The process was virtually the same as in the experimental group, with the only difference being the use of semantic information in the control group (Figure 4).

The experiments were double balanced in terms of learning and probing. In the training or learning phase, the training was balanced based on concepts. For each concept, seven exposures were conducted, resulting in a total of four concepts.

Table 3. Distribution example

Trial	Discriminative Stimuli	
	Concept 1	Concept 2
1	2	1
2	0	4
3	1	2
4	4	0
5	3	3

There were 5 probing trials per concept. Each trial consisted of a sample stimulus, six comparison stimuli, and discriminative stimuli presented with a balanced distribution of correct responses ranging from 0 to 4 for each concept (Table 3).

RESULTS

The main hypothesis of the research was tested using the data obtained from the experiment, a modified Welch's t-test was performed (Table 4), which yielded a p-value indicating statistically significant differences between the groups with verbal and nonverbal concept learning, with a higher number of nonverbal correct responses.

Table 4. Test for verbal and nonverbal groups

Group	N	Mean	SD	P
Non verbal	121	104.4298	14.49645	.003
Verbal	154	98.9870	15.72101	

The evaluation of the hypothesis was initially conducted solely based on the accuracy achieved in the experiment. However, data on errors made by the subjects during the experiment, were also collected. This is relevant because one of the characteristics of a concept is the ability to discriminate, which is reflected in the results through the quantity of "selection errors."

These errors occur when properties of unrelated objects are selected. Additionally, there is another type of error known as "generalization error," which occurs when the subject fails to select a quality of the base object, indicating a failure to generalize the concept.

To assess conceptual learning according to these considerations, errors were subtracted from the correct responses to re-evaluate the previously stated hypotheses. The same sample size (n) and statistical tests mentioned in Table 5 were used for this analysis.

Table 5. Overall test

Group	N	Mean	SD	Two-tailed p
Non verbal	121	88.8595	28.992	.003
Verbal	154	78.0455	31.317	

The results once again showed a significant difference where nonverbal learning accuracy was higher, rejecting the null hypothesis. Finally, to determine the effect size of the difference between the two groups, Cohen's d-test was used, yielding a result of 1.1.

This value suggests a large effect, as it exceeds 0.8. To analyze the variables' behavior in more detail, a structural equation model (SEM) was conducted, considering sex, nonverbal taxonomy, baseline anxiety (Axb), and nonverbal concept learning represented by the number of correct responses. The bootstrap process with 1000 samples (nboot) and a significance level of 0.05 (Alpha) was employed for this analysis.

Figure 5. SEM Axb, Gender, nonverbal/verbal taxonomy, and nonverbal concept learning

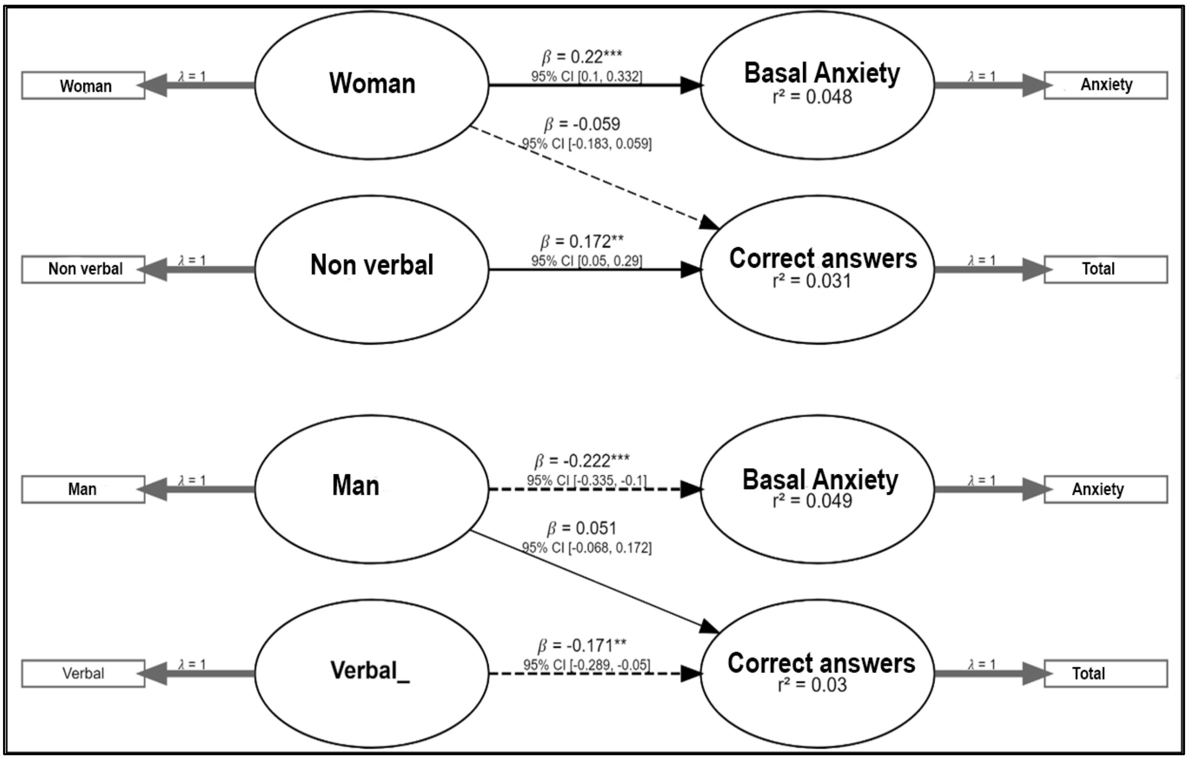


Figure 5 shows that, the variable woman seems to have a negative effect on concept learning, both verbal and nonverbal. However, this effect did not turn out to be statistically significant. On the other hand, a significant relationship was found between the variable female and baseline anxiety, indicating that women was more frequently associated with higher levels of baseline anxiety. Regarding the variable "non verbal taxonomy" a significant weight was found on the dependent variable of concept learning. This was evidenced by a T statistic of 2.8, surpassing the minimum threshold of 1.6, and the confidence interval (CI) values between the 2.5% CI and 97.5% CI not including zero.

In general, regarding verbal and nonverbal concept learning, women learned similarly in response to these variables. However, men had nonverbal and verbal concept learning scores of 107.2 and 98.8, respectively, with a higher number of correct responses for nonverbal concepts. After analyzing the means using the modified Welch's T-test, a p-value of 0.002 was obtained. When comparing the results between men and women in non-verbal learning, disparities were observed, as men achieved an average of 107.2 correct responses, while women had an average of 102.7 correct responses. However, when performing the statistical analysis using Welch's T-test, a p-value of 0.07 was obtained, indicating that there is no statistically significant difference between the sexes.

DISCUSSION

Addressing the research hypothesis, statistically significant differences were found between the mean scores in the learning of verbal and non-verbal concepts. It was observed that non-verbal concepts were retrieved to a greater extent than verbal concepts, with a large effect size. This finding is consistent with previous research reported in recent years (Margolis & Laurence, 2015).

The higher retrieval of non-verbal concepts compared to verbal concepts could be explained by the wide diversity of object-related properties that can be associated with a single word. This phenomenon is context-based and requires a greater amount of mental processing compared to a visual stimulus, which directly relates to a set of properties without the need for prior processing (Malt et al., 1999), while a concept without the use of verbs would theoretically require fewer mental operations.

Regarding demographics, women learned verbal and non-verbal concepts in the same way, while men showed greater learning in non-verbal concepts.

In terms of non-verbal learning, which encompasses storage and reactivation/recall, the first experiment found that subjects were able to construct concepts by combining properties without the need for verbs. They were also able to solve problems that required knowledge of these non-verbal concepts. In other words, the subjects recalled non-verbal information to solve each trial. From this, we can deduce that human beings are capable of acquiring knowledge and acting accordingly without the need to verbalize it.

Another consideration, as stated by Margolis and Laurence (2015), is that learning is not necessarily tied to words. However, a problem arises when trying to express what has been learned in a non-verbal manner. This occurs in various environments, such as the academic setting, where students who do not speak the native language declare their main problem as not being able to find or remember the appropriate vocabulary to communicate, even though they know the answer (Sifrar, 2006).

The experiment conducted in this research was based on the conceptual atomism proposed by Fodor (1998), as well as Tonegawa's engram theory (Tonegawa, 2015) for the creation and retrieval of concepts. Additionally, Hebb's theory (Hebb, 1932) was used to explain offline association or locking between properties. Taking this set of theories as a starting point, a specific definition of dynamic concepts was elaborated to be applied in this research.

CONCLUSION

The main objective was to contribute to the debate on the nature of concepts, drawing upon Fodor's ideas on concepts and considering the scientific advancements made at MIT with engram theory. All of this was conducted from the perspective of cognitive neuroscience, which is dedicated to the study of how the brain facilitates cognitive functions and how the functions of the physical brain can generate seemingly intangible thoughts, ideas, and beliefs (Gazzaniga, Ivry, & Mangun, 2019).

This description of the concept allows us to approach the study of cognitive learning to the real characteristics of the development of human knowledge, taking into account its individuality. This has been considered from various perspectives, starting with Ausubel (2002) and his concept of meaningful learning, which emphasizes the importance of each student's prior knowledge for the achievement of new cognitive structures. It also extends to neuroscientific studies indicating that individuals' experiences over the years lead to completely individual brain anatomy (Valizadeh, Liem, Mérillat, Hänggi, & Jäcke, 2018).

This implies that each concept is unique in each person and develops based on their experiences when interacting with the environment. In this new description, the concept is recognized as structureless and dynamic, which is closer to real learning, where knowledge constantly changes through feedback. The semantic aspect becomes just one property among others, and for social agreements in communication, knowledge about an object is conveyed through common criteria assigned to a symbol (Ausubel, 1983).

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Ethics

The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Institutional Review Board (or Ethics Committee) from Universidad Pedagógica de Durango (Acta No.001/23).

REFERENCES

Ausubel, D., Novak., J, & Hanesian, H. (1983). Psicología educativa: un punto de vista cognoscitivo. México: Trillas.

Ausubel. D. (2002). Adquisición y retención del conocimiento. Una perspectiva cognitiva. 2ª edición, Barcelona: Paidós Ibérica.

Beck, A. T. (1964). Thinking and depression: II. Theory and therapy. Archives of General Psychiatry, 10(6), 561-571.

Blumer, D. & Benson, D.F. (1975). Personality changes with frontal and temporal lobe lesions. En D.F. Benson y D. Blumer (Eds.), Psychiatric apsects of neurologcal disease. Nueva York: Grune and Stratton

Champely, S., Ekstrom, C., Dalgaard, P., Gill, J., Weibelzahl, S., Anandkumar, A., Ford, C., Volcic, R. & De Rosario, H. (2017). pwr: Basic functions for power analysis. Software https://cran.r-project.org/web/packages/pwr/

Cohen, J. (1988) Statistical power analysis for the behavioral sciences. New York: Routkedge. https://doi.org/10.4324/9780203771587

Cadenas Bogantes, D., & Castro Miranda, J. C. (2021). Analysis Of the Effectiveness of The Action Oriented Approach in The New English Program Proposed by The Ministry of Public Education in The Year 2018. Sapiencia Revista Científica Y Académica , 1(1), 45-60. Recuperado a partir de https://revistasapiencia.org/index.php/Sapiencia/article/view/13

Eichenbaum, H. (2016). Still searching for the engram. Learn Behav 44, 209–222 (2016). doi: doi.org/10.3758/s13420-016-0218-1

Fodor, J. (1975). The Language of thought, Cambridge, MA: Harvard University Press.

Fodor, J. (1998). Concepts: where cognitive science went wrong. Oxford: Clarendon.

Fodor, J. & Pylyshyn, Z. (2015). Minds without meanings. Cambridge: The MIT press. Pp. 21-40

Gazzaniga, M., Ivry, R. & Mangun, G. (2019). Cognitive Neuroscience [Quinta edición]. Canadá: W.W. Norton & company

Hebb, D. (1949). The organization of behavior. New York: John Wiley & Sons

Hernández-Pozo, M. R., Alvarado-Bravo, B. G., Espinosa-Luna, C., Barahona-Torres, I., Arenas-Cortes, M., Soriano-Lucio, E., Hernández Pérez, J. F., Govea-Martínez, L., González-García, C. D., Robles Beltrán M. A., López-Morales, U., Salazar-Serna, K. & Bobadilla-Odriozola, J. J. (2021). Sensibilidad a la ansiedad en Mexicanos durante la pandemia Covid19: Evaluación mediante el cuestionario ASI3. Escrito sometido a dictamen para su publicación.

Liu, X., Ramirez, S., Redondo, R., & Tonegawa, S. (2015). Identification and Manipulation of Memory Engram Cell. Cold Spring Harb Symp Quant Biol 79. 59-65 DOI: 10.1101/sqb.2014.79.024901

Malt, B., Sloman, S., Gennari, S., Shi, M. & Wang, Y. (1999). Knowing versus naming: Similarity and the linguistic categorization of artifacts. Journal of Memory and Language 40. 230 – 262.

Margolis, E. & Laurence, S. (1999). Concepts: Core Readings, Cambridge, MA: MIT Press.

Margolis, E. & Laurence, S. (2015). The conceptual mind: new directions in the study of concepts, Cambridge, MA: MIT Press.

Margolis, E. & Laurence, S. (2019). Concepts. the Stanford encyclopedia of philosophy (Summer 2019 Edition). Edward N. Zalta (ed.). Recuperado el 9 de marzo de 2020 de: https://plato.stanford.edu/archives/sum2019/entries/concepts/.

Nallapati, R., Zhou, B., dos Santos, C. N., Gulcehre, C., Xiang, B. (2016). Abstractive text summarization using sequence-to-sequence RNNs and beyond.

López, M. (2023). El Manejo de las Transacciones Online y la Protección al Consumidor. Emergentes - Revista Científica, 3(1), 77-96. https://doi.org/10.60112/erc.v3i1.22

Piaget, J. & Gabain, M. (1926). The language and thought of the child. Londres: K. Paul, Trench, Trubner & Co., Ltd

Quispe, A., Pinto, D., Huamán, M., Bueno G. & Valle-Campos, A. (2020). Metodologías cuantitativas: Cálculo del tamaño de muestra con STATA y R. Revista del cuerpo médico. 13(1). 78-83. DOI: https://doi.org/10.35434/rcmhnaaa.2020.131.627

Ramirez, S., Liu, X., Lin, P., Suh, J., Pignatelli, M., Redondo, R., Ryan, T. & Tonegawa, S. (2013). Creating a False Memory in the Hippocampus. Science. 341 387-391

Real Academia Española. (2019). concepto. Recuperado el 17 de noviembre de 2020 de: https://dle.rae.es/concepto?m=form (RAE,2019)

Rodríguez, M. (2007). Sobre conceptos primitivos - atomismo conceptual. SUMMA Psicológica UST. 4 (1), 31-45

Ryan, T., Roy, D., Pignatelli, M., Arons, A. & Tonegawa, S. (2015). Engram cells retain memory under retrograde amnesia. Science. 28. 1007-1013

Rodríguez Gómez, J. C. (2023). La importancia de la diversidad y la inclusión en el ámbito educativo. Estudios Y Perspectivas Revista Científica Y Académica , 3(2), 16-47. https://doi.org/10.61384/r.c.a.v3i2.30

Ríos Castro , N. (2022). La Evaluación y el Manejo del Dolor en Pacientes con Enfermedad Terminal. Revista Científica De Salud Y Desarrollo Humano, 3(2), 80-95. https://doi.org/10.61368/r.s.d.h.v3i2.37

Semon, R. (1923). Mnemic philosophy. Australia: Allen & Unwin.

Sifrar, M. (2006). Las dificultades lingüísticas y afectivas de la expresión oral en clase y en la vida real. XVII Congreso Internacional de la Asociación del Español como lengua extranjera (ASELE). Logroño, 27-30 de septiembre de 2006

Tonegawa, S., Pignatelli, M., Roy, D. & Ryan, T. (2015). Memory engram storage and retrieval. Sciencedirect.35.101-109

Valizadeh, S., Liem, F., Mérillat, S., Hänggi, J. & Jäncke, L. (2018). Identification of individual subjects on the basis of their brain anatomical features. Scientific Reports, April 4, 2018. DOI:10.1038/s41598-018-23696-6