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Investigating the Limits of Human Spatial Perception and Spatial Thinking

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Abstract

Visual mental images play an important role in thinking, but there is no agreement among cognitive scientists as to what are the kinds of symbols that the mind processes. Does thought consist of mental representations in the form of conditionals of the predicate calculus, or do we form mental models of the outside world which bear an analogical relation to the real world?

Aim: The basic aim of the present study is to contribute to the ongoing work on mental representations by extending the research to an unexplored area in the Greek scene, that of mental partitioning. Our sample consisted of 344 participants. For the statistical processing we employed reliability analysis, descriptive analysis and ANOVA in order to investigate the differences between scores in spatial perception, and mental partitioning. We detected significant peculiarities in the cognitive performance of the participants in the tasks of mental partitioning, indicating certain limitations inherent in human thinking.

Conclusion: The conclusion was that the task of mental partitioning of mental representations of a simple yet novel real object rests on previous abstract propositional thought and knowledge rather than on concrete perceptual processes like the ones proposed by Kosslyn and Sheppard.

Keywords: Representations; Cognitive penetrability; Mental partitioning

Introduction

We create representations to calculate space, distances and directions, and for this purpose the brain has a navigation system that makes use of neural algorithms. The spatial representational system has become better understood mainly in terms of the algorithms and internal maps it uses, but it still needs to be explored how different mental elements are involved and lead to the creation of representations. After all, is thinking words associated with sentences referring to situations or images that resemble the situations to which they refer? There was considerable disagreement between Kosslyn and Pylyshyn about the nature and significance of mental virtual representations. The core of the difference between their scientific positions was the answer to the question whether the language of thought is exclusively of a digital nature or of an analogous nature because it also uses mental images [1]. The main arguments in favor of images were scientific, firstly, the brain activates the same centers to visualize as well as to perceive, and secondly the brain damage that affects perception is also observed in mental virtual procedures. However, considers that the mental processes performed in mental images are subject to cognitive penetrability, that they are guided at an early stage by cognitive propositional elements. We thus come to the position that the relations between what I see and what I know are much more complex, not only in the mental image but also in the perception itself [2]. Given this difficulty, suggested that research is needed to employ depictable shapes and solids, for which individuals' knowledge is not given, and to involve mental processes that because they do not require special semantic knowledge may considered as mental virtual, purely pictorial or spatial. Regarding the above requirements well-known experiment with the vertices of the cube approaches the position that virtual processes are guided by cognitive propositional elements and provides support for Pylyshyn positions. Using the most common normal solid, the cube, Hinton has shown that once this shape changes mental arrangement in space it leads even suspicious individuals to errors that go unnoticed when people mentally manipulate an image of a cube or a three-dimensional representation in a standard position [3].

The mental partitioning

In psychology, few studies have attempted to identify the limits of the ability to mentally divide objects, although several studies have dealt with the transformation of objects or their modification at the mental level. No research has been done to detect and study the mechanisms, and to explore the limits of the mental bifurcation of objects which are merely comprehensible but of which the participants have no particular knowledge as well as the correlation of this capacity by performing in spatial capacity projects [4]. The researches so far have been mainly focused on the spatial-optical-construction ability and present differences in terms of both the theoretical framework on which they are based, the design, the sample they have used, as well as the methods of analysis and processing of their data. In any case, a key scientific challenge remains the question of whether there are works of mental dichotomy that help to determine the nature of mental representations to the point of answering the scientific controversy between Kosslyn and Pylyshyn and whether the theory of cognition then applies. Permeability to the point of establishing a new theory of propositional determination of perception [5].

Moebius strip

Moebius strip is the first surface of one face that was discovered and studied. The strip is a surface with only one face and one edge. To make it, cut a strip of paper, 5 cm high, 25 cm long, and then before gluing the two ends, rotate one of the two ends 180 degrees. The use of the strip in the study of representations helps us to understand the limited perceptions that most people have of space [6]. The first experiment was about the question of whether the language of thought that is considered as the basis of any mental process, is exclusively digital in nature or analogous in nature because it also uses mental images. In the control group we presented the Moebius strip and asked for its mental bisection, while in the experimental group we presented the same strip **(Figure 1)**.

Figure 1: Moebius strip.

Methods

For the purposes of the research, a scheme was used which is easily illustrated, but for which individuals have no particular knowledge. The Moebius strip has the above characteristics as well as a particularly strange property, its longitudinal bifurcation leads not to two strips but to a double entwined strip with half width and twice the length of the original. The first experiment was about the question of whether the language of thought that is considered as the basis of any mental process, is exclusively digital in nature or analogous in nature because it also uses mental images. In the control group we presented the Moebius strip and asked for its mental bisection, while in the experimental group we presented the same strip perceptually, and after the participants were convinced and stated that they could visualize it, we withdrew the strip and asked for the longitudinal mental bisection her mental illustration [7]. We assumed that if we observed the same or similar success in both groups then Kosslyn's position would be strengthened, if the experimental group had a significant failure in the division and the control group had a significant success, then Pylyshyn's position would be strengthened. What we did not expect, is what finally emerged, the complete failure of both teams in the project.

The research plan

The participants of the research were divided into two subgroups: the control group (N=186, 54.1%) in which the individuals saw how the Moebius strip was constructed and we asked them to mentally bisect the shape they saw, and the experimental group (N=158, 45.9%), in which people were informed and saw how the strip was made but when they were sure that they could depict it mentally, we withdrew it and asked for the mental bifurcation in its mental depiction. This separation was made to investigate a possible difference in performance between the perceptual and mental manipulation of the strip [8].

Hypothesis

The main hypothesis of the research was that there are spatial works, such as the mental partition of the Moebius strip, in which mental images are not used but are subject to what called cognitive penetrability. That is to say, given that no person who took part in the research is already aware of the Moebius strip, its performance in the division projects will not be affected by what people see and try to manipulate mentally, but by what they already know. It is expected that most participants will not make much mental effort, and will be led to the wrong solution using established mental patterns. If participants can mentally depict two simple shapes, the Hinton cube and the Moebius strip, their possible low performance will lead us to support the position that there is an increased difficulty in mentally manipulating the relevant images. Specifically for the mental partition of the strip, the possible answer that the partition will create two separate pieces will lead to the support of the position that the visual mental display depends on the specific work of research from an established form of thought and knowledge, the abstract propositional knowledge about the world, rather than by perceptual processes [9]. The specific mental processes of manipulating the cube and dividing the strip will include and will be based mainly on propositional representations, so the relevant virtual processes will be guided by cognitive propositional elements (Hypothesis 1). In the case of strip splitting, mental processing will not be facilitated by the perceptual condition (Hypothesis 2) **(Figure 2)**.

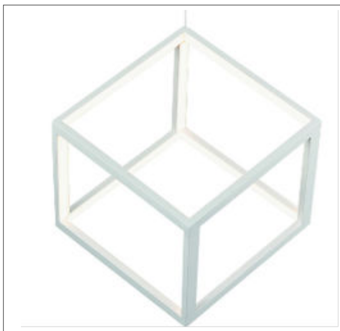

Figure 2: Hinton cube.

Hinton 1 and Hinton 2 projects

To identify the statistical significance of the relationship between the performance of the participants in the task of finding the number of vertices of the inverted cube (Hinton 1), and the performance in the task of presenting the arrangement of the vertices in space (Hinton 2), the x2 independence test was applied. There was a statistically significant correlation between performance in the Hinton 2 project and in the Hinton 1 project, x2 (N=129, BE=1), $p<0.001$. Out of the 160 participants who answered correctly in the Hinton 1 project (proposal representation) only 31 people (24.03%) answered correctly in the Hinton 2 project. Most people who responded correctly to the first task (Hinton 1) made the wrong mental manipulation of the image in the second task (Hinton 2). This confirms hypothesis 1 (**Table 1**).

Tests	Correct answers	Percent (%)	Wrong answer	Percent (%)
Hinton 1	160	46.5	184	53.5
Hinton 2	31	9	313	91
Partition Moebius strip	9	2.6	335	97.4

Table 1: Frequency of answers to the tests of the research.

Experimental condition

Attempt to mentally divide the strip: In order to examine the hypothesis that in the case of the partitioning of the Membius strip the mental processing is not facilitated by the perceptual processing (hypothesis 2), the performances of the two experimental groups in the specific project were compared. To identify a statistically significant relationship between the performance of the two groups, the x2 independence test was applied [10]. A statistically significant correlation was found between the performance of the experimental group and the performance of the control group x2 (N=156, BE=1)=43.59, $p<0.001$. Of the 186 people who saw the strip and tried to split it (control group) 179 people (96.24%) gave the wrong answer and of the 158 people who tried to split the mental image of the strip 156 people (98.74%) also gave the wrong answer. The binomial test for success in the mental partitioning project also showed that there is a statistically significant difference in favor of the percentage of those who failed ($p<0.001$) in the control group and a statistically significant difference in favor of the percentage of those who failed in the experimental group ($p<0.001$). The two teams showed no differences in their performance. This confirms hypothesis 2 [11].

The relationship between age and performance in Hinton 1, Hinton 2, and the Moebius strip partitioning project: According to the results for the first two projects (Hinton 1 and Hinton 2) in the first part of the survey there were no significant differences in performance between participants in the two age groups. Of the 9 people who gave the correct answer to the test of dividing the strip of Moebius, the youngest showed better performance. The binomial test for the success or failure of each age group in the strip partitioning project showed that there is a statistically significant difference in favor of the younger in age ($p<0.001$).

The relationship between gender and performance in Hinton 1, Hinton 2, and the Moebius strip partitioning project: According to the results for the first two projects there were no significant differences in performance between men and women. Of the nine people, however, who gave the correct answer to the test of partitioning the strip of Moebius, the men showed better performance. The binomial test for the success or failure of men and women in the strip partitionig project showed that there is a statistically significant difference in favor of the men who participated ($p<0.001$).

Results

According to the results, only 46.5% of the participants answered correctly to the theoretically easy task of the number of vertices of the cube in the first task (Hinton 1). If we assume that during their attempt at this project the individuals used a virtual representation then this type of representation did not help them to answer correctly. We believe that the orientation of the cube at one of its vertices and the strange position it takes make it difficult to attempt its virtual representation, while those of the participants who correctly answer the first problem believe or that they use the propositional representation: "the cube has eight vertices, if I subtract the two support of them, there are six left "or they are quite good at mentally handling the image of the cube, but a fact that should have led to a better success rate in the work that followed, which clearly required mental manipulation of the inverted cube image (Hinton 2). In other words, it seems that there are spatial works to which it is difficult to answer correctly using only the virtual representation and in some cases of spatial tests the mental manipulation requires in addition to the image the use of a propositional representation. Also, the people in the second project (Hinton 2) find it difficult for the vast majority to manipulate the image of the cube. Only 31 of the 344 participants managed to define the found it difficult to manipulate an image, although in the first test they had easier access to a propositional representation and Moebius strip, only nine of the 344 people answered correctly and the mental manipulation of the image was impossible **(Table 2)**.

		Mental partition of Moebius strip	Total	
Experimental condition		Wrong answer	Right answer	
	Experimental group	156	2	158
	Control group	179	7	186
	Total	335	9	344

Table 2: Frequency of correct answers in the partitioning test of the strip as function in two different conditions: mental and real manipulation.

In this project it seems that the previous knowledge had a catalytic effect: "what is cut creates two separate pieces" and led the participants to a wrong answer in 97.3%. Regarding the variables examined for mental partitioning, for the very low percentage of participants who gave the correct answer, age and gender show a tendency to influence this ability in the test of mental partition with men and younger people to perform better, but without leading us to sufficient support for this position. Of particular interest was the fact that the condition in which some participants saw the strip and tried to split it, while others tried to give an answer after imagining it, did not significantly increase the percentages of correct answers. This means that the cognitive penetrability of Pylyshyn should be extended to issues of perception and not only to issues of mental imagery. The comparison of the two experimental groups shows that the group of those who saw the strip performed better, but we can not with these results support the position that the mental processing of partitioning is facilitated by the perceptual condition.

The cognitive behavior of individuals when solving problems of mental partition of objects, and especially in trying to solve the problem of mental partition of the Moebius s trip.

Conclusion

The small success rate of finding the right solution to the main problem we posed in the present study both for those who saw the strip, but also for those who tried to handle it mentally, leads us to the conclusion that the cognitive penetrability defined by applies to the specific transformation projects with the difference that it now extends to the perception of the strip. The large percentage of failure of individuals to find the right solution to the problem of mental partition of the strip, supports the position that there are problems of mental transformation in which experience and knowledge do not help but prevent finding the right solution. The people who took part in the research show that they cannot mentally manipulate this image, but even if we accept that they manipulate an image, they end up with a wrong answer in the largest percentage of the sample. The basic principle of the propositional form of representation is that words and images are represented in an abstract form which indicates the meaning and significance of knowledge. Individuals encode and manipulate all information in the form of the propositional representation. When they want to use this information they retrieve the propositional representation and based on it they reproduce and manipulate the information. Participants also showed difficulty in mentally manipulating the strip even when they saw it. They used the available cognitive patterns and tried to create semantic connections of the old with the new knowledge in order to understand the problem and give the right solution. In any case, for the test of mentally partition of the Moebius strip, what individuals are trying to manipulate is influenced by their pre-existing knowledge which confirms circular synthetic theory.

The position that individuals can perform various mental transformations and calculations in all three dimensions for external objects using images cannot be supported by the results of the present study. The fact of the low success rate in the test of partition leads us to the conclusion that the law of minimum mental effort applies. There is an attempt to solve the mental task with the spontaneous/fast system of thought. Participants used a fast and spontaneous system of thought that worked automatically with associations, with little or no effort, without a sense of voluntary control, with cognitive biases, with a limited understanding of logic, and for this reason most came to the wrong conclusion. According to the results, the independent variables age, profession and education affect the performance of spatial perception in the mental partitioning projects that were used. The best performance in both types of projects was presented by individuals under 25 years of age. The level of education affects only the performance in the projects of spatial perception and not the performance in the projects of mental partition, with the persons of higher education having the best performance. Performance in tests of spatial perception predicts performance in tests of mental partition and vice versa. The cognitive behavior of individuals when solving problems of mental partition of objects, and especially in trying to solve the problem of mental partition of the Moebius strip, presented various, and important peculiarities that mainly concern the limitations to which human thought is subject. Participants presented mental tendencies similar to their previous experience, which prevented them from adopting other alternative and perhaps more effective solutions. Their performance on the Moebius strip partition test showed that spatial thinking is influenced by what individuals already know, not by what they see or mentally manipulate in their minds.

This conclusion leads us to support the position that the process of mental manipulation of the mental or external representation of a simple, unprecedented and existing object, is influenced by the propositional rather than the virtual form of representation. Participants showed a defining tendency to focus their thinking on a specific idea and created particular difficulties in accepting a new idea or approach, such as the fact that dividing the strip would create one piece. In this test they looked for a short way to connect the initial situation with the target. They used their pre-existing knowledge, believing that this would facilitate the solution of the problem. Individuals in the process of mentally dividing the Moebius strip see what they know and not what actually exists. This position approaches the position of Pylyshyn, who supported the presence of processes of conceptual formation of perception through centrifugal neuronal effects and in particular the position that virtual processes are guided by cognitive propositional elements. It seems that a series of centrifugal processes of information affect the way we perceive, while experiences shape our theories and the way we perceive the world, at least in the case of solving problems of optical transformation such as the mental partition of the Mebius strip.

References

1. Bartolomeo P, Erme PD, Perri R, Gainotti G (1998) Perception and action in hemispatial neglect. Neuropyschol 36: 227-237.

2. Goldenberg G (1993) The neural basis of mental imagery. Baillieres Clin Neurol 2: 265-286.
3. Hinton G (1979) Some demonstrations of the effects of structural descriptions in mental imagery. Cogni Sci 3: 231-250.
4. Bartolomeo P (2008) The neural correlates of visual mental imagery: An ongoing debate. Cortex 44: 107-108.
5. Kreiman G, Koch C, Fried I (2000) Imagery neurons in the human brain. Nature 408: 357-361.
6. Dehaene S, Naccache L (2001) Towards a cognitive neuroscience of consciousness: Basic evidence and a workspace framework. Cognition 79: 1-37.
7. Shepard RN, Metzler J (1971) Mental rotation of three-dimensional objects. Science 171: 701-703.
8. Dejong G (1979) Prediction and substantiation: A new approach to natural language processing. Cogni Sci 3: 251-273.
9. Shepard RN, Judd SA (1976) Perceptual illusion of rotation of three-dimensional objects. Science 191: 952-954.
10. Meijer F, Broek EL (2010) Representing 3D virtual objects: Interaction between visuo-spatial ability and type of exploration. Vision Res 50: 630-635.
11. King DJ, Hodgekins J, Chouinard PA, Chouinard VA, Sperandio I, et al. (2017) A review of abnormalities in the perception of visual illusions in schizophrenia. Psychon Bull Rev 24: 734-751.