SIMILES AS A TOOL FOR EXPLORING CHILDREN'S THINKING ABOUT GEOMETRICAL SHAPES

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Abstract: *This paper focuses on the role of similes in exploring the way children conceive geometrical shapes. It is an experimental study involving ninety-five children divided into three age groups. Three tasks were given to the children: a comprehension, a production and a metacognitive one. The main results suggest that similes are a natural way of describing geometrical shapes for all age groups. They also show that children base their choices of similes on a wide range of experiences. Moreover the use of similes in certain cases imply a primitive way of conceiving the geometrical shape while in other cases a more advanced one.*

Introduction

The ability to perceive similarities and analogies –a crucial factor for the processes of recognition, classification, and learning- is one of the most fundamental aspects of human cognition. Given that similarity judgments and analogical reasoning are based on people's representation of entities, their study requires a number of assumptions about how knowledge is represented and how these representations change. (cf. Lakoff and Johnson, 1980; Vosniadou and Ortony, 1989).

Children's use of similes could be a way of exploring their representations of entities. A simile is a figure of speech where X is compared to Y using the words *as* or *like* or *looks like*. Similes are considered to be a useful tool for our study because together with metaphors and metonymies are ways of expressing analogical reasoning. In the last decade, the metaphorical use of language has emerged as an area of interest in mathematics education research. Metaphors and metonymies have been used in the teaching of mathematics as a way of helping children to attribute meaning to complex mathematical concepts (Presmeg, 1992,1998; Sfard, 1991). Pirie and Kieren's work (1994) refers to the role of metaphors and similes on children's mathematical understanding. They suggest that there is a relationship between the categories of the formalizing level of understanding and metaphors and similes.

Thinking about geometrical shapes does not occur only in a geometrical context because children base their thinking on figures to which they attribute physical and perceptual properties. A number of researchers talk about the difference between what a figure "shows" and what it "represents", recognizing children's difficulties in distinguishing a geometrical object from a physical object (Duval,1995; Fischbein, 1993; Mariotti, 1995; Potari and Spiliotopoulou, 1996). Therefore, in the process of understanding geometrical shapes and their properties, children make connections between different domains of experience which is the essence of metaphors and similes. In the area of geometry, the possibilities that the metaphors and similes offer for exploring the kind of connections children make in the process of conceiving geometrical shapes have not been systematically studied. The work of Triadafillidis and Potari (in press) is an example of research in this area which shows that children spontaneously use similes to describe three dimensional objects as a way of getting a sense of the characteristics of these objects. The spontaneous use of similes in children's descriptions of geometrical shapes is an area also studied in the present research. However, our research extends its parameters to include the "constrained" use of similes during a process of mapping similes provided by the researchers to a number of geometrical figures as well as the way children reflect on similes, evaluate and modify them.

The present study is part of a wider research effort into the role of language with respect to the way children build the concept of geometrical shape. Data came from children's work in three tasks: a comprehension, a production and a metacognitive one (Potari, Diakogiorgi, Gioni, Zanni, 2002). Similar types of tasks can be encountered in the research literature on children's thinking in relation to geometrical shapes (Hershkowitz, 1989; Clements, Swaminathan, Hannibal & Sarama, 1999). However, the fragmented manner in which the comprehension process, the production process and the metacognitive process are approached does not provide us with an overall picture of children's thinking. On the contrary, our study aims to investigate how these processes are linked together and in this paper through the use of similes.

Methodology

The data presented in this paper come from an experimental study involving ninety five children from two primary schools in Patras, Greece. The children were divided in three age groups: 30 from second grade (7 years old), 32 from fourth grade (9 years old) and 33 from sixth grade (11 years old). The experiment was conducted in three phases (the comprehension, the production and the metacognitive phases) and lasted five months with short intervals between the phases.

Comprehension phase: The children were given 19 different geometrical shapes, mostly quadrilaterals, some of them chosen to be familiar even to the youngest children while some others to be unfamiliar even to the oldest ones. The shapes were drawn on a piece of paper and the criteria used for their choice were the orientation of the shapes, their typicality (prototypical images), their convexity and their form (e.g. the size, the number of sides). We also took into account what is taught in school on geometrical shapes which is certainly related to the previous criteria.

The children were asked to match nineteen similes (eg. it looks like a diamond, it looks like a tie, it looks like a copy book), six geometrical terms (square, rectangle, oblique parallelogram, rhombus, trapezium and quadrilateral) and sixteen statements expressing properties of quadrilaterals (eg. it has four equal angles) to the given shapes. The tasks were given in the form of worksheets and were completed in children's regular classroom.

Production phase: Unlike the previous phase, in this phase and in the following one, the children were taken from their regular classroom into another room where they worked individually on the tasks. The children were presented with a square, a rhombus, a rotated square and a kite, each drawn on a separate piece of paper, and each presented one after the other. The instructions given were the following: " Imagine that you want to help a friend of yours who cannot see this shape to draw it exactly as it is. Give him as much information as you can but try not to use the shape's name". After completing this task the children were asked to name each of these shapes in as many ways as possible.

Metacognitive phase: In this last phase, the children were first asked to comment on and evaluate both their own description and the one given by the researchers concerning the shape of the kite. The researchers' description consisted of some typical expressions and terms that were drawn from the children's descriptions. We attempted to integrate elements that indicated different levels of geometrical thinking varying from primitive to more advanced. Thus, we included both mathematical terms and informal language expressions, references to the shape's properties or to its holistic form as well as correct or incorrect descriptive elements. Three different descriptions were constructed for each age group and the children were told that these descriptions were produced by another pupil of the same age. The researchers read the constructed description and each child's transcribed description, sentence by sentence, asking the child to evaluate its appropriateness. They also asked them to give reasons for providing such descriptions as well as to suggest some changes that they considered necessary. Finally, the whole description was read again and the children were asked to make an overall judgment.

The data from the comprehension phase was the children's written responses while for the production and metacognitive phases the videotaped and transcribed verbal interactions between the researchers and the children were employed. In this paper we base our analysis on data concerning one geometrical shape, the kite.

Results

The process of analysis

The analysis of the data was conducted on two levels. At first, we attempted to investigate how the groups of children who had participated in the experiment used the similes in the comprehension and the production tasks. In particular, in the comprehension task, we identified the number of children who had chosen the given similes in order to form a hierarchy of similes for each age group in terms of the frequency with which they were chosen by the children. On the basis of the claim that the use of metaphors and similes reflect children's understanding of geometrical shapes (Pirie & Kieren, 1994), we analysed the hierarchical patterns in each age group in order to make some assumptions about the ways children perceive the given geometrical shape. In the production task, we first identified the similes and the frequency with which the children used them in their descriptions. We then formed categories based on the nature of the object used for the analogy. Our main goal was: a) to test through these data some issues emerging from the analysis of the comprehension data, b) to explore possible issues about children's representations of geometrical shapes and finally c) to look for possible relations of children's behaviors in the comprehension and in the production tasks.

On the second level, we analysed the data coming from the responses of ten children in each group across the three tasks, including the metacognitive task. The data were scrutinized in order to address a number of questions that could not be answered in the global analysis of the first level. By analyzing each individual's responses we wanted to examine the degree to which the children use similes, to explore the function of the similes in the children's descriptions, to deepen our understanding about the meaning that children attribute to specific similes and finally to make some assumptions about the way children "see" the geometrical shapes based on our findings coming from the three tasks.

Hierarchical patterns of similes in the comprehension task

In Table 1 we present the similes in hierarchical order according to the rate of children's choice in the comprehension task for the "kite" and for each age group. The simile's structure is "it looks like x" where x is the object presented in the table.

Grade 1 (Similes)	Grade 2 (Similes)	Grade 3 (Similes)
Tie (70%)	**Tie** (86%)	**Tie** (79%)
Rocket (41%)	**Rocket** (52%)	**Diamond** (59%)
Diamond (37%)	**Paper airplane** (48%)	**Kite** (55%)
Paper airplane (33%)	**Kite** (31%)	**Paper airplane** (31%)
Kite (26%)	**Diamond** (28%)	**Rocket** (24%)
Book marker (7%)	**Book marker** (24%)	**Book marker** (3%)

↓ HIERARHY

Table 1: Children's choices of similes in a hierarchical order in the comprehension task

All the children in each age group chose a simile to match to the given figure. The dominant choice for all the groups was "it looks like a tie" which is probably the only simile that contained an object showing the large difference in size between the two pairs of the figure's sides. It also seems to be the closest one to the form of the shape. Thus, *similarity* seemed to be an important factor on children's choices. *Familiarity* of the physical object seems to be another factor in children's choices. For example, the object kite in some cultural contexts could be expected to be the most common choice. However, in Greece the physical object kite is usually of a hexagonal shape and very rarely of the quadrilateral shape that the geometrical object "kite" has. This is probably one reason why the kite becomes a more frequent choice in the age group whose range of experiences with the physical object increases.[1] Another factor that seemed to play a role in children's choices was *the resemblance of the shape to a known geometrical shape* which in this case is the rhombus. This is probably a reason why the oldest children, who have been taught about the rhombus in school, use the simile "it looks like a diamond" to describe the geometrical kite too. On the other hand, the fact that the same simile was chosen quite frequently by the younger children who do not possess this knowledge suggests other factors to which the children's choices could be attributed. A possible explanation could be based on the way the children perceive the shape. For the second and fourth grade, it seems that a pattern of similes, rocket – diamond – paper airplane, emerges that possibly indicates a similarity grounded in the salient features or the salient feature of the figure which in the case of the kite could be the "pointedness" of the shape.

The kind of similes in the production task

In this task very few children did not use a simile in their descriptions (22%, 4% and 14% for the second, fourth and sixth grade, respectively). From those children who used similes in their descriptions, about half of the second and fourth grade and a third of the sixth grade used more than one simile in their descriptions. Comparing the similes used in this task with those in the comprehension task, we meet the same similes again but less frequently, due to the fact that in the production phase the use of the similes is spontaneous. We also noticed a variety of similes (especially in the second and fourth grades) which, nevertheless, all refer to objects which share a common feature that of "pointedness". The following examples illustrate the above interpretation: "it looks like a cone", "it looks like a knife", "it looks like a tent", "it looks like a spaceship" "it looks like a hill". There are also some similes which indicate a dynamic perception of the shape: "it looks like a train that goes to the left". On the first level, we classified the similes in four groups according to two criteria: whether the object referred to is solid or plane and whether the object is physical or geometrical. The results showed the children prefer to use physical objects in their similes, some solid (it looks like a rocket) and some good approximations of plane shapes (it looks like a broken glass). Few children referred to geometrical shapes: " it looks like a triangle", "it looks like a rhombus" "it looks like a pyramid".

The use of similes across the three tasks

Among the similes children used in their description there were some they had also used in the comprehension task. Although we have noticed some developmental differences in the comprehension and the production tasks, the most apparent differences emerged in the metacognitive task. For example, the youngest children had difficulty justifying the use of a certain simile, to decide about its appropriateness and to modify it. On the other hand, the oldest children' s metacognitive judgments revealed an increasing degree of consciousness. Thus, the oldest children were

[1] The geometrical object "kite" is not studied in primary school geometry

becoming more capable providing reasons for accepting or refuting the similes. They could also modify a simile, offer a new one or replace a simile used in their own or in the "constructed" production.

The metacognitive phase also helped us to verify our hypotheses about the meaning that the children attributed to the similes. The following explanation of a seven years old boy about the meaning of the simile "it looks like a sword" indicates this possibility. The boy placed his hand along the smallest diagonal of the kite and showed the two isosceles triangles. Then showing the triangle with the smaller sides he said "If we do this (the dissection), that (the triangle) [while rotating the shape] is what will hold it (the sword) at the back". This explanation also shows the child's ability both to see the shape dissected in parts and to make a number of dynamic transformations of the geometrical shape to fit the physical object.

The coexistence of the similes with other ways of description

The analysis of the kind of similes that children used in their descriptions revealed two types of perception: one referring to a rather static way of perceiving the shape based either on its form or on a discriminated feature, and another indicating a dynamic way of perceiving the shape based on a number of different transformations (eg. rotating, cutting into parts, moving, lengthening). In the first case, to a large extent, similes coexisted with a very primitive way of noticing the elements of the shape (sides or angles) and usually with confusion between the concept of angle and its sides. However, this was not always the case as there were some children who showed a rather static way of perceiving the geometric shape yet they could give detailed information about the elements and the properties of it as is demonstrated in the following example: Aggeliki, an eleven years old girl, described: "It has 4 angles. Two of them are equal and the others as well. Two of them are small, the others are big. It looks like a spaceship". Different patterns of coexistence between the dynamic way of perceiving the shape and the way of conceiving it also seemed to appear. Thus we see that Dionysius, a seven years old boy, perceives the shape dynamically but from his description: "it looks like the previous (the rhombus). It is long" and his explanations in the metacognitive task, demonstrated a rather holistic way of conceiving the shape. On the other hand, Alexei, a nine years old boy uses a number of dynamic transformations like, cutting and moving in his description: "If we cut the top, then the top is a triangle, while the other is a big triangle like a bee's stinger, like a train which goes to the left". In the metacognitive task, it appeared that he had a deep understanding of the concept of geometrical shape and its properties but he was not keen to include this type of information in his description. Finally, Andreas, an eleven year old boy, gives information about the number of sides and angles, the equality of the sides and the type of the angles: "It has two sides equal and another two. The two (meaning angles) are acute and the other obtuse. It looks like an arrow". Moreover, he seems to transform the shape, mostly by rotating it, when he attempts to justify some parts of his description.

By further analyzing the way that the similes coexisted with other kinds of information in children's descriptions, we identified the following different functions performed by similes: The similes usually referred to the overall shape and rarely to its properties. For example, Konstantinos, an eleven years old boy, talking about the sides of the kite said: "it is not like the copybook (referring to the perpendicularity of the sides), but diagonal (meaning non parallel)". The simile was often used as a way to justify another kind of description which sometimes was also a simile: "it looks like a rhombus, it is larger, like a piece of paper, like a knife, like a prickle". In some cases, the similes just added another piece of information about the shape, an example is Andreas' description presented in the previous paragraph.

Discussion - Conclusion

The central issue of this paper has been the investigation of the role of similes, a form of figurative language, in the process of recognizing, describing and reflecting on geometrical figures. Although in this paper only a preliminary analysis and some first results are presented, we feel that our research addresses some important issues on the relation between similes and the way children perceive a geometrical shape. Pirie and Kieren's (1994) claim that understanding at the property noticing level entails the use of similes seems to also hold in our case for some children but it cannot be a general statement. Our study indicates that this relationship is more obscure and complex as there is a wide range of factors that underlie this relationship. The interplay of children's experiences with the physical object, the experiences with the geometrical object, and the ways of perceiving the figure, determine to a certain degree, children's choices of similes. In fact, our study shows that the use of similes indicates in certain cases a primitive way of conceiving the geometrical shape while in other cases a more advanced way where children's attention is centered on the geometrical properties of the shape. The above finding did not emerge only from the analysis of the similes themselves, but from an analysis that took into account both similes and other types of descriptions children produced as well as explanations and judgments children proposed in the metacognitive task.

The findings seem to challenge the assumption that there is a sharp dichotomy between holistic perception and dimensional perception (see Vosniadou and Ortony, 1989, p. 4) and their correspondence to the notions of primitive and advanced way of conceiving a geometrical shape. The dynamic way of conceiving a geometrical shape that was a strategy used by a number of children does not fall into this duality and further research is needed to illuminate the complex relationships between these notions. Moreover, this first analysis of our data demonstrates the potentiality of the metacognitive activity to improve children's understanding in geometry and approaches empirically what Pandiscio and Orton (1998) address at a theoretical level about the interplay between development and instruction.

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