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FORMAL AND LOCATIVE CATEGORIES: ARE THERE TYPICAL INSTANCES?

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Two experiments on a population of 4 to 6 year olds attending a nursery school furnished the opportunity to study locative categories in relationship to their natural context, i.e., shapes. Experiment I deals with formal categories and shows that representativity is not uniform: Some shapes were selected as typical, whereas others were considered a-typical. Experiment II analyzes the locative categories "in", "above", "below" and "between" in relationship to the typical and a-typical shapes defined in Experiment I. The results reveal that localization shows greater typicality (general consensus among the subjects) as the shape itself became typical. Both experiments point to the importance of a joint investigation of categorical structuring and context.

Recent studies on natural categories, (e.g., Lakoff, 1982) clearly point to renewed interest for the field of typicality. The classical notion of categorization focused on criteria for membership: an instance was defined as a member of a category if it possessed the necessary and sufficient properties of that category. In this frame of reference, all instances thus had the same status.

Studies in the field of "natural categorization" have shifted interest from membership to that of categorical representativity. Numerous experimental findings have shown that the status of all instances is not equivalent; some are rather highly representative of their category and can be termed "typical" instances. Others are unrepresentative and are considered to be atypical.

This representativity gradient covaries with what has been called the "family resemblance" of the instances (Rosch & Mervis, 1975). Typical instances are perceived as being similar, when contrasted with others. In addition, individual properties seem to have a differential effect on decisions regarding membership in categories. In general, these findings tend to show that a large number of dependent variables used in psychology research may be affected by the degree of representativity of category instances (for a review, see Cordier & Dubois, 1981; Smith & Medin, 1981).

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Up to the present time, most studies have dealt exclusively with object categories (Rosch & Mervis, 1975). However, the study of other categories appears to be both feasible and worthwhile (Lakoff, 1982; Langacker, 1984). The experiment described in this paper was designed to examine locative categories jointly with form. This association arose from the nature of the experimental situation itself, which involved localization in spatial contexts.

In her study of categorization, Rosch starts with an analysis of the color and shape categories which individuals perceive directly. Her previous research (Rosch, 1973) on a group of individuals with no prior terms for color ranges or shapes — the Dani tribe of New Guinea — showed that color and shape could be represented by a natural prototype, centered around the focal element of the given category. As regards shape, the principal factor dealt with in the present experiment. Rosch states that some are more perceptually salient than others. This idea is congruent with Gestaltist tradition which claims that the most well-balanced, "good" figures act as the focal element of a category. Since this focal element embodies the most salient properties, it is preferred, and thus becomes the most representative[1].

Experiment I was constructed to test Rosch's findings on a population of 4-6 year olds. The experiment consisted in asking children to sort two sets of polygons (triangles and squares). Polygons judged to be typical by the subjects were assumed to be those which could be qualified as "good" figures (i.e., the equilateral triangle and the square, respectively). No differences were expected between age groups for the simple reason that the processes leading to structural perception, if not innate, appear very early in life (Bornstein, 1981).

The analysis of shape and sematic categories, both of which are now well-documented in literature, was extended to the investigation of a much less well-known area of typicality: locative categories. Two hypotheses were put forward: 1. the semantic pole of a prepositional item can be defined as a category of meaning, constituted by all the possible localizations subsumed by this preposition; 2. on the representational level, these localizations do not necessarily have the same degree of representativity; some may be more typical of their category than others.

1. The term "focal" applies to the study of natural categories and will not be extended to the field of semantic categories. It is used here to stress the fact that perceptual determination is at a maximum in this field.

In one of the rare studies devoted to this topic (Erreich & Valian, 1979), categories were derived from prepositions or prepositional compounds such as "in" "above", "below" and "next to". The subjects (aged 4-6 and adults) were asked during one phase of the experiment to locate a dot in relationship to a square. The results, as expected, showed that use of the first three prepositions corresponded to typical localizations coinciding with the specific characteristics of a square: "in" was used for the center, "above" and "below" were used to describe location along the vertical axis dividing the shape symmetrically in two. Age of subjects was shown to have a significant effect.

Experiment II in this paper was designed to study locative categories whose scope had been widened to test for possible relationships between locative categories and shape. This was done by systematic modification of the polygons in relationship to localizations, which was intended to provide answers to the following three questions:

1. Regardless of the nature and the shape of the reference polygon, do typical localizations emerge?
2. If so, will a differential effect for age be observed? (i.e., given that typical localizations are associated developmentally with typical polygons first).
3. What is the nature of the representations involved in accomplishing these tasks?

Rosch (1973) hypothesizes that the role of a "good shape" concerning perceptual cues is linked to the focal elements. This implies that figurative elements are present in the cognitive representations of this category (Denis, 1979). Are similar figurative elements brought into play in the cognitive representations of locative categories? If this is the case, an interaction between formal and locative categories should be observed when their cognitive representations share salient perceptual features (i.e., the position of the invididual as regards a symmetrical axis). In other words, a typical shape should favorize a typical localization.

Experiment I

Experiment I analyzes categories of shapes in terms of natural categorization. Two theoretical reasons justify this: a. from a developmental point of view, the importance of natural prototypes in the construction of categories can be examined; b. these prototypic elements can bbe described. This description may make global reference to Gestalt theory

(Rosch, 1973, 1978) or may include such dimensions as verticality, horizontality, or orthogonal symmetry, in a more analytical framework (Bornstein, 1981).

This experiment tests whether shapes can be ranked along a typicality scale. In other words, a classification task should show which elements are the least, and the most typical, for each category of shapes. Age should not be a significant differentiating factor.

Method

Materials: The children were presented two series of geometrical figures: series of triangles, and a series of quadrilaterals. These geometrical figures were varied so as to be more or less "well -balanced" or "good" shapes. The series of triangles was composed of an equilateral triangle, an isosceles triangle, a right-angled triangle and two different scalene triangles having identical areas. The quadrilaterals were composed of a square, a rectangle, a parallelogram, a convex quadrilateral, and a concave quadrilateral (having identical areas). Each figure was drawn on a 10 × 15 cm file card and centered carefully on the card.

Procedure and Instructions: The children were instructed to classify the polygons in each series. The instructions were worded as follows: "Look carefully at the five drawings in front of you. They are not the same. Show me the one you would pick first. Which one is it? After that one, which one would you choose?" etc. until none were left. The child's preference was thus associated with the typicality of the shape. This preference was assumed to be motivated by both emotional and perceptual and cognitive factors of categorial structuration. The hypothesis here was that the latter outweigh the former.

Subjects: The sample was composed of 60 children divided into two age groups of 30 children each (mean ages 5,6 and 4,1 respectively). Each child was tested individually. The experiment lasted between 5-10 minutes[2].

2. Particular thanks should be given to the primary school inspector of the Montvilliers area, the Head of the "Ecole Marius Grout" Mrs Ernoult, and Mrs Malthieux, the Head of the "Ecole des Jardinets". Gratitude should also be extended to Mrs Lemaitre, Mrs Paillette and Mrs Pestel for their assistance in assuring that these experiments could take place in ideal conditions.

Results

For each geometrical figure, the number of children in each group classifying a given figure in a given rank was computed (first rank, second rank ..... etc.). Geometrical figures were then tested two by two to determine whether a given figure X was chosen over a given figure Y. A Kendall Coefficient of Concordance (W) was used for calculating the association among sets of ranks for each age group and for each series of polygons. The Kendall W shows that there was agreement among subjects for degree of typicality of the five polygons in each series. These results are given below:

QUADRILATERALS (for K = 30, N = 5)		
5,6 year olds	: Ws = 704	p. < 05
4,1	: Ws = 936	p. < 05
TRIANGLES (for K = 30, N = 5)		
5,6 year olds	: Ws = 1054	p. < 01
4,6	: Ws = 715	p. < 05

Agreement across subjects was significant: the five polygons can be ranked over a typicality dimension. Secondly, in each series, scores for the two most extreme polygons in terms of typicality were tested (the equilateral *vs* right-angled triangles and the square *vs* concave quadrilateral). No significant difference was observed for the two age groups.

Discussion

As expected, natural categorization can lend itself to an investigation of shape categories. Different geometrical figures do not have an equivalent status, some are judged to be typical of their category with relative stability (square, equilateral triangle) whereas others are considered to be less typical (concave quadrilateral, right-angled triangle). The "good" shapes prove to be the focal elements of the formal categories. This trend, originally described by the Gestaltists, has received later formal support from experimental data such as Attneave (1957), Mendelson and Siu Ping Lee (1981). Bornstein's (1981) work shows that children exhibit a preference for symmetry as early as 12 months of age (see also Paraskevopoulos, 1968). Furthermore, among the shapes having a symmetrical axis, symmetry is preferred to verticality (Bornstein, Ferdinandsen & Gross, 1981). However, symmetry as compared to verticality is present in both of the figures that the subjects in this experiment judged to be typical. This may be because the typicality dimension used in this experiment in fact opposes symmetrical to

unsymmetrical patterns. But the lack of age-linked variation suggests that mastery of focal stimuli discrimination occurs at an early age. Thus it seems reasonable to assume that the representation of formal categories composed of figurative elements derived from perceptual information has an analogous structure for 4,1 and 5,6 year olds.

EXPERIMENT II

Experiment II consisted of a production task designed to analyze cognitive representations of four locative categories, in relationship to the typicality/non-typicality of the representation of the situational context. The four locative categories were "in", "above", "below" and "between". These categories were chosen because they correspond to a level of acquisition suitable to a 4-6 year old range; i.e., they fit with this age group's ability to situate a point on a precise location within a polygon.

The following hypotheses were put forward:

1. Cognitive development will result in progressive stabilization of the internal structure of categories. The different locations will therefore be more homogeneous in the 5,6 year olds that in the 4,1 year olds.
2. The internal structure of the locative categories will be associated with "contextual shape" and more specifically with the degree of typicality. Localizations will vary inversely with the typicality of shapes, i.e., the less typical the shape, the more varied the localization.

Method

Materials and Procedure: The production task materials were composed of a sub-set of the same materials used in Experiment I. This sub-set included the most typical and the least typical of each of the polygons chosen in Experiment I. These geometrical figures were each centered on a 21 × 15 cm sheet of paper, with an equal amount of space above and below each drawing. For the study of "between", the polygons were smaller but identical to the ones used in the first test. They were reproduced twice on the same sheet. The distance between polygons was identical for all the figures in the two series. The subjects were randomly presented with successive pairs of each polygon series. They were asked to place a cross either "in" the drawing, "above" it, "below" it, or "between" the two drawings. Each child was tested for all the polygons in both series and for one preposition chosen at random at a time. The

child was then requested to complete the same procedure for the remaining prepositions until all had been tested. The child was then given the other series of geometrical figures, using a different order of prepositions. Series order for geometrical figures was kept random. In total, each subject was thus requested to make 16 crosses (2 series × 2 polygons × 4 prepositions).

Instructions: The instructions given for the production task were the following: "You are going to put a cross "in" the drawing (or "above" ...) Where do you think you should put the cross?"

Subjects: The same subjects as in Experiment I were used. Each task was individual and lasted 5-10 minutes. All the subjects had a clear understanding of the prepositions employed thanks to prior in-class preparation by the teachers. The use of these prepositions is part of the traditional nursery school curriculum and are acquired through manual activities (color the star "over" the cross blue) or through gestures or physical activity (stand "between" Catherine and Sebastian).

Results

For each of the geometrical figures in the two series, and for each preposition, there was a range of 30 points for each age group. The quantitative measurement device constructed to test for typical representations took the following form:

— vectors were determined from an arbitrary location on the drawing. These were expressed as

$$\frac{\Sigma \overrightarrow{ODi}}{n} = \overrightarrow{OG}$$

where Di refers to the set of points (crosses) the children had marked, and G the center of gravity.

— Once G had been calculated, the index of dispersion was obtained for these points to locate their center of gravity. Low scatter here indicated a certain consensus for cognitive representation of locative categories whereas high scatter meant an absence of a common cognitive representation, or its fluctuation.

The dependent variable was the distance (D) for each subject from the center of gravity of the experimental group (defined by the intersection of

factors A and B, see below). The dependent variable was the direct expression of the range of score variability. In principle, the dependent variable should have used the square of this distance (since the total inertia of the scatterplot was obtained by the sum of the squares of these distances from the center of gravity of the scatterplot) however D rather than D^2 was used since the D^2 distribution tends to be skewed (it is a well-known fact that ANOVAs are robust to slight deviations from normality).

Tab. 1. — Distance from the center of gravity (cm) as a function of subjects' age and type of geometrical figure

type of geometrical figure	equilat. trig.		right-ang. t.		square		concave quad.	
prepositions	4.1	5.6	4.1	5.6	4.1	5.6	4.1	5.6
in	0,72	0,81	0,76	1	0,64	0,75	0,65	1,2
above	1,07	0,73	2,85	1,97	1,11	1,29	2,57	1,78
below	1,04	0,88	1,44	1,42	1,02	0,88	1,34	1,16
between	0,96	0,81	1,01	0,91	0,71	0,51	0,93	0,90

For each preposition, the data were analyzed in a S(A)*B ANOVA (with S = 30 subjects, A = 2 ages of the subjects, and B = the four types of polygons; A and B considered as fixed factors). The different hypotheses were expressed as a set of 3 orthogonal contrasts on the main effect of B. The first ($\psi 1$) opposed the typical polygons to the atypical (equilateral triangle and square *vs* right-angled triangle and concave

Tab. 2. — Main effects for each preposition

prepositions / sources	in	above	below	between
between subjects				
A	N S	F = 5,42 *	N S	N S
S	——	——	——	——
within subjects				
B	N S	F = 35,74 §§	F = 9,506 §§	F = 8,798 §§
$\psi 1$	F = 5,7 *	F = 102,44 §§	F = 25,77 §§	F = 12,97 **
$\psi 2$	N S	N S	N S	F = 8,98 **
$\psi 3$	N S	F = 4,7 *	N S	F = 4,42 *
A B	N S	F = 3,92 **	N S	N S
B S	——	——	——	——

* : $p < .05$ ** : $p < .01$ § : $p < .001$ §§ : $p < .0001$

quadrilateral); the second contrast ($\psi 2$) opposed the triangles to the quadrilaterals, and the remaining contrast ($\psi 3$) opposed the right-angled figures to "non right-angled figures"[3].

In almost all cases, the statistical trends were similar, regardless of preposition. More specifically, the average distance from the center of gravity was always shorter for the typical polygons (square, equilateral triangle) than for the less typical figures. Secondly, the average distance from the center of gravity was shorter for the 5,6 year olds than for the 4,1 year olds for the prepositions "above". Nevertheless, a non-significant trend was observed for the prepositions "below" and "between" (see Table 1).

Discussion

This finding is in line with the working hypothesis that the representation of prepositional meaning appears to be dependent on the representation of the situation or context. The more typical the context, the more typical the representation of the localization studied. The responses show little variation from the average focal representation. On the contrary, the less typical the shape, the less likely it was to produce a typical locative representation. This finding calls for two comments. First, it is appropriate here to consider a preposition or prepositional compound as a category of meaning which vary as a function of the representativity gradient. Some are high in typicality (as shown by agreement among subjects) whereas others are low in representativity (thus producing a wide range of responses). The obvious relationship between the prepositional representation and the situational context should also be stressed. The degree of typicality of a prepositional representation covaries with the degree of typicality of the geometric form. This points to the flexibility of the typical representation.

Contextual dependency may also be a function of the nature of the representation at hand. These representations are most likely dependent upon figurative features and it can be assumed that the perception of an axis of symmetry plays an important part in both formal and locative categorization (Erreich & Valian, 1979). This axis of symmetry, which is salient in the case of "good" figures, may have led the children to choose the most typical shapes, and in the case of the production task, to put a cross somewhere along this axis. However, the task is in reality more complex in the production task since it requires some sort of "mental

3. I am greatly indebted to Hervé Abdi who performed the statistical analyses.

materialization" of this axis. This helps explain why subjects have a tendency to cope better with this problem as they get older. Conclusions may also be drawn here as regards the role of the nature of the polygons on result variability. "Landmarks" are not necessarily equally salient in both cases.

General Discussion

All instances of a given category (perceptual, locative or semantic) cannot be assigned an equivalent status, contrary to the classical Aristotelian definition of categories. Certain preferred instances appear to be more representative. This is not a new finding, and several articles have already been devoted to this topic (Cordier & Dubois, 1981; Lakoff, 1982; Smith & Medin, 1981). The purpose of the present experiment was to examine the relationships between categorical structuring and context, which in the case of locative categories seems straightforward. Consensus among subjects, i.e., respective distance of average localizations from the center of gravity, is much higher in typical contexts. Does a similar relationship exist within the semantic field? This question will form the basis of future research (Cordier, 1985). This field merits thorough study since it serves to link categorical structure and functioning.

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