The role of featural variability in children's generalization of new concepts

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Abstract

When subjects are confronted with new stimuli and have to learn to categorize them adequately, they have to segment the stimuli into relevant features for categorization. In the experiments reported here, children had to discover a rule for categorization. A central question is whether children aged four or six who were able to discover the rule in a simplified version would generalize it to a "complex" version of the relevant features (i.e., in which there is more background noise) that they would be unable to learn before thirteen with no pre-training. The conditions promoting the generalization from the simple version to the complex were also investigated. Two conditions were compared: relearning with or without feedback. Results showed that children aged 4 and 6 could generalize the "simple" version of the target concept to more complex versions of the same concept, either with and without feedback in the generalization phase.

Introduction

During their development, children have to learn to categorize stimuli according to adults' standards. In order to achieve this correctly, they have to find the relevant features for categorization. If their particular task is to learn to categorize a set of new objects into two new categories, they will have to find the features that characterize the stimuli of each category and that distinguish them from stimuli of the other category. Thus, children, like adults, are presumed to formulate and test simple hypotheses concerning the rule that define membership. This means that participants will analyze stimuli into their dimensions and test whether each dimension partitions the set of stimuli. Various dimensions of the stimuli contribute to the difficulty of the task such as salience of dimensions: a non salient relevant dimension among salient irrelevant dimensions presumably requires more systematic analyses of the stimuli than a salient relevant dimension among non salient irrelevant dimensions.

Variability in the perceptual manifestation of a relevant feature can hinder this relevant feature and impede its discovery. For example, compare Figure 1A stimuli with Figure 1C stimuli which define two experimental conditions. In the two conditions, the stimuli come from two categories defined by the same relevant features. Each stimulus has four "legs", with one category being defined as 1 isolated leg and 3 connected legs (1+3), the other category being defined as "two sets of two connected legs" (2+2). In Figure 1C the length, shape, size of the legs were made more variable than the legs in Figure 1A. Preliminary results obtained by Thibaut (1997, 1999) indicate that the rule (1+3 vs. 2+2) could be discovered from the age of four in the case of Figure 1A stimuli whereas children under thirteen could not find the equivalent rule for Figure 1C stimuli. Figure 1B stimuli elicited intermediary results: most children aged ten discovered the rule.

Thibaut (1997, 1999) suggested that young children had problems either in screening the stimuli, or inhibiting irrelevant features, or plan systematic comparisons between stimuli. The purpose of the present contribution is to assess to what extent young children (four- or six-year olds) who discovered the relevant features for categorization 1+3 vs. 2+2 in the simplified version (Figure 1A) would be able generalize these features to more complex versions of the same features (Figure 1B and 1C). In other

words, once he/she has learned to apply a classification rule in a low variation context (such as Figure 1A stimuli), is a child able to apply it in a high variation context ?
Studies on generalization generally take a different perspective from the one followed here. Usually, children first learn a given concept, then they are presented with a set of new stimuli, the purpose being to analyze to which new stimuli participants generalize the concept. Here the issue is to analyze to what extent children who discovered a rule for categorization in a simplified context will be able to generalize it to more complex objects for which they would be unable to discover the rule if they had to discover it without being first presented to the simple version. This is important because a positive answer would mean that an appropriate learning sequence can lead to an understanding of concepts which, otherwise, would remain out of the scope of the child conceptual world.
Two generalization conditions will be compared. In the first one, children will be given feedback when they will learn to apply the simple rule to the complex stimuli. In the second condition, there will be no such feedback. It is believed that feedback will promote the understanding of the equivalence between the known simple version of the rule and its complex version. This is because, if young children do not perceive this equivalence at first glance, they can test different implementations of the simple rule in terms of the complex rule. Getting feedback at each trial, they have the opportunity to adjust their representation of the rule to the particulars of the new stimuli. In the no feedback condition, successive trials do not bring any information about children's successive hypotheses.

Experimental Design

Preliminary results (Thibaut, 1997) have shown that children under thirteen could not parse Figure 1C stimuli adequately. In the same way, children most of children under eight could not find the relevant feature for categorization in the stimuli displayed on Figure 1B. On the other hand, the majority of children aged four could find the relevant features 1+3, 2+2 in stimuli such as the ones displayed in Figure 1A. The purpose of the experiment was to assess whether children aged four and six who would find the relevant features for categorization in the situation displayed in Figure 1A would also be able to generalize them to the stimuli displayed in Figures 1B or 1C.

Methods

Participants. Fourteen 6-6.11 year olds participated in the complex transfer items with feedback condition, eleven 6-6.11 year olds participated in the complex transfer items with NO-feedback condition, fourteen 6-6.11 year olds participated in the semi-complex transfer items with feedback condition, fifteen 6-6.11 year olds participated in the semi-complex transfer items with NO feedback condition, eleven 4-4.11 year olds participated in the complex transfer items with feedback condition, twelve 4-4.11 year olds participated in the semi-complex transfer items with feedback condition and twelve 4-4.11 year olds participated in the complex transfer items with NO feedback condition. All children were tested individually.
Materials. The learning stimuli (simple stimuli) are presented on Figure 1A. The 16 stimuli were composed of four legs which were thin and vertical. There were eight 1-3 stimuli and eight 2-2. In this condition, the purpose was to remove salient irrelevant features for categorization. There were two sets of transfer stimuli, complex and semi-complex.
For the semi-complex transfer stimuli, a set of 16 stimuli was constructed. The irrelevant cues "thin" "vertical", "the rightmost leg pointing to the right", and "large" were crossed with the cues "one leg plus three legs" (1+3) and "two pairs of legs" (2+2) according to four types of stimuli. There were four 1-3 stimuli and four 2-2 stimuli with "thin" legs and "the rightmost leg pointing to the right", and four 1-3

stimuli and four 2-2 stimuli composed of "broad and vertical legs" (see Figure 1B for exemplars of the 4 types of stimuli).

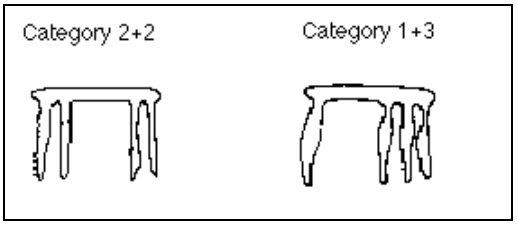

Figure 1A: two "simple" stimuli.

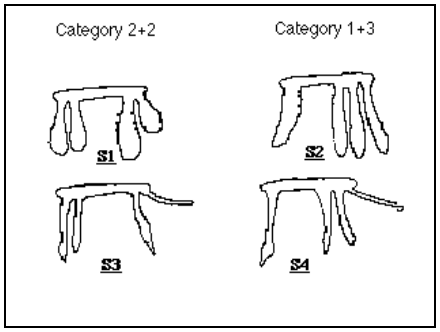

Figure 1B. Four semi-complex stimuli.

The complex transfer stimuli were outlines of unknown shapes composed of two parts, the upper part (the body) and the lower part (four legs). In five out of the eight stimuli, the body had a mushroom-like shape in the case of category 1+3, and an angular shape in the case of category 2+2 stimuli. These two shapes were perceptually salient. The three remaining stimuli from each of the two categories were constructed with three different bodies (UP1, UP2, UP3) which were present in both categories and, thus, could not be used as cues for categorization (see Figure 1C). Each stimulus lower part consisted of four legs spatially grouped either as one leg on the left and three legs on the right in category 1+3, or two pairs of legs in category 2+2 (see Figure 1C).

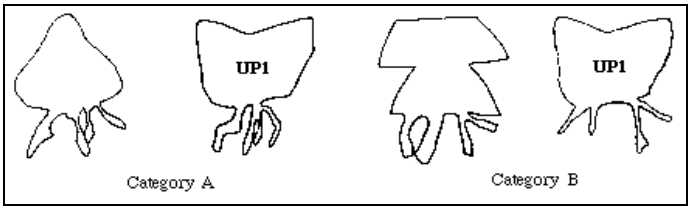

Figure 1C. Four complex stimuli from categories 1+3 and 2+2. The first stimulus has the upper part of category 1+3 and the third stimulus has category 2+2 upper part. The UP1 stimuli are neutral stimuli.

Procedure

Learning phase. Participants were presented with the simple version (Figure 1A) of the stimuli and received the appropriate feedback after each answer. The set of stimuli was presented until the child made no mistake during two successive presentations of the set of stimuli or after nine presentations.

Transfer phase. Once they had learned the rule for categorization for simple stimuli, children had to categorize the transfer stimuli. In the complex stimuli with feedback and in the semi-complex with feedback conditions, children were presented with the stimuli (complex or semi-complex) in the same way as in the learning phase. In the complex with NO feedback and in the semi-complex with NO feedback conditions, stimuli were presented. Children received no feedback after their classification. In these conditions, the learning criterion was the same as in the learning phase.

Table 1. Number of subjects who reached the criterion in the two age groups and the various experimental conditions: with or without training with simple stimuli and with or without feedback in the transfer phase

Condition	Four-year-olds		Six-year-olds	
	Correct	Failure	Correct	Failure
Complex stimuli (no training with simple stimuli)	0	10	0	10
Semi complex stimuli (no training with simple stimuli)	0	10	6	8
Training condition and transfer with complex stimuli and no feedback	1	11	6	5
Training condition and transfer with complex stimuli and feedback	4	7	9	5
Training condition and transfer with semi-complex stimuli and with feedback	9	3	12	2
Training condition and transfer with semi-complex stimuli and NO feedback	8	6	11	4

Results and discussion

The purpose of the experiment was to assess whether children who had first learn the rule for categorization with the simple stimuli would be able it to the semi complex or the complex condition when a feedback was provided or not. Results are summarized in Table 1. Chi square comparing data obtained in the control condition (no training with simple stimuli, Thibaut, 1997) with the new data (training with simple stimuli) revealed a significant difference in the majority of cases ($p < .05$), except in the "generalization to complex stimuli and no-feedback" and "generalization to complex stimuli with feedback" conditions with children aged four. In this condition, a majority of children failed to generalize correctly.

In sum, in a majority of conditions, training with the simple stimuli influenced generalization positively. This is important because, it suggests that people can generalize what they have learned before to situations that would have been beyond their learning without this training. However, this conclusion holds only for the generalization to semi-complex stimuli. In the case of complex stimuli, the majority of children aged six generalized to the complex stimuli, whereas most children aged four failed to generalize with these stimuli.

The results indicate that dimensional variability must be included in any model of concept learning. First, the probability that a relevant dimension will be discovered depends on the presence and the structure of the other dimensions (irrelevant) that compose the stimuli and, more specifically, that participate in the manifestation of the rule. Second, in order to understand whether or not a particular instance of a dimension will be discovered by children, one has to include the history of categorization of the participants. By history of categorization, I mean the categorizations already performed by an individual (see Schyns, Goldstone, & Thibaut, 1998; Thibaut & Schyns, 1995). The present data suggest that the history of categorization influenced positively the way children generalized the rule. To summarize, a model of categorization and generalization has to take selective sensitivity to a particular dimensions into account provided that this notion also incorporates the notion of variability in the instanciation of the dimension across stimuli. It must also incorporates the history of categorization

with a particular category in order to understand whether or not children are able to generalize a given dimension to new instances of this dimension. The present data show that knowing the history of categorization, one can predict whether a set of new stimuli is learnable. Complementary, one can predict which history of categorization is necessary to promote generalization to subsets of highly variable stimuli. This is particularly important given that, in a majority of cases, we do not encounter identical instances of the same category.

From an educational point of view, following the learning strategy used here, one can bypass the role of the salient irrelevant features that would mask the relevant features for categorization whereas starting with the complex stimuli would lead to the incorrect conclusion that young children are unable to abstract the rule for categorization.

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