How Can We Promote Generalization of Novels Concepts?

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Abstract

One major issue in education is generalization. In many learning situations, participants do not generalize beyond the situations in which they were trained or generalize to situations that are quite similar to the training phase. The purpose of the present contribution is to study conditions that would promote generalization in new concept learning situations. When subjects are confronted with new stimuli and learn to categorize them according to a rule, they have to segment the stimuli into relevant features for categorization. Our central question is to address the question of "history of categorization" that is whether a simplified version will help children to generalize to perceptually more "complex" versions of the relevant features they would be unable to learn with no pre-training with the simpler version.

The results indicate that 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 [5]. More generally, we want to argue for a conception of learning which promotes comparisons between instances and which conceives generalization as a constructive process rather than as an automatic process.

Introduction

During their development, children have to learn to categorize stimuli according to adults' standards. In the course of learning, students are confronted to the same purpose, at any age. In general, learning situations involve the necessity to learn a specified concept. This implies at least two things. The first is that children have to learn the concept. This can be established in different ways. The second is that they should be able to generalize it in new situations. In the case of categorization, learning a new concept should mean that they have to find the relevant features for categorization and apply it to new objects. 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 1B 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 1B the length, shape, size of the legs were made more variable than the legs in Figure 1A.
Thibaut [6] [7] 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 a more complex version of the same features (Figure 1B). 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 new stimuli, the purpose being to analyze to which new stimuli participants generalize the concept. Here, I 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.

Experimental Design

Preliminary results have shown that children under thirteen could not parse Figure 1B stimuli adequately. 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 Figure 1B.

Methods

Participants. Children aged 4;0 to 4;11 and 6;0-6;11 participated in the experiment. They 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. There were two sets of transfer stimuli, complex and semi-complex.

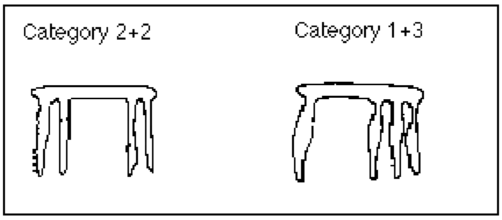

Figure 1A: two "simple" stimuli.

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 which were conceived to be perceptually salient. 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 1B).

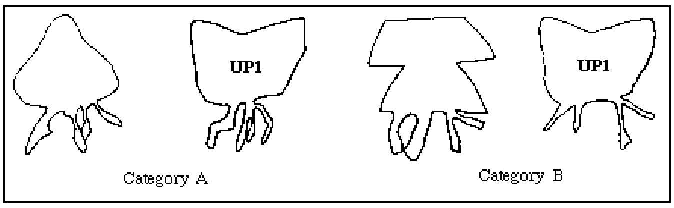

Figure 1B. Four complex stimuli from categories 1+3 and 2+2. The first stimulus has the upper part of category 1+3 and the third stimulus has category 2+2 upper part. The UP1 stimuli are neutral stimuli.

Procedure

Learning phase. Participants were presented with the simple version (Figure 1A) of the stimuli and received feedback, until they understood the rule.
Transfer phase. Once they had learned the rule for categorization for simple stimuli, children had to categorize the transfer stimuli.

Results and discussion

The dependent variable was the number of children who found the rule for categorization before the end of the learning phase for the complex stimuli. Chi square comparing data obtained in the control condition (no training with simple stimuli, with the new data (training with simple stimuli) revealed a significant difference ($p < .05$) for the six-year-olds. However, most children aged four failed to generalize correctly.

In sum, 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. Recall that children could not learn the rule before the age of 11 when there was no training phase.

The results indicate that dimensional variability must be included in any model of concept learning. 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. In other words, in many situations, salient irrelevant features must be inhibited in order to find the feature relevant for categorization. Also, when the first hypothesis must be abandoned, children must be flexible to find new hypotheses, that is they have to rely on their executive functions (see [3] [8], for a discussion of the role of inhibition and flexibility in the similar context of analogical reasoning, and [9], for a discussion of the role of perceptual features and conceptual features in categorization).

How comparison can boost conceptual generalization rather than perceptual generalization.

As a second case, we want to stress the importance of comparisons during learning. Gentner, Namy and colleagues [1], [2] have demonstrated that comparisons between similar items belonging to the same category (i.e., having the same name) will lead children to conceptually based generalized, whereas "no comparison" situations will promote perceptually-based generalizations. For example, Namy and Gentner [2] compared a "no comparison" condition in which they introduced a bicycle and gave them a novel name. Then, children were shown two stimuli, one perceptually similar to the bicycle but belonging to another category (glasses) and another stimulus belonging to the same category but perceptually different (rollerblade). In the comparison condition, children were shown a bicycle and tricycle (with the same novel name) and then the same glasses and rollerblade. In both cases, they to select another object with the same name among the two transfer objects. In the "no comparison" they chose the perceptually similar object whereas in the "comparison" condition they chose the taxonomically related object (rollerblade). This suggests that comparison promotes the discovery of deep commonalities that are used for generalization.

General discussion

We suggested that, 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 (see [5] [6] [7]).

The present data suggest that the history of categorization influenced positively the way children generalized the rule. Following this, 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.
Another important point is the role of comparison which promotes conceptual generalization, rather than perceptually-based generalizations. 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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Acknowledgment

The authors wish to thank the “Conseil Régional de Bourgogne-Faber Program” for their financial support.