Pre-linguistic category formation in infants

Tamami Sudo (sudo@brn.dis.titech.ac.jp)
Department of Computational Intelligence and Systems Science
Tokyo Institute of Technology, Yokohama, Japan
Sony Computer Science Laboratories, Inc.
Tokyo, Japan

Ken Mogi (kenmogi@csl.sony.co.jp)
Sony Computer Science Laboratories, Inc.
Tokyo, Japan

Abstract

It is known that infants are aware of the category of objects in daily life before explicit vocabulary acquisition starts (Eimas and Quinn 1994). Infants are able to recognize the various types of "cars" in real life situations as well as in symbolic representations such as pictures, as belonging to a single category. Even though attributes such as color, texture, size are not the same for these images, infants are able to perceive them as cars. It has been suggested that the ability of categorization is a meta-knowledge tightly coupled with an infant's language acquisition (Nazzi and Gopnik 2001), and is likely to play an essential role in its overall cognitive development. In addition, pre-linguistic categorization is likely to play a central role in linking language processing to the more general cognitive processes. In this study, we conducted a series of experiments to investigate the process of such a categorization in an infant's pre-linguistic development.

Introduction

The human linguistic system is complex and arbitrary. Nevertheless young children become fluent speaker of the native language in a short period. Acquiring this complex linguistic system in a fairly short time is an absolute marvel, reflected in the characteristic human cognitive development (Obler & Gjerlow, 1999). It has been known that young children are able to master the use of the native language without any special training. An environment where they can participate in the usual social exchange is sufficient. During the development in the period from 1.5 to 6 years after birth, infants add new words to their vocabulary at an average rate of 8 words a day. In this period, the infants aren’t provided with a definition of the meaning or the usage of the new words. Infants learn by an inference from the conversations that they encounter.

It is unacceptable to explain the learning of language in a way that is dependent on a solid and formal acquisition of each word. If the acquisition of the name of an object is done in a one by one examination of the unique properties of the objects in relation to all the other objects in the world, vocabulary acquisition should take an enormous time. It is a logical impossibility to make reasonable inferences from only a limited amount of information on the objects that a particular word is apparently referring to. Despite these seeming theoretical impossibilities, children can acquire a particular meaning from the enormous possible set of meanings of the words referring to the objects (Soja, Carey & Spelke, 1991).

Role of Cognitive Constraint

At least one thing is clear in the children’s word learning. When children listen to a new word, they never explore the whole domain of the logically possible meaning of the particular word in question. In the majority of cases children “guess” the meaning of the words which they listen to for the first time and assign a temporary meaning to that word after making proper reasoning. Such a temporary assignment of the meaning of the word has been called "fast mapping" (Carey & Bartlett, 1978).

As a possibly effective method of dissolving the apparent difficulty in coming to an understanding of an infant’s language acquisition, and accounting for the seemingly effortless way in which children conduct fast mapping, recently the concept of cognitive constraint (Carey & Bartlett, 1978) has entered the mainstream approach.

The cognitive constraint here refers to the conceptual scheme that children retain internally when they encounter a new word. The cognitive constraint effectively narrows the range of search that needs to be done in the acquisition of new words (e.g., Markman & Hut
cinson, 1984; Landau, Smith & Jones, 1988; Markman & Wachtel, 1988; Markman, 1989; Taylor & Gelman, 1989; Hall, 1991; Clark, 1993). This concept is introduced in a marked contrast with the philosophy of behaviorist psychology in which children’s learning and development are attained through the inputs and feedbacks from the outside. The cognitive constraints are
metaphors with which the cognitive linguists try to account for an infant’s inherent ability of language development in the pre-linguistic period.

The specific nature of the cognitive constraint that has been advocated up to the present can be classified roughly into the following two classes. One is the knowledge on how a word can be made to represent a general concept. Another is the knowledge on the structure of the vocabulary such as what kind of meaning a word can possibly have.

It is known that infants are aware of the category of objects in daily life before explicit vocabulary acquisition starts (Eimas & Quinn, 1994). Infants only a few months old are able to separate complex visual stimuli into generic object categories (e.g. Quinn & Eimas, 1996). For instance, infants are able to recognize the various “cars” - pictures of cars in books, real cars running on the street etc., as belonging to a single category. Even though the various attributes such as color, texture, size are not the same for a real car and a picture car, they are able to perceive them as belonging to a single category. As a result of this categorization process, children as young as 30 months old can markedly differ in their abilities at the perceptual level (Gelman & Markman, 1986, 1987). It has been suggested that the ability of categorization is a meta-knowledge tightly coupled with an infant’s language acquisition (Nazzi & Gopnik, 2001), and is likely to play an essential role in its overall cognitive development. For example, a familiar object such as an apple can take various forms, when it is cut and dressed. The child is apparently able to recognize these physically different entities as belonging to the same category.

Based on the hypothesis that knowledge for the perceptual category representations of objects exists before explicit verbal ability appears (Eimas & Quinn, 1994; Gelman & Markman, 1986; Stager & Werker, 1997), we conducted a series of experiments in order to understand the process of such a categorization in an infant’s pre-linguistic development.

**Experiment 1: Phonological Association Task**

When infants in the pre-linguistic period encounter various situations where the usage of language is involved, how do they make the word-object association? In order to clarify this point, we conducted a series of experiment as will be described in further detail below.

**Method**

**Participants** Twelve 12 to 20 months - old infants participated in the study. (The younger group: M = 14 months, range = 12m1d-14m19d. the elder group: M = 18 months, range = 16m3d-20m17d). They were volunteers from the Early Development Activity Center, Sony Foundation for Education, Tokyo.

**Procedure** The Infants sat in a reclining seat facing two monitors (size: 30cm x 40cm), positioned at a distance of 150 cm from the infants. The infant’s mother was present in the same room. As the two monitors simultaneously displayed two different pictures, the name of one of the objects were given as an auditory stimulus. Each pair of pictures was presented for 10 seconds. 10 trials were conducted. By measuring the mean looking time, we investigated the ability of the infants to generalize over image variations in associating the images with audio stimulus.

**Stimulus Design** Pictures of an apple were presented in one of the monitors, while other objects were presented in the other monitor. The objects were tuned in the salient features such as color, form, and size. The apple was given either as a whole, cut half, or dressed as a rabbit.

<table>
<thead>
<tr>
<th>Table 1: Stimulus Objects Used in Ex. 1.</th>
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<tbody>
<tr>
<td>Target category (apple)</td>
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<tr>
<td>Whole apple photo</td>
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<tr>
<td>Whole apple picture</td>
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<tr>
<td>Half apple photo</td>
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<td>Whole apple photo</td>
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<td>Half apple photo</td>
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<tr>
<td>Whole apple photo</td>
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<tr>
<td>Whole apple picture</td>
</tr>
<tr>
<td>Rabbit-shaped apple photo</td>
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<tr>
<td>Rabbit-shaped apple photo</td>
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<tr>
<td>Rabbit-shaped apple picture</td>
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</tbody>
</table>

**Results and Discussion**

A repeated-measure ANOVA with pairing objects (apple vs. other) revealed a significant difference (the younger infant group: F (1, 38) =3.336, p=0.076, the elder infant group: F (1, 18) =36.05, p<0.001, total: F (1, 58) =16.11, p<0.001), while no significant effect of the physical shape of the apple was observed. This result is consistent with the interpretation that the infant is able to recognize the physically different forms of apple as belonging to the single category, even before explicit, verbal ability emerges.
The experiment is based on a preferential looking paradigm, and does not address the explicit abilities of the infants to use the acquired category in a linguistic or pre-linguistic context. With that limitation in mind, these results are consistent with the interpretation that the infants are apparently able to perceive physically different objects as belonging to a single category of an “apple. These results are also indicative of the developmental process in the infants to perceive the various objects in the environment as belonging to specific categories.

This experiment alone does not tell us how the infants are able to conduct this pre-linguistic categorization. There could be two major ways of realizing the categorization. Firstly, the infants could use the perceptual similarities between the various forms of apple. Even when the apple is cut in half or dresses as a rabbit, there are visual similarities (such as the color or the texture) that the infant could utilize in the categorization process. Alternatively, the infants can use the single auditory label (“an apple”) as common to the various appearances of an apple. The first strategy is more perceptually based, whereas the second strategy is tightly coupled with the linguistic maturity to come. The infants could utilize these different strategies to a varied extent at different stages of development.

In order to clarify this point, we conducted a second series of experiments, where we presented two different age groups of infants with several pictures of different objects in a contingent context.

### Experiment 2: Visual-Pairing and Naming Task

In this experiment, we investigated whether there are significant changes of the ability for categorization and naming in formative stage. The key question was whether the infants depended on visual information or linguistic information when they perceived the different forms of an object (e.g. apple) as belonging to the same category.

#### Method

**Participants** Two groups of infants (n=14) aged round 14 months (M = 14m5d), and 20 months (M = 19m16d) participated in the study.

**Procedure** Each infant was tested individually. The infant was seated on a mother’s lap across a table from the experimenter. The experiment consisted of two stages, the habituation phase and the test phase. In the habituation phase, the infants were presented with pictures of an apple. In the test phase, the experimenter showed the pictures that are different from the one used in the habituation phase though they are in the same context. The experimenter presented the infants with pairs of pictures (e.g., an apple, a car, a rabbit, a cat) and asked them a series of questions. In the visual-pairing task, the question (in Japanese) was “Kore to onaji mono wa dotti?” [Which is the same thing as this?]. In the naming task, the experimenter asked (in Japanese) “’Ringo’ [object’s name] wa dotti?” Which is (an) apple?]. The infants answered by pointing to a picture. Both of these procedures were repeated for the seven sets of pictures presented.

#### a.

![Habitation phase](image1)

“Which is ?

[Picture of apple]

#### b.

![Habitation phase](image2)

“Which is an apple?”

[Picture of apple]
Results and Discussion

The results of the visual pairing task and the naming task were analyzed separately. For each trial, infants were given a score of 1 when they chose the correct object, and a score of 0 when they chose the other. Mean total scores per age and task are given in Table 2. Repeated-measure ANOVAs were conducted to determine whether infants were choosing the correct picture significantly above the chance level. In the visual-pairing task, these analyses revealed that infants of the younger group were responding at chance (M = 3.50, SD = 3.14, F (1, 14) = 0.00, P = 1.00), while infants of the elder group were responding above chance level (M = 4.83, SD = 0.17, F (1, 10) = 64.0, P < 0.001). In the naming task, significantly high correct rates above chance were revealed in both the younger group (M = 5.25, SD = 1.36, F (1, 14) = 18.05, P < 0.001) and the elder group (M = 5.83, SD = 0.57, F (1, 10) = 57.65, P < 0.001).

Table 2: Mean Numbers of Correct Responses.

<table>
<thead>
<tr>
<th>Age</th>
<th>Visual</th>
<th>Naming</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 months</td>
<td>3.50</td>
<td>5.25</td>
</tr>
<tr>
<td>20 months</td>
<td>4.83</td>
<td>5.83</td>
</tr>
</tbody>
</table>

Table 2: Mean Numbers of Correct Responses.

Figure 4: Percent correct responses according to age

It is expected that an apple would be a familiar object in the life of the participating infants, although no explicit questionnaire was conducted. Dressing the apple as a rabbit is a widely conducted custom in Japanese households, e.g. when the infants bring their lunch to the nursery or the kinder garden. Therefore, we can assume that an apple would be a fairly familiar object to the infants by these ages.

The marked difference in the correct rate for the visual and naming tasks are interesting. These results are consistent with the interpretation that infants give priority to linguistic information over the visual information when the presented stimuli are well known to them.

Conclusions

We have described a series of experiments aimed at clarifying the ability of categorization in infants. The results are consistent with the interpretation that the infants are able to judge objects of different visual appearances as belonging to the same category, even before explicit language usage starts. It is therefore suggested that categorization of familiar objects precedes explicit language abilities, and is probably tightly coupled with the language development process itself. It has been much debated whether children weigh shape similarity more heavily than conceptual similarity, invisible to the eye, such as taxonomic relatedness or functional commonality (e.g., Soja, Carey & Spelke, 1992; Gelman, Coley & Gottfried, 1994). Through several developmental phases, conceptual similarity seems to take precedence over shape similarity. On the other hand, it is possible that the infants apply both of these principles to word-object association and perceptual categorization as the situation demands. The higher correct rate for the naming task compared to the visual task in experiment 2 is consistent with the interpretation that infants are more conceptually driven than visual driven in the judgment of categories.

The ability to identify as belonging to the same category objects which bears no or little resemblance, and to judge objects which bears a strong resemblance to each other as belonging to different categories, are formed through the stages of the development (Gelman & Markman, 1986, 1987). The understanding of the concept of identity plays the prominent role in perceptual categorization.

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References


