Development of Taxonomic Organization of Named and Pictured Categories

Barbara Tversky
Stanford University

A shift toward a taxonomic basis for organization of both named and pictured objects was demonstrated in children 3, 4, 6, and 8. On each trial, a child was shown or told to think about an anchor object and two alternative objects, one sharing a perceptual feature and the other from the same superordinate category. Children were asked which alternative goes better with the anchor, and why. After completing the set of trials, the children were presented with them again and asked if the unselected alternative could also go with the anchor, and if so, why. For both pictured and named objects, the youngest children used and justified both perceptual and taxonomic groupings. With age, children came to prefer taxonomic organization and also became increasingly aware of both possibilities. The only effect of depletion was to facilitate articulation of perceptual justifications. Thus, perceptual organization in young children cannot be attributed to an inability to ignore visual information but seems to be based on the centrality of perceptual features to the representation of objects.

One of the significant cognitive changes to occur at about the age of schooling is a shift in the basis preferred for organization of concepts (e.g., Bruner, Olver, & Greenfield, 1966; Kagan, Moss, & Siegel, 1965; Meltzman, Deutsch, 1977; Meltzman, Tversky, & Baratz, 1981; Perlmutter & Rickis, 1979; Sharp, Cole & Lave, 1979; see review by Markman & Callanan, 1984). During the nursery school years, children frequently group objects by concrete properties, putting together objects that share color or shape, rather than objects that share only function or other abstract features. So, young children will group an apple with a ball rather than with a banana because both are round or they will group a tomato with a fire engine rather than a cucumber because both are red. Perceptual features are used in grouping tasks in spite of the fact that children at this age often know the superordinate categories and can be induced to use them effectively in a variety of tasks (e.g., Kohasigawa & Middelton, 1972; Moely, 1977; Steinberg & Anderson, 1975). Thematic rather than taxonomic groupings are also common at this age (e.g., Smiley & Brown, 1979). For instance, children will group a spider and a web together, rather than a spider and a beetle, because a spider and a web share a thematic relation. Both perceptual and thematic organization have a basis in the visual world: perceptual grouping on salient visual features, and thematic groupings on familiar visual scenes. Taxonomic grouping, in contrast, is based on shared function or shared superordinate category.

Although this taxonomic shift is reliable enough to be used as a classroom demonstration, the reasons for this dramatic shift in organization remain controversial. All of the previous experiments have used pictures of objects; some have argued that young children are unable to suppress the visual information regarding color and shape in favor of the more valid, functional information that category membership provides (e.g., White, 1983). Some support for this position comes from a study comparing thematic and taxonomic
sorting. In a typical sorting task, children are presented with a number of objects or pictures of objects and are asked to put together the ones that belong together. Markman, Cox, and Machida (1981) reasoned that children may believe that the spatial arrangement of objects per se has significance, so that the request to group objects on a spatially extended surface may require conceptual reorganization. These researchers extended the extent of thematic sorting in preschoolers by having them sort the objects into transparent bags. Thus, young children made more taxonomic groupings rather than thematic groupings when visual support for thematic groupings was reduced. Although both perceptual grouping and thematic grouping are early forms of organization preferred to taxonomic grouping, they differ in that in perceptual grouping, the objects share features (albeit concrete ones), but in thematic grouping the objects share a relation but do not typically share features (see Markman, 1981).

At the same age that children prefer thematic or perceptual organization to the taxonomic organization preferred by older children, children demonstrate no difficulty whatsoever in differentiating objects into basic level categories in the same manner as older children and adults. Different instances of basic level categories, such as shoes, chairs, and cars, share both perceptual and functional features (Rosch, Marvin, Gray, Johnson, & Boyes-Braem, 1976; Tversky & Hemenway, 1984). Although perceptual and functional properties of objects converge at the basic level, they diverge at a more abstract, superordinate level. Superordinate categories rarely share perceptual properties but do share function (Tversky & Hemenway, 1984; Rosch et al., 1976; Smith, Balzano, & Walker, 1978); for instance, vehicles are used for transportation, musical instruments to make music. When children group different objects by perceptual rather than functional criteria, they seem to be attempting to form superordinate categories by the process of vertical pruning. Although the vertical pruning is relatively easy to draw two different objects so that they have the same shape, it is more difficult to elicit similar shapes from just the names of objects. Presuming identical that shape similarity was more available when the objects were also approximately the same size (e.g., cherry, button).

Proceedure

Each subject accompanied the experimenter to a quiet room near the classroom. In the verbal condition, the experimenter said: "We are going to play a game of what things go with other things. I'll say the name of something, like 'doll,' then I'll say two other things, like 'dress' and 'bed.' Your part in the game is to tell me what you think goes best with the doll, a dress or a bed."
Table 1  Stimuli Used in Determining Grouping Preferences

<table>
<thead>
<tr>
<th>Anchor</th>
<th>Perceptual Taxonomic</th>
</tr>
</thead>
<tbody>
<tr>
<td>snake</td>
<td>boar (long)</td>
</tr>
<tr>
<td>plume</td>
<td>clock (round)</td>
</tr>
<tr>
<td>bell</td>
<td>rope (long)</td>
</tr>
<tr>
<td>ball</td>
<td>hand (round)</td>
</tr>
<tr>
<td>cucumber</td>
<td>flashlight (cylindrical)</td>
</tr>
<tr>
<td>carrot</td>
<td>radish (pea)</td>
</tr>
<tr>
<td>cherry</td>
<td>button (round)</td>
</tr>
<tr>
<td>screwdriver</td>
<td>pencil (long)</td>
</tr>
<tr>
<td>lettuce</td>
<td>frog (green)</td>
</tr>
<tr>
<td>bear</td>
<td>chocolate (brown)</td>
</tr>
<tr>
<td>lips</td>
<td>tomato (red)</td>
</tr>
<tr>
<td>lemon</td>
<td>sun (yellow)</td>
</tr>
<tr>
<td>fire engine</td>
<td>apple (red)</td>
</tr>
<tr>
<td>beans</td>
<td>grass (green)</td>
</tr>
<tr>
<td>strawberry</td>
<td>blood (red)</td>
</tr>
<tr>
<td>turtle</td>
<td>avocado (green)</td>
</tr>
</tbody>
</table>

Let's try that one for practice; what goes better with the doll, a dress or a bed? Once the subject had made a selection, the experimenter responded with, "Good, why do you think the (selected object) goes better with the doll?"

After the subject's response, the experimenter presented a second practice item (desk; chair; lamp). The procedure for the pictorial condition was identical, except that the subject was asked questions about the objects instead of naming them, and the instructions were appropriately modified.

The stimulus list was presented twice to each subject. For the first presentation, the experimenter presented the stimuli in random order and in the same manner as the two practice items. On half the trials, the taxonomic alternative was presented first, and on half the trials, the perceptual alternative was first. The sequence of alternatives was randomized for half the subjects in each age/sex group, and mirror image sequences were presented to the other half of the subjects. For each trial in the second presentation, the experimenter asked, "Before, you said you liked the (selected object) better with the (anchor object). How about the (mirror image) object? Could it go with the (mirror object) too?" After the subject's answer, the experimenter asked, "Why do (don't) you think so?"

Results

Children's first and second choices and justifications were recorded. Justifications were coded as perceptual when they referred to a shared perceptual characteristic, typically shape or color. They were coded as taxonomic when they referred to the name of the superordinate category or to a common function (e.g., "you eat them," "you drive them."). This proved to be a liberal classification of taxonomic choices because of the prevalence of items that could be called food, and the salience of that category for growing children.

In fact, the younger children answered "they're both food" and "you eat them" very frequently, whereas older children tended to answer, "In a more adult fashion, they're both fruit" or "they're both vegetables." These categories were by no means exhaustive. There were a number of "don't knows" or failures to respond as well as a number of ad hoc justifications, especially among the younger children.

For instance, one child said the carrot went better with the ruler than with the peas "because the ruler measures the carrot." Another child said the fire engine goes with the car than with the apple "because the fire engine pulls the car when it's broken." These justifications were not categorized as either perceptual or taxonomic.

The question was asked of the first-trial taxonomic choices with appropriate justifications. The third analysis of first-trial perceptual choices, appropriately justified. The fourth analysis was of the extent of justified changing of organization from the first trial to the second trial. Thus, to be counted, the child had to make a taxonomic choice and justify it taxonomically on one trial and make a perceptual choice and justify it perceptually on the other trial. The order of selection was irrelevant. The justification criteria was adapted because several of the younger children automatically responded "yes" or "no" to the second trial question ("Can the [unselected object] also go with the [anchor object]?"), giving explanations like "it's a car" or "it can" or "it can't." In all four analyses, condition (pictorial vs. verbal), age, sex, and perceptual feature (shape vs. color) were treated as main effects. Sex was not a significant factor in any of the analyses.

Table 2 reports the mean taxonomic choices by age, presentation condition, and type of perceptual feature. Taxonomic choices increase with age, F(3, 144) = 27.78, p < .0001, and were slightly higher when the alternative organization was based on shape than on color, F(1, 144) = 16.19, p < .0001. The tendency to make more taxonomic choices when shape was the alternative was slightly stronger when presentation was pictorial: perceptual feature type by presentation condition F(1, 144) = 6.09, p < .01. This result is small and disappears when the three-year-olds are eliminated from the data.

From the age of 6, in each condition, children's preferences for taxonomic grouping differ significantly from chance responding (p < .003 by t tests). Before the age of 6, children's choices do not differ from chance responding except in two cases: 3-year-olds prefer group by color rather than category in the pictorial condition (t = 2.83, p < .01), and 4-year-olds prefer group by category rather than shape in the pictorial condition (t = 4.35, p < .001). Thus, although there is no overall effect of pictorial as opposed to verbal presentation, in this study there was some evidence for weak local effects, namely inhibition of taxonomic versus color groupings for 3-year-olds and facilitation of taxonomic versus shape groupings for 4-year-olds. In light of the absence of global effect and of the conflicting nature of the local effects, it seems unwise to base conclusions on these findings.

Table 3 displays the mean justified taxonomic choices by age, presentation condition, and perceptual feature. Justified taxonomic increases with age, F(3, 144) = 81.35, p < .0001. The only other significant effect is the interaction between the presentation condition and the perceptual feature, F(1, 144) = 0.43, p < .05. For verbal presentation, there are more justified taxonomic choices when the alternative is color than when the alternative is shape; the opposite holds for pictorial presentation. This effect is small and vanishes without the three-year-olds.

Table 4 presents the number of justified perceptual choices by age, presentation condition, and type of perceptual organization. Justified perceptual choices decrease with age, F(3, 144) = 7.59, p < .0001. The percentage of perceptual choices that are justified, of course, increases with age, but the number of perceptual choices decreases with age. Perceptual justifications are more prevalent for color choices than for shape choices, F(1, 144) = 25.50, p < .0001, but this is primarily due to color justifications: perceptual type by presentation condition F(1, 144) = 6.15, p < .01. In the pictorial presentation,
perceptual justifications start at a high level in the youngest children and decrease with age. In the verbal condition, perceptual justifications are at a low level at age 3, increase at age 4, and decrease thereafter.

Thus, although the choices of 3- and 4-year-olds did not differ from chance responding for the most part, the justification data indicate that not all of the youngest children’s responses were random. In fact, 37% of the 3-year choices and 56% of the 4-year selections were appropriately justified. The percentage of justified responses increased with age so that 78% of the 6-year selections and 87% of the 8-year selections were appropriately justified. In the 4-year-olds, the percentage of justified choices was greater for perceptual choices (61% for verbal presentation and 73% for pictorial presentation) than for taxonomic choices (50% for verbal presentation and 46% for pictorial presentation). This was also true of the 3-year-olds with pictorial presentation, but not with verbal presentation. In the older groups of children, the percentage of justified taxonomic choices exceeded the percentage of justified perceptual choices in all conditions.

Finally, Table 5 contains the mean number of justified organization shifts from first to the second trial. These increase with age, $F(3, 144) = 39.20, p < .00001, \text{with pictorial presentation}, F(1, 144) = 23.02, p < .00001, \text{and with grouping by color}, F(1, 144) = 42.08, p < .00001. The increase in organization shifts with age is slightly larger for color than for shape; perceptual feature by age $F(1, 144) = 3.33, p < .05$; this increase in shifts with color and age is slightly stronger for verbal than pictorial presentation: feature type by age by presentation condition $F(1, 144) = 3.13, p < .05$.

To summarize, for all four dependent variables, age was a highly significant factor. The number of taxonomic choices, the number of justified taxonomic choices, and the plasticity of grouping increased with age, whereas the number of justified perceptual choices decreased with age. There were no consistent effects of perceptual feature, color or shape, on degree of taxonomic responding. The presentation condition, pictorial or verbal, had no consistent effect on number of taxonomic choices or on the number of justified taxonomic choices. Pictorial presentation facilitated articulation of perceptual justifications, particularly of color, and particularly by the 3-year-olds. Pictorial presentation also affected organizational flexibility, particularly in the older children. Because these children grouped and justified taxonomically on the first trial, the effect of pictorial presentation on the older children was to facilitate perceptual justifications on the second trial.

**Discussion**

Patterns of grouping objects from age 3 to age 8 were almost identical for objects presented as pictures as for objects referred to by name, indicating that both forms of presentation tap the same underlying representation of the objects in memory. Young children group common objects both by perceptual features of the objects and by taxonomic category when the objects are referred to by name only as well as when represented by pictures displaying the relevant properties. By six years, perceptual grouping has diminished considerably in both presentation conditions. These ages concur with ages obtained for the taxonomic shift in other studies using pictorial stimuli of common objects. Preschoolers frequently prefer to group objects by the perceptual features underlying basic level categorization, whereas school-age children prefer object groupings based on the conceptual features underlying superordinate categorization (e.g., Bruner et al., 1966; Melkman et al., 1981).

Unlike thematic organization, then, organization by perceptual features does not depend on the presence of spatial or visual support for its execution. Justifications for grouping, like other metacognitive knowledge (Flavell, 1978), lag considerably behind grouping behavior. Among the 3- and 4-year-olds, fewer than half of their taxonomic choices were justified appropriately. Some of their justifications were perceptual, such as grouping a teapot instead of a clock) with a plate because “they’re white” or “they’re made of glass” or even “they’re both the same, almost round.” Other youth’s justifications for taxonomic choices were thematic, such as grouping a saw (rather than a pencil) with a screwdriver because “the saw and the screwdriver are the same” or even “they’re both the same.” Other youth’s justifications for taxonomic choices were thematic, such as grouping a saw (rather than a pencil) with a screwdriver because “the saw and the screwdriver are the same” or even “they’re both the same.” Other youth’s justifications for taxonomic choices were thematic, such as grouping a saw (rather than a pencil) with a screwdriver because “the saw and the screwdriver are the same” or even “they’re both the same.” Other youth’s justifications for taxonomic choices were thematic, such as grouping a saw (rather than a pencil) with a screwdriver because “the saw and the screwdriver are the same” or even “they’re both the same.” Other youth’s justifications for taxonomic choices were thematic, such as grouping a saw (rather than a pencil) with a screwdriver because “the saw and the screwdriver are the same” or even “they’re both the same.” Other youth’s justifications for taxonomic choices were thematic, such as grouping a saw (rather than a pencil) with a screwdriver because “the saw and the screwdriver are the same” or even “they’re both the same.” Other youth’s justifications for taxonomic choices were thematic, such as grouping a saw (rather than a pencil) with a screwdriver because “the saw and the screwdriver are the same” or even “they’re both the same.” Other youth’s justifications for taxonomic choices were thematic, such as grouping a saw (rather than a pencil) with a screwdriver because “the saw and the screwdriver are the same” or even “they’re both the same.”
information about function and subordinating category is added to the information about appearances of objects (Harré, 1982) so that both forms of organization become available. If both taxonomic and perceptual forms of organization are available, and if perceptual features are as accessible as more abstract features, and perhaps more so, then why is there a shift toward reliance on abstract features for grouping? Acquisition of knowledge does not seem to explain the entire phenomenon. In retrieval tasks, taxonomic features are more effective than perceptual features at all ages (e.g., Kobasigawa, 1977; Lange, 1978; Melkm-an, et al., 1981), presumably because of their greater validity. Grouping, however, is an encoding task, where objects are presented and features or relations of them extracted as a basis for organization. During the early school years, children become more active and strategic in many cognitive tasks (e.g., Brown, 1975; Flavell & Wellman, 1977; Neisser, 1976) and come to suppress immediate, salient responses in favor of slower, more advantageous ones (White, 1965). Among the strategies acquired is that of encoding information into memory in anticipation of retrieval, of organizing information in storage in order to facilitate using it at some later time (Gordon & Flavell, 1977; Tversky & Teifler, 1976). These studies, together with the present results, suggest that the shift toward taxonomic organization seems to depend on the one hand, on acquisition of knowledge, of enriching representations of objects to include functional and taxonomic information as well as perceptual information, and on the other hand, on acquisition of strategies, of encoding in anticipation of retrieval.

References