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COMPARING DIMENSIONAL CATEGORIZATION IN NATURAL AND ARTIFICIAL CONTEXTS: A DEVELOPMENTAL STUDY AMONG THE ZINACANTECOS OF MEXICO*[1]

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SUMMARY

This study of cognitive processes among the Zinacantecos of Southern Mexico focused on the role of familiarity and cultural relevance in the development of categorization behavior. The major findings were as follows:

1. The ability to use verbal concepts in sorting and resorting an array of objects developed with age in both schooled and unschooled Zinacantecos.
2. No aspect of sorting behavior showed a positive effect of familiarity of object domain. On the contrary, grouping and regrouping familiar objects (flowers) by color sometimes was done more poorly than grouping and regrouping unfamiliar objects (rods) because of the irrelevance of the color dimension to flower bouquets in the context of Zinacanteco culture. Flower sellers, moreover, did not sort flowers better than other subjects.
3. Although the species dimension is relevant to categorizing the culturally familiar flowers, its use as a basis for grouping developed after all other dimensions used in the experiment—color, length, and

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circumference—probably because of its multidimensional perceptual qualities.

A. Introduction

In cross-cultural research on cognition, there has been a great deal of interest recently in the effect of familiar or culturally relevant materials on performance in categorization tasks. This interest reflects the proposition that the complex category system possessed by every culture for organizing the world should be manifest in the categorization behavior of individuals. The argument continues that these conceptual skills may fail to manifest themselves in an experimental situation because of being assessed with culturally inappropriate materials. While a number of studies have used both familiar and unfamiliar materials in testing various aspects of concept formation and use (3, 6, 7, 8, 10), none has held other features of the task constant while varying familiarity.

Irwin and McLaughlin's (7) excellent study among the Mano in Liberia has come the closest to fulfilling this criterion. They compared two groups of school children (mean ages 12 and 15.5) with a group of illiterate adults in sorting two sets of stimuli: cards and bowls of rice. The cards displayed two-dimensional geometric figures varying according to number, color, and shape. The bowls of rice varied according to size, type of rice, and cleanliness of rice. The major finding was that whereas illiterate adults could not shift from one basis of classifying the cards to another, they could do so with the bowls of rice. The two literate groups carried out the reclassification tasks equally well with both sets of materials. In this experiment, familiarity of objects is confounded with familiarity of modes of representation. Thus, it is impossible to determine how much of the poorer resorting performance of the illiterate adults, using depicted geometric figures, stems from the unfamiliarity of abstract geometric shapes and how much stems from the unfamiliarity of two-dimensional representation. Surely a major effect of schooling would be to increase this latter skill. Our study among the Zinacantecos of Southern Mexico differed from Irwin and McLaughlin's in the use of three-dimensional objects in both the familiar and unfamiliar sets of stimuli.

Putting familiarity of mode of representation aside, we must distinguish four other types of familiarity or cultural relevance for the purposes of this experiment:

Type 1. *Objects* may be familiar or foreign, apart from how they are categorized.

Type 2. *Features* are culturally familiar if their labels follow linguistic usage.

Type 3. A *dimension* is familiar when a category label is used to exclude objects differing in terms of a single linguistically marked featural contrast.

Type 4. An *object-dimension relationship* is culturally relevant if the dimension actually functions to categorize these particular objects in that particular culture.

Object familiarity can vary independently of features and dimensions. In our experiment, we held familiarity of features and dimensions constant while varying the familiarity of the object domain to be categorized. Irwin and McLaughlin (7) failed to do so in their experiment. In addition to the fact that there was no real correspondence between the variable attributes of the cards and those of the rice, each variable attribute of the rice was really a bundle of at least two correlated features. For example size of bowl was correlated with amount of rice. Thus, the grosser differences in the rice stimuli may have contributed to the better performance of the illiterates.

The fourth type of cultural familiarity—the relevance of attributes for a particular set of objects—presupposes familiarity of *objects, features,* and *dimensions.* Given familiar objects, features, and dimensions, a featural dimension can have greater or lesser functional significance for a particular domain of objects. In our study, we compared the categorization of a given set of familiar materials, using featural dimensions varying in their functional relevance for this particular domain. (In the Irwin and McLaughlin study the effect of this type of familiarity could not be separated out from the effect of the materials.) Thus, the task became one of successively recategorizing the same set of stimuli according to different featural dimensions.

Miyamoto (9) carried out a concept formation study in Zinacantan. He used a procedure in which boys from eight to 16 years of age were given objects one at a time and were asked to name similarities as successive culturally familiar objects were added to the group. Because this task requires the formulation of the grouping criterion or intensive definition, it is a purely inductive task. Older Zinacantecos were less willing to seek culturally irrelevant concepts. One manifestation of this resistance was the *decrease* in size of object groupings with *increasing* age. They were more concerned with important differences than unimportant similarities.

Miyamoto points out that one problem may have been that for the Zinacantecos, as for most people in most cultures, a question means that the asker needs some information the person being asked is likely to have. In an experiment the opposite is true: the interlocuter already has the information, and the true purpose of the question is to assess the mental functioning of the person being questioned.

Miyamoto did not study recategorization. But clearly, recategorizing the same stimuli under different criteria would fall under the rubric of an arbitrary task, required of the child in order to display his mental processes rather than in order to satisfy some real informational need of the experimenter. Recategorization of the same array demands stimulus grouping that ignores a difference upon which an earlier categorization was based. If a grouping is useful, moreover, why undo it and form another? In the light of these considerations and Miyamoto's results, one would not expect recategorization to develop with age in Zinacantan. [A number of studies have found recategorization performance to be relatively poor in the absence of Western influences like formal schooling (3, 4, 6, 8, 12).][2] But if the difference Miyamoto observed was caused by the cultural definition of the situation rather than by a general difference in competence, then one might expect that explicit redefinition of the experimental situation could alter behavioral development: children would show an increasing ability with age to ignore observed differences in making new similarity groupings, thus improving in their ability to deal with an arbitrary reclassification task. A deductive task provides this type of explicit structure, for the experimenter gives the intensive definition of each concept to be applied by the child.

Studies of classificatory behavior which deal exclusively with deductive processes are rare. Generally concept experiments are set up so that the ability of the subject to induce a general principle from exemplars presented by an experimenter is basic to any deductive application of principles to new examples (concept attainment tasks). Sometimes the stimulus materials are such that the subject has a choice of alternative inductive generalizations which are suitable to the stimulus conditions (concept formation or sorting tasks). The deductive aspect of such concept formation experiments actually amounts to knowing how to apply a conceptual definition, which may or may not be verbalized as some sort of label. This

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[2] Price-Williams (11) found that illiterate Tiv subjects could switch from one classificatory base to another, but because of the structure of the materials and task, they may have done so without violating earlier groupings, as Fjellman (3) points out.

is the extensive aspect of concept knowledge: being able to make the distinction between exemplars and nonexemplars. This selection process is at the heart of the comprehension side of language and therefore deserves study as a phenomenon in itself without the added complication of inductive processes. Thus a deductive or verbal comprehension task seemed an appropriate vehicle for studying the effects of naturally occurring categorical grouping on categorization skills in general.

The experiment to be described was designed to answer three main questions:

1. Will recategorization performance develop with age if explicit conceptual definition (that is, a deductive task) counteracts the culturally given interpretation of the problem?
2. Will the cultural familiarity of the object domain affect categorization and recategorization performance if all other factors are held constant?
3. Will the cultural relevance of a featural dimension for a familiar domain affect categorization or recategorization in that domain?

B. Method

1. *Ethnographic Background and Experimental Rationale*

The participants in the experiment were Zinacantecos, members of a Mayan group dwelling in the highlands of Chiapas, Mexico, near the Guatamalan border. The Zinacantecos are ethnically distinct from other Mexicans; they speak their own language, Tzotzil, and take pride in traditional behavior. [A detailed ethnographic description of Zinacantan is provided by Vogt (13).]

Since a categorization skill in which cultural differences often appear is the ability to shift from one attribute base to another in categorizing a single set of objects, this skill was compared in two domains, one familiar, one alien to Zinacanteco culture. The familiar domain was flowers, the unfamiliar domain was wooden rods. Each domain was represented by an array varying in three attributes: color, species, and length for the flowers; color, circumference, and length for the rods.

Even within Zinacantan, however, not everyone has the same degree of experience in grouping flowers. Some children sell flowers on the highway that runs by the edge of the village or *paraje*. A major aspect of this work is arranging flowers in bunches and tying them up. Thus, not only flowers themselves but the operation of grouping them has functional significance in Zinacantan. If such grouping experience is relevant to the development of categorization skills, then flower sellers ought to classify better than non-flower-sellers, at least within this domain. This notion could be tested by comparing flower sellers' performance with that of other children in the present experiment.

2. *Procedure and Tasks*

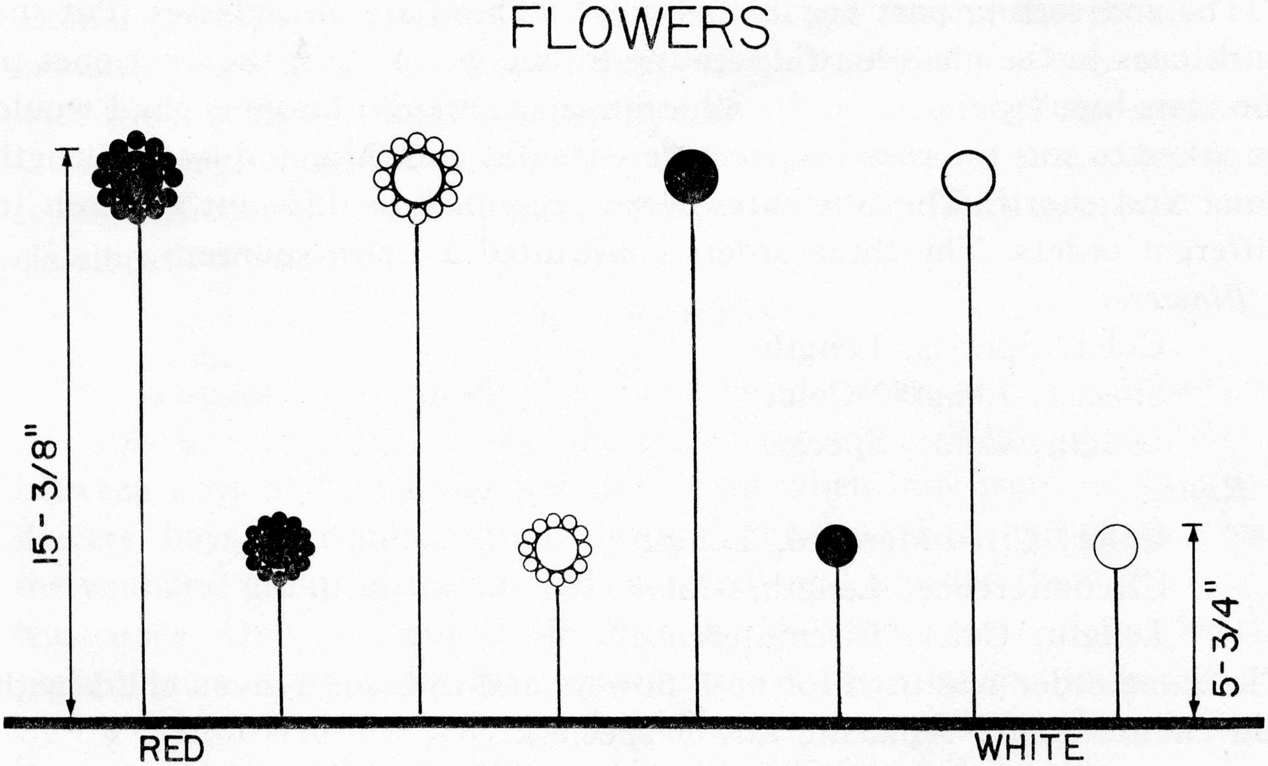
The experimental context was unfamiliar in the Zinacanteco culture. Though some of the boys probably participated in Miyamoto's (9) concept formation experiment in 1968, the summer before ours, experiments are not a normal part of Zinacanteco life. We called ours "playing" and said we were trying to tell how well different children "played."

The experiment was conducted by C. Childs in fluent Tzotzil while Greenfield recorded the children's responses. Our procedure was developed and pretested in collaboration with Xun Pavlu, our Zinacanteco assistant. Although we dressed as Zinacantecos, we were still probably somewhat strange to our subjects. In terms of experimental design, however, the identity and cultural distance of the experimenters was roughly a constant factor for every group. It would, therefore, not affect group differences.

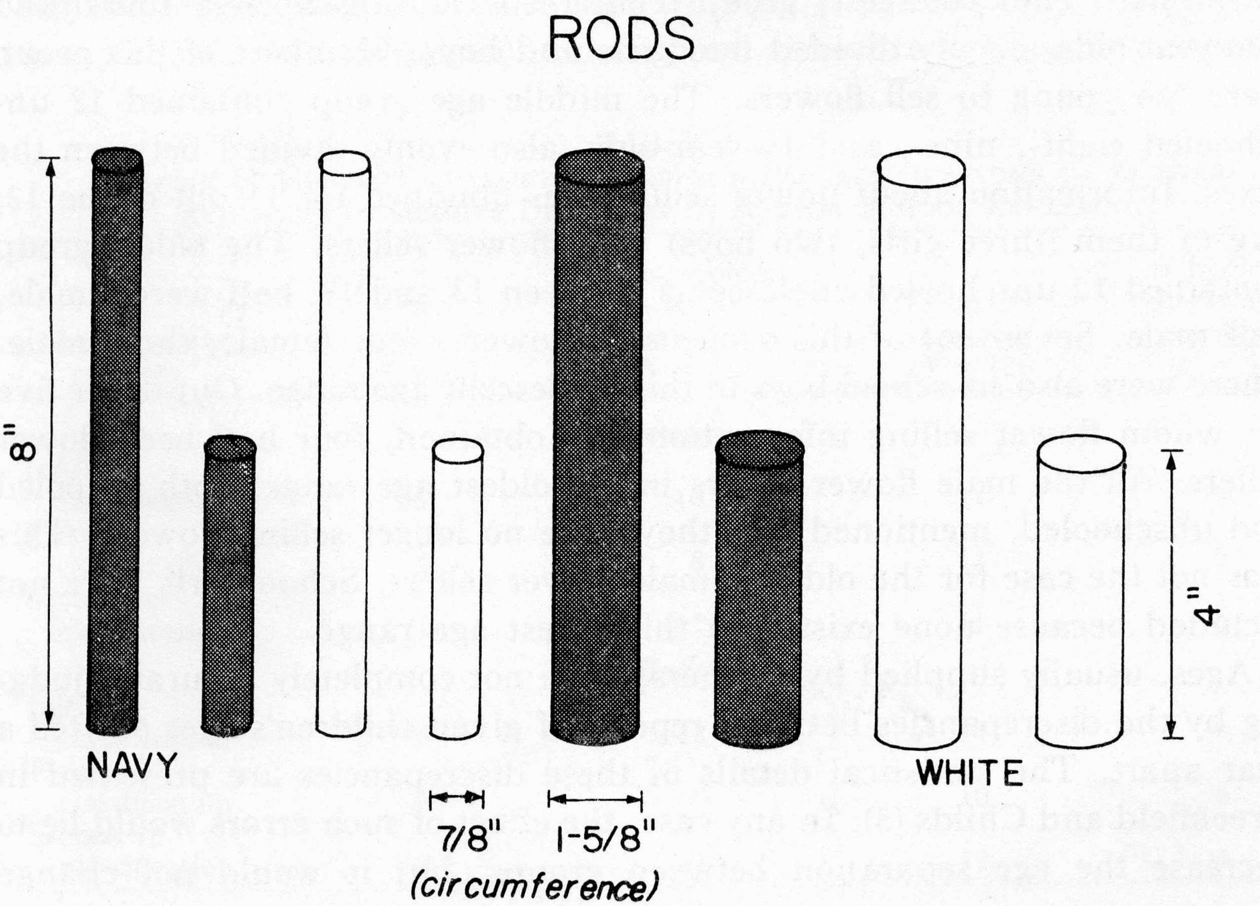
The first task involved sorting and resorting a set of eight flowers, varying along three bipolar dimensions: color, length, and species. The total array is presented in Figure 1. It can be seen that every combination of attribute values appears once in the array and that sorting along any single dimension splits the total array into two groups of four.

Similarly, the second task involved sorting and resorting a set of eight wooden rods, also varying along three bipolar dimensions: color, length, and circumference (Figure 1). Thus, two out of the three dimensions—color and length—were the same in both arrays. But the species dimension of the flowers was replaced by the circumference dimension of rods. [The rod task was a modification of Nixon's reclassification test, described by de Lacey (2).] Each child was asked to sort each array three different ways. For example, the experiment could start with the child being asked to sort the flowers by color: "There are two ties. Tie the red ones into a bouquet with the tie here" (pointing to one tie). "Tie the white ones into a bouquet with the tie here" (pointing to the other tie). Next he or she would be asked in a similar way to sort by species (gladiolus and carnation or gladiolus and dahlia, depending on what was available that day). Last the child would be asked to sort by length (long and short).

FIGURE 1
STIMULUS ARRAYS



Flower length varied somewhat from day to day.
Lengths shown are illustrative.



The rod sorting part began this way" "There are two glasses. Put the dark ones in the glass here" (pointing to one glass). "Put the light ones in the glass here" (pointing to the other glass). Similarly the same child would be asked to sort the rods by circumference (fat and thin) and last by length (long and short). The attributes were presented to different children in different orders. The three orders constituted a Latin square:

Flowers:

Color, Species, Length
Species, Length, Color
Length, Color, Species

Rods:

Color, Circumference, Length
Circumference, Length, Color
Length, Color, Circumference

The same order was used for both flowers and rods for a given child (with rod circumference replacing flower species).

3. *Experimental Design*

The participants in the study were constituted into groups along the dimensions of age, sex, work (whether or not they sold flowers), and schooling. The youngest group contained 12 unschooled four- and five-year-olds, evenly divided into girls and boys. Members of this group were too young to sell flowers. The middle age group contained 12 unschooled eight-, nine-, and 10-year-olds, also evenly divided between the sexes. Information about flower selling was obtained for 11 out of the 12; five of them (three girls, two boys) were flower sellers. The oldest group contained 12 unschooled adolescents between 13 and 18; half were female, half male. Seven out of this group sold flowers, four female, three male. There were also six school boys in this adolescent age range. Out of the five for whom flower selling information was obtained, four had been flower sellers. All the male flower sellers in the oldest age range, both schooled and unschooled, mentioned that they were no longer selling flowers. This was not the case for the oldest female flower sellers. School girls were not included because none existed in this oldest age range.

Ages, usually supplied by mothers, were not completely accurate, judging by the discrepancies between reports of given children's ages elicited a year apart. The statistical details of these discrepancies are presented in Greenfield and Childs (5). In any case, the effect of such errors would be to decrease the age separation between groups, but it would not change ordinal position or produce any overlap in age among the groups. The increasing age span of our older experimental groups is a way of dealing with the fact that estimates of age decrease in accuracy as age increases.

This design made it possible to assess the effects of sex, age, flower selling, schooling, and familiar materials on the children's approach to the classification tasks.

C. Results

The youngest group made the fewest correct sorts and resorts and was the only one in which a sex difference appeared. While the difference between boys and girls was not significant when they were working with flowers, boys did significantly better with the rods. Four out of six boys in the youngest group sorted the rods correctly and resorted them correctly at least once. Only one out of six girls in this group reached this level of performance. Comparing the performance of the youngest boys and girls by the Mann-Whitney test, we find that the boys did significantly better than the girls with unfamiliar rods ($p < .03$, two-tailed test).

The ability to classify and reclassify the same set of objects developed with age in both domains (Table 1). An analysis of errors reveals something about the nature of this process of development. Incomplete sorts (nonsystematic errors) and failures to sort were most prevalent in the youngest group (10 out of 12 children) and dropped almost to nothing in the middle

TABLE 1
Number of Correct Classifications and Reclassifications of Flowers and Rods in Groups Differing in Age or School Experience

Classification category	4 to 5-year-olds ($N = 12$)	Unschooled 8- to 10-year-olds ($N = 12$)	13- to 18-year-olds ($N = 12$)	Schooled 13- to 18-year-olds ($N = 6$)
Flowers				
Initial classification	5	10	11	6
First reclassification	4	8	12	6
Second reclassification	1	7	11	6
Rods				
Initial classification	8	12	11	6
First reclassification	4	9	10	6
Second reclassification	4	11	12	6

(one out of 12 subjects) and oldest unschooled groups (two out of 12 subjects). (Note from Table 1 that no errors of any kind occurred among the adolescent school group.) Shifting our attention from nonsystematic to systematic errors, we find several major types. One was an attempt to create groups sharing more than one attribute. Operationally this revealed itself on the first sort in the formation of a group of two (e.g., the two red carnations) and a group of the remaining six flowers (because only two groupings were allowed). On later sorts, this strategy was manifest in the same way, but one of the two attributes would be taken from an earlier sort: if the above example of two red carnations were used to illustrate this way of proceeding, the child would have correctly sorted by color on the preceding trial and would now be responding to a request to sort by species. This strategy used on resorts could also be considered resistance to violating earlier groupings to make new ones. Six children out of the 12 youngest used one or the other of these two strategies. Only two children in the next age group and none in the oldest made this type of error. Thus the ability to base groupings on but a single attribute and to make a complete switch from one type of attribute to another develops with age. Another major error strategy relates to a more complete failure to switch from one attribute dimension to another. Here the child perseverates a dimension from an earlier trial. Nine out of 12 of the four- and five-year-olds manifest this error strategy at least once (It is probably clear that a single child can make more than one type of error and that the error categories are not mutually exclusive). This number drops to five out of 12 among the eight- through 10-year-olds and to one out of 12 among the 13- through 18-year-olds. Thus, an important skill underlying recategorization is the ability or willingness to decompose a grouping formed earlier, and our analysis of errors indicates that this is one of the last skills to develop. Of all the categorization skills studied in this experiment, the undoing of groupings probably has the least relevance to the demands of practical life (although much relevance to Western science). Subdivision of existent groupings, a common error pattern as we have seen, also demands hierarchical structuring of a domain in terms of multiple dimensions, but has much more relevance to daily life. Nevertheless, by adolescence almost everyone (unschooled as well as schooled) could classify and reclassify both flowers and sticks according to three different attributes.

But familiar materials did not lead to more skillful performance with the array of flowers. In fact, a significant difference in the reverse direction appeared: 11 children in the two younger groups sorted and resorted rods better than flowers; only two sorted flowers better than rods (p = .02, two-tailed sign test). The experimental design was such that all children sorted flowers first. The reason for this quirk of formal design was to maximize classification performance by starting with a familiar task —making bouquets of flowers. For this reason we cannot tell from this result alone whether the effect is due to learning occurring during the experiment or to the perceptually clearer nature of the rods. As there was no feedback within the experiment, opportunities for learning ought to have been minimal. If, moreover, five minutes' experience with the rods can counteract the effect of many years' experience with the flowers, then the effect of this experience cannot be a very strong one.

Additional results also cast doubt on the importance of learning as an explanation for the better performance with rods. In the first place, flower sellers did not perform significantly differently from non-flower-sellers with either set of materials. If familiar materials do not augment performance, the flower sellers' experience with these materials ought not to do so either, just the result we have found. In the second place, the difference between ease of sorting flowers and rods is concentrated in certain attribute dimensions. This patterning, now to be described, cannot be explained by the general factor of learning occurring in the course of the experiment, for order of attribute dimensions was counterbalanced across subjects.

Does the relevance of an attribute dimension to a particular domain affect ease of sorting? Species seemed the most functional or relevant attribute for sorting flowers. Observation of actual bouquets for sale in Nabenchavuk confirmed the impression that species was the primary basis of organization. Yet of the three attributes on which the experimental array of flowers differed, species was the last to appear in development (Table 2).

TABLE 2

FREQUENCY OF CORRECT USE OF VARIOUS ATTRIBUTES FOR CLASSIFYING AND RECLASSIFYING FLOWERS AND RODS IN GROUPS DIFFERING IN AGE OR SCHOOL EXPERIENCE

Attribute	Unschooled 4- to 5-year-olds ($N = 12$)	Unschooled 8- to 10-year-olds ($N = 12$)	Unschooled 13- to 18-year-olds ($N = 12$)	Schooled 13- to 18-year-olds ($N = 6$)
Flowers				
Color	5	9	12	6
Length	5	8	11	6
Species	0	8	11	6
Rods				
Color	8	12	12	6
Length	4	10	12	6
Circumference	4	10	9	6

It was not used at all among four- to five-year-olds. Both color and length were used significantly more often at this age level ($p = .06$, two-tailed sign test). Among the youngest children the relevance of species apparently cannot overcome the fact that it is a complex multidimensional attribute, whereas color and length are unidimensional. If one wanted to argue that length is equally relevant to making bouquets because of the design of the experimental materials (see last paragraph in the Results section), it would still be the case that species grouping develops later than color grouping and that, in general, order of development of the various featural dimensions is not predicted by their relevance to the task of making bouquets.

The four- and five-year-old group is both young and lacking experience with flowers, so it is hard to pinpoint the source of their difficulty with species. But correct use of the species attribute jumps dramatically to equal the other two attributes in the middle age group, the point at which flower selling first appears. If this were not an effect of specific experience with flowers, one would expect skill with the other attributes to improve equally. But this does not happen, even though the use of color and length is far from perfect in the middle age group. Thus, task relevance in a particular culture plays a part once the requisite cognitive capacities have matured. Maturation is probably also a factor in the development of attribute use, for use of *all* attributes, not just species, improves with age.

While sorting by species develops last, sorting by color develops first and is, overall, the easiest basis for sorting (Table 2). Color is significantly easier than circumference (rods only): nine children succeed in the color sort and fail in the circumference sort ($p = .002$, one-tailed sign test). Color is also easier than length (rods and flowers together): seven children succeed better with color than length, while only two do better on length than color ($p = .09$, one-tailed sign test).

Although, overall, it is easier to sort by color than by any other attribute dimension, flowers are harder to sort by color than are rods. Six children (all in the two younger groups) correctly sorted the rods by color but not the flowers; the reverse never occurred in any group. The chance probability of this difference is .03, according to a two-tailed sign test. The relevance of a featural dimension to particular domains seems to be operating here: color is the least relevant dimension for making flower bouquets; this is not the case for rods. Hence, more children are able to use color in sorting rods than flowers. But why is color less relevant to bouquets than species or length? Although naturally occurring Zinacanteco bouquets seemed to respect species lines, length of stem is generally correlated with species. In the case of our experimental materials we arbitrarily cut half the members of a given species much shorter and equalized species size differences by making the "long" flowers of different species the same. So, while it would make sense to a Zinacanteco to make bouquets by species, these bouquets violated a length grouping; and length is clearly important in the mechanics of tying bouquets. Therefore, it would also make sense to make bouquets consisting of flowers of uniform length but mixed species. In contrast, however, bouquets that respect color lines but violate both species and length boundaries make no sense at all, especially when naturally occurring Zinacanteco bouquets often are composed of flowers of different colors but the same size and species. Hence it appears that when an attribute dimension violates the practical requirements of a task it becomes harder to apply to that task domain.

D. Discussion

The ability to apply an intensive definition stated by the experimenter in resorting an array of objects developed with age in both schooled and unschooled Zinacantecos. Thus older Zinacantecos were more able than younger ones to ignore important observed differences in forming new groupings. This developmental trend is the reverse of that noted by Miyamoto (9): in a different categorization situation older Zinacanteco subjects were less willing than younger ones to ignore important differences in defining larger new equivalence groupings. Because the present experimental task required application of a given selection criterion (deduction) rather than formation of the criterion (induction), its requirements were more explicit, less ambiguous. That resorting developed with age under these conditions is further proof that Miyamoto's developmental trend toward smaller groupings was caused by the cultural definition of the situation rather than by an underlying lack of conceptual competence. Our results show that a shift in situational definition can quickly reveal this competence.

Our results show that no generalizations about the effect of familiarity can be made without specifying the type of familiarity and the nature of the effect. Under most circumstances in the present study, familiarity failed to exert a positive effect on sorting performance. For example, flower sellers did not perform significantly better than subjects without flower selling experience. Closer analysis indicated that sorting and resorting flowers (familiar objects) was actually more difficult than sorting and resorting the unfamiliar rods, for two specific reasons. First, the youngest children had the greatest difficulty in sorting by species. The ability to sort by species developed last, even though species has great relevance to making flower bouquets (Type 4 familiarity). Furthermore, it was more difficult for the youngest children to sort flowers by species than to sort rods by any attribute, even though flowers are the more familiar objects (Type 1 familiarity). Thus, universal factors, whatever they may be, seem to override the specific cultural environment in determining the developmental sequence of conceptual capacities.

The second source of difficulty with flowers was manifest when a subject was asked to make bouquets of uniform color. Because the dimension of color is irrelevant to the task of forming bouquets, it is harder to arrange bouquets by color than to divide rods into containers on the same basis. Here is a trace of the resistance to functionally irrelevant similarities found by Miyamoto (9). For the rods, in contrast, color is as suitable a dimension for grouping as any, as well as being the simplest from a strictly cognitive point of view. Thus, once the basic cognitive capacity to use a given dimension in categorization has matured, the ease with which it is applied to a given domain does depend on the relevance of the dimension for that particular domain.

While the familiar materials caused some difficulties in the younger children, the oldest subjects, comparable to Irwin and McLaughlin's (7) group, performed almost perfectly with both sets of materials even without formal schooling. It is hard to know whether this difference in results relates to the deductive nature of the task, the three-dimensional quality of the stimuli, or the requirements of Zinacanteco culture. Irwin and McLaughlin themselves provide evidence in favor of the first possibility. They found that Mano subjects who could verbalize the basis for one grouping were more likely to succeed in shifting to another attribute basis for a later grouping. But in our concept application task the experimenter always provided the verbal criterion. Thus, one can tentatively conclude that difficulty in switching from one classificatory base to another with unfamiliar materials lies much more in *generating* possible attributes applicable to the array than in *switching* per se. In any case our results show that successive recategorization of culturally meaningless materials can develop in the absence of literacy and schooling.

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