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Analytic and holistic modes of learning family-resemblance concepts

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Three studies examined how individuals learn concepts structured according to family-resemblance principles. The materials were cartoon faces varying in the attributes of hair, mustache, ears, and nose. In contrast to previous studies purporting to show holistic modes of learning family-resemblance concepts, the present studies indicate that many individuals learn such concepts by an analytic, attribute-plus-exception rule. The attribute-plus-exception rule characterized the learning shown by adults under both intentional (Studies 1 and 2) and incidental (Study 3) learning conditions and by children under intentional learning conditions (Study 2). There was no evidence to indicate that a holistic mode is a more primitive one, since it did not occur more frequently among children or adults under incidental learning conditions. It is suggested that the extent to which holistic or analytic modes of learning are observed will be found to depend on an interaction among stimulus, task, and observer factors.

Research on human concept formation has been heavily influenced by challenges to a so-called "classical" view of categorization in which particular attributes are thought to determine with certainty whether objects are members of particular categories (see, e.g., Rosch & Mervis, 1975; E. E. Smith & Medin, 1981). Whether a rigid adherence to the classical view truly captures the spirit of any psychological theories of concept formation is unclear (see E. E. Smith & Medin, 1981, especially p. 22). What is clear, however, is that many theoretical and empirical approaches are explicitly opposed to a view of categorization that involves a strict reliance on necessary, defining features, and are consistent with a view of categorization in which individual attributes are thought to be characteristic of a category but not necessarily defining (see Medin & E. E. Smith, 1984, and E. E. Smith & Medin, 1981, for reviews).

Along with an emphasis on characteristic, as opposed to defining, features have come a number of distinct but interrelated approaches to concept learning which are relevant to the present studies. One of these is that rather than studying the acquisition of well-defined concepts that are structured to be consistent with the principles of a classical view, many investigators have examined the learning of ill-defined concepts (e.g., Hartley & Homa, 1981; Homa, 1978; Kemler Nelson, 1984; Medin, Altom, & Murphy, 1984; Medin & Schwanenflugel, 1981; Rosch & Mervis, 1975). The term *ill-defined* is, itself, ill-defined in that it has been used by different investigators to refer to different types of category structures. In the most general sense, ill-defined categories are those "that do not have defining features" (Medin, 1983, p. 226). Of most interest in the present context are ill-defined categories that are structured by overall similarity or by family-resemblance principles (see Kemler Nelson, 1984; Mervis & Rosch, 1981; Rosch & Mervis, 1975) in which members of a category share more features with one another than they do with members of a contrasting category. In these categories, information about category membership is distributed across several attributes, and no one attribute is either necessary or sufficient to assure complete success in determining the category membership of all exemplars. Still more specifically, the family-resemblance structures examined in the present studies are those in which the members of a category are more similar to one another in overall appearance than they are to members of a contrasting category.

Concurrently with this upsurge in research on ill-defined categories, a number of investigators have begun to study holistic or nonanalytic modes of concept acquisition (see, e.g., Brooks, 1978; Kemler Nelson, 1984). As with the interest in ill-defined categories, the interest in holistic modes of learning is based, at least in part, on the observation that natural categories have ill-defined or family-resemblance structures. Presumably, if membership in many natural categories is not defined by a single attribute, then an effective way of learning such categories might be to focus either on the overall appearance of objects or on some holistic combination of attributes, rather than to analyze objects into their component attributes. Thus an emphasis on nonanalytic modes of learning seems warranted.

Like the term *ill-defined*, the term *holistic* has been used in a variety of ways. Since the present studies are most closely related to the work of Kemler Nelson (1984), her distinction between analytic and holistic modes is intended when these terms are used in this paper. The distinction is that "in the analytic mode, stimuli are compared and contrasted according to their constituent properties or at-

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tributes; in the nonanalytic or holistic mode, they are related according to global relations of overall similarity" (Kemler Nelson, 1984, p. 735).

The increased interest in ill-defined categories and holistic modes of processing also coincides with work on developmental changes in classification behavior. A number of investigators have shown that young children use holistic, overall similarity rules to classify materials for which adults use analytic, dimensional, or featural rules (Shepp, Burns, & McDonough, 1980; L. B. Smith & Kemler, 1977; Ward, 1980). The young child's holistic mode of processing has often been cited as being potentially advantageous for learning ill-defined natural categories that may have a strong family-resemblance structure (Kemler, 1983b; Medin, 1983; L. B. Smith, 1979). Thus the young child, who may be at a disadvantage in learning analytic or "classical" concepts in the laboratory, may possess a mode of processing uniquely suited to learning real-world categories, or artificial categories that have a family-resemblance structure.

One additional aspect of research on concept learning that is relevant to the present studies is a growing interest in the acquisition of concepts under implicit or incidental learning conditions (e.g., Brooks, 1978; Dulany, Carlson, & Dewey, 1984; Kemler Nelson, 1984; Reber, 1976; Reber & Lewis, 1977). As an example of that interest, Kemler Nelson (1984) provided an explicit account of the connection between incidental learning and holistic or nonanalytic modes of concept learning. The main idea is that a more primitive, less strategic type of learning should occur under incidental conditions than under intentional learning conditions in which the individual is goal-directed and perhaps in search of a specific categorization rule. Since a large body of research in both cognitive and developmental psychology is consistent with the idea that a holistic mode is more *primitive* (e.g., Shepp, 1978; J. D. Smith & Kemler Nelson, 1984; L. B. Smith & Kemler, 1977; Ward, 1980, 1983; Ward, Foley & Cole, 1986), incidental learning conditions would be expected to foster a more holistic mode of concept learning. Kemler Nelson (1984; see also Kemler, 1983b) also studied the intriguing connection between the young child's more primitive, holistic approach to tasks and the same type of processing thought to be fostered by adults under incidental learning conditions. Presumably, both adults operating under incidental learning conditions and young children should be attuned to the holistic, family-resemblance structure of categories and should readily learn categories that have that type of structure.

Clearly, the way in which individuals of different ages learn ill-defined categories is an important topic for future research. In addition, the possibility of holistic or nonanalytic modes of learning and concept acquisition under incidental learning conditions are important topics. These topics have taken on added importance due to proposals regarding the structure of natural categories (Rosch & Mervis, 1975; Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976) and the fact that much of our learning about the real world occurs incidentally as a result of interaction with objects in the world (see, e.g., Kemler Nelson, 1984).

Because of the potential importance of ill-defined structures, holistic modes, and incidental learning conditions, it is crucial to be extremely careful in determining the type of learning that is actually occurring. Close consideration of some of the work in these areas suggests that nonanalytic learning has been assumed when analytic learning may actually have occurred. The present studies were designed to evaluate the extent to which analytic or holistic modes of processing occur during the acquisition of ill-defined categories that possess a strong family-resemblance structure.

A potential problem with some previous studies purporting to show holistic, nonanalytic modes of learning can be illustrated by reference to a study by Kemler Nelson (1984, Experiment 4) in which children learned to categorize cartoon faces. The faces varied in the attributes of hair, mustache, ears, and nose. For ease of reference, consider that each of the four attributes can assume one of three ordered levels that will be designated 1, 2, and 3. The hair can be curly (1), wavy (2), or straight (3); the mustache can be clipped (1), medium-length (2), or handlebar (3); the ears can be large (1), medium (2), or small (3); and the nose can be tall-thin (1), medium (2), or short-fat (3). A formal representation of the type of family-resemblance problem used is shown in Table 1. Note that the characteristic, or most typical, values for Category A are curly hair, clipped mustache, large ears, and a tall-thin nose, whereas the characteristic values for Category B are straight hair, handlebar mustache, small ears, and a short-fat nose. Despite the fact that those values of the attributes are characteristic of the categories, none of the attributes are criterial or defining since they are not true of all category members. Note also that each face takes on the characteristic value for three of the four attributes but that the specific bundle of three characteristic attributes is different for each face in a given category. Finally, note that the attribute structure is such that the members of each category ought to be perceived as highly

Table 1
Example of the Structure of a Family-Resemblance Problem

Face	Hair	Mustache	Ears	Nose
		Category A		
1.	1	1	1	2
2.	1	1	2	1
3.	1	2	1	1
4.	2	1	1	1
		Category B		
5.	3	3	3	2
6.	3	3	2	3
7.	3	2	3	3
8.	2	3	3	3

Note—This is an example problem. Four such problems were created, and 12 observers learned each. The faces denoted are ones that were presented during learning.

similar to one another and very different from the members of the contrasting category.

In the process of determining the category membership of any individual face from Table 1, selective attention to the single attribute of hair (or any other attribute) as an independent feature is neither necessary nor sufficient to assure completely accurate performance. It is not sufficient in the sense that a focus on hair alone can lead to the correct answer for Faces 1-3 and 5-7, but can provide no information regarding the category membership of Faces 4 and 8. Similar observations can be made for the other three attributes as well. Selective attention is not necessary because the faces within each category are presumably much more similar in overall appearance to one another than they are to the members of the opposite category. Thus, in Kemler Nelson's (1984) view, rather than adopting an analytic mode and comparing faces in terms of independent component attributes, such as hair, an individual could perform adequately by adopting a holistic or nonanalytic mode and comparing faces in terms of their global, overall similarity. Presumably, in making such comparisons, the individual could treat each face as a single holistic entity.[1]

Kemler Nelson (1984, Experiment 4) showed that kindergartners learned concepts like that exemplified in Table 1 as quickly as did fifth-graders, but they performed much more poorly on criterial attribute problems that required a focus on a particular attribute. Likewise, under incidental learning conditions, college students shifted toward family-resemblance solutions and away from criterial attribute solutions to concept problems that could be solved by either type of rule (Kemler Nelson, 1984, Experiment 2). Kemler Nelson concluded that both adults who have not been given explicit instructions to learn a rule and young children approach tasks in a holistic manner that facilitates the learning of such family-resemblance concepts.

Although a holistic style of attending to the overall appearance of objects could provide enough information to allow the individual to learn categories such as those depicted in Table 1, there are other, more analytic approaches that could also lead to a solution. The fact that selective attention to one attribute will not always lead to the correct categorization does not mean that participants will not attempt to learn the problem with such strategies (see, e.g., Martin & Caramazza, 1980). As an example, the learner could selectively attend to a single attribute. This approach would facilitate learning about the characteristic values of that attribute for the contrasting categories and could thus lead to correct responding for six of the eight faces. This approach would also allow the person to identify the remaining two faces by the presence of the noncharacteristic value of the attended attribute. Presumably, then, the person could learn that those two faces were exceptions to the analytic rule and must be considered separately.

The single-attribute and holistic approaches can be elaborated further by describing what might occur on a given trial. On any given trial, the participant must decide whether the stimulus presented belongs in Category A or Category B. To make that decision, the individual presumably must compare the presented stimulus to some internal representation. Depending on the particular model adopted, that internal representation might take the form of an evolving prototype (e.g., Reed, 1972), a set of individually stored exemplars (e.g., Medin & Schaffer, 1978), some combination of the two, or some other type of structure. Regardless of which of these types of representations is assumed, an individual adopting an analytic, single-attribute approach would make the comparison on the basis of different information from that used by an individual adopting a holistic approach. The single-attribute learner would, at least initially, search for a match on his or her preferred attribute between the presented object and the stored information. In contrast, an individual adopting a holistic approach would compare the presented and stored information in terms of global similarity relations.

Although Kemler Nelson (1984) provided evidence against single-attribute learning in a previous study (Experiment 1), the structure of the categories was different from that used by Kemler Nelson in later studies. Specifically, in her first study, each member of a given category possessed one attribute that was characteristic of the opposing category, a situation that is likely to discourage learning by way of specific attributes. To illustrate the structure of those earlier categories, refer to Table 1 and replace all of the 2s in Category A with 3s and all of the 2s in Category B with 1s. In the later studies, as indicated in Table 1, category members took on intermediate values of an attribute (2s) rather than values characteristic of the opposing category, and this situation seems less likely to discourage analytic, single-attribute learning. Since data from categories of this latter type were used to support claims of holistic modes of learning, it is important to determine the extent to which such categories may foster other, more analytic modes. To this end, we conducted a series of studies to assess the extent to which individuals adopt analytic modes in processing information from categories of the type shown in Table 1. The stimuli used were cartoon faces modeled as closely as possible after those used by Kemler Nelson (1984).

Transfer items of the type depicted in Table 2, which can be useful in determining whether a person adopted an analytic or holistic mode of processing in his or her attempt to learn concepts of the type in Table 1, were used in three different studies. Faces T1 and T2 in Table 2 are the prototypical examples of Categories A and B, respectively, since they have the characteristic (i.e., most common) levels of each of the attributes for those categories. Regardless of which type of approach the person has taken in attempting to learn the items in Table 1, T1 and T2 should be identified as members of Categories A and B, respectively. If the person has adopted a nonanalytic mode and focused on holistic, overall appearance in attempting to learn the concept, then Faces T3, T5, T7, and T9

Table 2
Example of Test Items for Problem Shown in Table 1

Face	Hair	Mustache	Ears	Nose
T1*	1	1	1	1
T2†	3	3	3	3
T3	3	1	1	1
T4	1	3	3	3
T5	1	3	1	1
T6	3	1	3	3
T7	1	1	3	1
T8	3	3	1	3
T9	1	1	1	3
T10	3	3	3	1

*Category A prototype. †Category B prototype.

should be Category A faces and Faces T4, T6, T8, and T10 should be Category B faces, since that would be consistent with the global similarity relations among the stimuli. Similarity, of course, can be determined in a variety of ways (see, e.g., E. E. Smith & Medin, 1981). However, whether similarity is determined by some additive combination of matches on the attributes or by a multiplicative combination of differences, and whether it is computed by considering the number of features shared with the prototype or the number of exemplars to which an item is highly similar, the former items are more similar to Category A and the latter are more similar to Category B. In contrast, if a person has adopted an analytic approach and attempted to learn the concept by focusing on a single attribute and then learning exceptions to that rule, then a different pattern of performance on the test items would be expected. For example, an individual who has focused on hair and learned that most faces in Category A have curly hair should place Face T3 in Category B and Face T4 in Category A, even though Face T3 has more features in common with members of Category A and Face T4 has more features in common with members of Category B. Such a classification would violate the principle of holistic, overall similarity, but would be consistent with an analytic focus on a single attribute.[2] Similar predictions could be made for an analytic focus on one of the other three attributes.

Prior to conducting the three studies reported below, a pilot study was conducted to verify that the similarity relations assumed to be true in the previous paragraph do in fact hold.[3] The results of that study revealed two important features of the stimuli. One is that the categories depicted in Table 1 have strong global similarity structures. This was revealed by the fact that each member of a given category was nearly always rated as more similar to each other member of the same category than to any member of the contrasting category. The second is that items of the type T3, T5, T7 and T9 (see Table 2) were perceived as more similar to the prototype of Category A than the prototype of Category B, whereas the reverse was true for T4, T6, T8, and T10. Since perceived similarity was not overly influenced by differences along any one specific attribute, faces of the type described in Table 2 are useful for discriminating between learning based on overall similarity and learning based on a single attribute.

To summarize, the present studies were concerned with the way in which participants learn, or attempt to learn, ill-defined family-resemblance category structures of the type depicted in Table 1. The salient features of those categories are that (1) there are characteristic but not defining features, (2) information about category membership is distributed across several attributes, (3) members of a given category possess different but overlapping bundles of characteristic attributes, and (4) as revealed empirically by way of similarity judgments, there is a strong overall similarity structure such that the members of each category are much more similar to one another than to members of the contrasting category. (See Kemler Nelson, 1984, for further elaboration on these points.)

The first study in the present series was designed to examine the use of analytic modes of processing in adults' attempts to learn concepts under intentional learning conditions. The second study examined whether young children also exhibit analytic modes of learning, and the third study tested whether incidental learning instructions shift learners to more holistic rules or to analytic rules that differ from the experimenter-defined analytic rule. The rationale for each study will be presented separately in more detail in the sections that follow.

STUDY 1

As noted, this study was designed to examine different rules by which individuals attempt to learn family-resemblance concepts of the type depicted in Table 1. The two rules of most interest were (1) holistic, similarity-based and (2) single-attribute. Since Kemler Nelson (1984) found that young children performed extremely well on such problems and since young children have been found to respond holistically to a wide variety of materials (see, e.g., Kemler 1983b; Shepp, 1978; L. B. Smith & Kemler, 1977; Ward, 1980), it may be that holistic approaches are extremely effective and would be employed by all or most individuals. On the other hand, since explicit rule learning instructions appear to lead individuals to more analytic approaches (Kemler Nelson, 1984; L. B. Smith, 1979) and since Martin and Caramazza (1980) found that participants attempted to learn even family-resemblance categories by way of analytic approaches, it might be predicted that the rule learning instructions of the present study would lead individuals toward a more analytic, single-attribute approach.

Several pieces of converging evidence were used in an attempt to identify the presence of single-attribute rules. First, as indicated previously, a particular pattern of responding to the test items could indicate an individual's reliance on a single attribute. Second, assuming that an individual is attempting to learn the concept on the basis of one attribute, that attribute would lead quickly to the correct answer on six of every eight learning trials. The remaining two trials would presumably require more time since the learner can no longer rely on the information available from the favored attribute and must either guess or check the values of the other attributes. In either case, reaction time should be longer on those two trials. Finally, an individual should continue to make errors for the two ambiguous faces for some minimum number of trials after achieving perfect performance on the other six faces. That is, the learner presumably must acquire information about the characteristic levels of his or her preferred attribute for the two categories prior to learning about exceptions to that rule (see Martin & Caramazza, 1980). So, for example, an individual who focuses on hair as an attribute should learn to correctly categorize the three members of Category A that have curly hair (Faces 1-3) and the three members of Category B that have straight hair (Faces 5-7) in Table 1 relatively quickly. The individual should exhibit longer reaction times and more errors to the other two ambiguous faces (4 and 8).

Method

Subjects. Participants consisted of 48 undergraduate students at Texas A&M University. Their participation was solicited as an optional curricular assignment in conjunction with an introductory psychology course.

Stimuli. The stimuli were cartoon faces as previously described. The faces were approximately 6 in. tall and were mounted on 8½ × 11 in. ivory-colored backgrounds. The hair and mustaches were yellowish-blonde and the noses and ears were tan.

Four clusters of faces were created, with each cluster consisting of a pair of prototype faces (one for Category A and one for Category B), eight learning faces (four for each category), and eight test faces (two constructed to test for learning by each of the four attributes). The four clusters were created so that, across the eight prototype items, each extreme level of a given feature (1 or 3) occurred equally often with each extreme level of the other features. The learning faces, as shown in Table 1, were created by substituting an intermediate value of an attribute for one of the characteristic (prototype) values in each face. The test faces (T3-T10 in Table 2) were created by substituting a value that was characteristic of the opposing category for one of the characteristic (prototype) attributes. Participants were equally divided among the four clusters.

Procedure. During the learning phase of the experiment, participants were told that they were to imagine a world in which one could discriminate between firemen and policemen on the basis of how their faces appeared. They were then told that they were to learn to discriminate the firemen from the policemen.

On each learning trial, participants were presented with one of the eight learning faces and asked to indicate whether the face was that of a fireman or a policeman. Participants were told after each response whether their choice was correct or incorrect. All eight faces were presented in one random order and this procedure was repeated four times with different random orders for a total of 32 learning trials. Response times for each trial were recorded using a hand-held digital stopwatch.

In the testing or transfer phase, subjects were presented with the 8 learning faces, 8 test faces, and 2 prototype faces. These 18 faces were presented one at a time in a random order, and this procedure was repeated with a different random order for a total of 36 testing trials. No feedback was given to the participants as to the correctness or incorrectness of their responses during the testing trials. Response time for each trial was recorded in the same manner as in the learning phase. The test phase immediately followed the learning phase.

Results and Discussion

Participants who correctly classified faces on at least 12 of the 16 transfer trials that involved the original learning items were considered to be *learners*. This criterion was chosen because it involves more correct responding than would be expected on the basis of chance (binomial probability $< .05$) and thus indicates that an individual has learned at least something about the category structure. All 48 individuals tested met this criterion.

Performance on the test items was used to classify participants into groups of those who learned (or were attempting to learn) by way of a single attribute and those who learned by way of some other rule involving either a holistic assessment of overall similarity or some combination of attributes. Since each of the eight test items was presented twice during the transfer phase, there are 16 responses relevant to this classification. For a single-attribute learner, 4 of those responses involved *critical test items* and the remaining 12 involved the other test faces. Which test items were critical depends on the particular attribute in question. For each of the four attributes on which the faces varied there were two critical test faces. A critical test face for a given attribute was identical to one prototype on that single attribute, but different from that prototype on the remaining three attributes. That test face was also different from the other prototype on the criterial attribute, but identical to that second prototype on the remaining three attributes. As an example, the two critical test faces for the attribute of hair are T3 and T4. Using the patterns shown in Tables 1 and 2 as examples, an individual responding on the basis of the single attribute of hair would presumably place critical test item T4 in Category A and critical test item T3 in Category B for both presentations of each of those two faces. The individual would also place T5, T7, and T9 in Category A and T6, T8, and T10 in Category B on both presentations of each of those six faces. Similar patterns can readily be determined for each of the other three attributes. An individual showing at least 15 out of 16 responses consistent with a particular single-attribute rule was judged as learning according to that rule. An individual using a holistic, overall similarity approach would place T3, T5, T7, and T9 in Category A and T4, T6, T8, and T10 in Category B for both presentations of each of those faces. However, in practice any individual who did not show a clear single-attribute pattern was assigned to the holistic group since those individuals were assumed to have focused on either multiple attributes or global similarity rather than on one attribute.

Based on the above procedures, 22 of the 48 individuals tested were identified as single-attribute learners.[4] Of those 22, the number judged to have learned by the attribute of hair, mustache, ears, and nose was 5, 7, 2, and 8, respectively.

It might be argued that since a relatively lax learning criterion of 12 out of 16 was used, some of the individuals identified as attribute learners responded on the basis of partial rather than complete category knowledge. This would not alter the basic conclusion that that category information, either partial or complete, was acquired through an analytic approach of focusing on a single attribute. However, at least some of the individuals identified as attribute learners may have acquired information only about the characteristic value of the attended attribute and not about the exceptions to that rule. Such knowledge would be enough for the individuals to correctly classify 12 of the 16 presentations of the original learning faces on the transfer trials and thus meet the criterion for learning. With additional learning trials, these individuals may have gone on to learn about the exceptions. However, without evidence to support this possibility, it may be better to consider individuals who showed an analytic pattern but performed less than perfectly on the transfer trials to be *single-attribute* learners rather than *attribute-plus-exception* learners. The classification *attribute-plus-exception* may be better reserved for those individuals who showed an analytic pattern and correctly categorized all 16 presentations of the original learning items during the transfer task.

Individuals who performed perfectly on the original learning items that were presented during transfer can be thought of as demonstrating complete knowledge of the category structure. Thus it becomes interesting to examine their performance separately. In addition, since the above discussion implies that these individuals may differ from those with only partial category information, it becomes important to compare the performance of the two groups.

Of the 48 individuals tested, 17 performed perfectly on the original learning items presented during the transfer task and 31 made at least one error. Of the 17 perfect performers, 6 fit the single-attribute pattern and 11 did not. Of the other 31 individuals, 16 fit the single-attribute pattern and 15 did not. Although the proportion of single-attribute learners is somewhat lower in the group of perfect performers, a chi-square test indicates that assignment to the single-attribute versus holistic group is statistically independent of whether or not the person performed perfectly on the transfer trials ($\chi^2 = 1.17$, $p > .20$). Thus, in a statistical sense, individuals who demonstrated complete knowledge of the concept were neither more nor less likely to show an analytic pattern than those who demonstrated only partial knowledge of the concept.

To provide converging evidence on the use of single-attribute rules and to provide further comparisons of complete and partial learners, we performed several additional analyses. First, mean correct reaction times during learning were computed separately for the two *ambiguous learning faces* and the remaining six faces for each single-attribute learner. As with the critical test faces, which learning faces are *ambiguous* depends on the specific single attribute upon which the learner appears to have focused. For example, Learning Faces 4 and 8 are ambiguous for an individual who has selectively attended to the attribute of hair. Response times on the first eight learning trials were excluded from this analysis. The mean correct reaction times and standard deviations for the ambiguous learning faces and for the other learning faces are presented in Table 3, separately for those who performed perfectly during transfer and those who made errors, as well as for the groups combined. An analysis of variance was conducted on the reaction times using item (ambiguous vs. other) and group (perfect vs. nonperfect) as between-subjects factors. As indicated by the means in Table 3 and as confirmed by the analysis of variance, reaction times to the ambiguous items were significantly longer than those to the other learning items for both groups [$F(1,20) = 13.20$, $p < .01$].[5] There was no effect of group ($F < 1$) and no group × item interaction ($F < 1$). Thus individuals identified by test item performance as being single-attribute learners showed the expected increase in reaction time to the ambiguous faces that cannot be classified on the basis of that attribute whether they had performed perfectly during transfer or not.

Errors during the learning phase of the present study also converge on the notion of single-attribute learning, and on the similarity in the patterns of performance shown by perfect performers and those who made errors during transfer. Five of the 6 perfect performers and 11 of the 16 nonperfect performers made their last learning trial error on one of the ambiguous learning faces. Both distributions are significantly more extreme than would be expected by chance (binomial probability < .05). In addition, of the 16 single-attribute learners who made errors on the learning items that were presented in the transfer task, 11 made those errors only on the ambiguous items.

Table 3
Mean Reaction Times and Standard Deviations (*SD*) of Single-Attribute Learners in Study 1 to the Ambiguous Learning Items and Other Learning Items and to the Critical Test Items and Other Test Items

	Items							
	Ambiguous Learning		Other Learning		Critical Test		Other Test	
Group	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
Complete-Knowledge	2.22	0.73	1.51	0.58	3.03	1.43	2.49	0.89
Partial-Knowledge	2.01	1.03	1.43	0.56	2.58	1.07	2.38	0.94
Combined	2.07	0.95	1.45	0.55	2.70	1.16	2.38	0.98

Note—Means are shown separately for those who achieved perfect performance on the learning items presented during transfer (complete knowledge) and for those who made errors (partial knowledge), as well as for the groups combined.

This distribution is also significant by way of a binomial probability test ($p < .05$).

Thus, there is strong converging evidence that nearly half of the college students tested in the family-resemblance concept problem learned or attempted to learn that concept by focusing all or most of their attention on a single attribute and then learning to deal with the exceptions to that rule. Furthermore, since some individuals learned by way of each of the four attributes, it is unlikely that the results are a function of flawed stimulus materials in which a single feature is so salient that it entirely dominates responding. Finally, there is no evidence to indicate that individuals who showed complete knowledge of the concept adopted approaches that were different from those who showed only partial knowledge.

Although their categorization decisions appear to be determined by only one attribute, an important question regarding the 22 individuals identified as single-attribute learners is whether or not they were influenced at all by the other attributes. One interpretation of their performance is that they focused only on one particular attribute and learned nothing at all about the others. An alternate interpretation is that they obtained information about more than one attribute but assigned much more weight to one. Since individuals have been shown to process covariation among the features of objects even under implicit learning conditions (see, e.g., Lewicki, 1986), it is possible that the single-attribute learners acquired information about covariations among all four attributes even if they were attempting to learn about only one attribute.

Since reaction time has been shown to be a sensitive measure of covariation knowledge (Lewicki, 1986), reaction times to the test items were examined to determine whether or not the single-attribute learners were influenced by the other attributes. Of the 16 transfer trials on which test items (T3–T10) were presented, 4 involved the critical items in which the single attribute of interest was pitted against the remaining three attributes. Again by way of example, for a hair attribute learner, Faces T3 and T4 are critical items because they pit classification based on hair against classification based on any or all of the other attributes. A learner who had category-relevant information about more than one attribute but who assigned the greatest weight to hair might be slower in making categorization decisions for Faces T3 and T4 than for Faces T5–T10 because the latter present no conflicting information about category membership from the other attributes. For each individual, mean reaction times were computed for the four transfer trials involving the two critical test items and for the remaining 12 transfer trials involving the other six test items. Again, this procedure requires that the mean RTs be computed on different items for different individuals. The mean reaction times and standard deviations for the critical test items and for the other items are shown in Table 3. Although the difference is not large, it is statistically significant [$F(1,20) = 7.25, p < .05$]. Thus there is some indication that these individuals were influenced by more than one attribute. Therefore, either consciously (Dulany et al., 1984) or unconsciously (Lewicki, 1986; Reber, Allen, & Regan, 1985) they must have acquired information about the mapping of attribute levels to categories for more than one attribute. On the other hand, they apparently placed so much weight on one single attribute, or perhaps even consciously attended to only one attribute, that identity on that attribute always determined their categorization decision, even when all three of the remaining attributes represented potentially conflicting information. As in the analysis on ambiguous learning items, there was no group (perfect vs. nonperfect) effect ($F < 1$) and no group × item interaction [$F(1,20) = 1.51, p > .23$], again confirming the basic similarity between those who had complete and those who had only partial knowledge of the concept.

In contrast to the 22 individuals who showed a strong reliance on a single attribute, the remaining 26 appeared to use a more even weighting of attributes or a purely holistic, overall-appearance approach. These latter individuals appear to have been just as effective in learning the concept as were the single-attribute individuals. For example, as can be seen in Table 4, there was no significant difference between the groups in terms of the number of correct classifications of the original learning items during transfer ($F < 1$). It appears then that either single-attribute or multiple-attribute, holistic approaches are equally effective for learning the present family-resemblance concepts.

One interesting feature of the present results concerns the overall correct reaction time during learning, which is also shown in Table 4 separately for single-attribute and other types of learners. As can be seen, the single-attribute learners responded more quickly, and the difference was statistically significant [$F(1,46) = 4.75, p < .05$]. This result stands in contrast to the results of previous studies that indicate that fast responding is associated with more holistic types of classification and slow responding is associated with more analytic types of classification (J. D. Smith & Kemler Nelson, 1984; Ward, 1983; Ward et al., 1986). The reason for the discrepancy is not immediately obvious but may reside in the different types of materials or tasks used. However, since the types of

Table 4
Mean Number and Standard Deviations (*SD*) of Correct Classifications of Learning (Learn) and Prototype (Proto) Items on Transfer Trials and Correct Reaction Time (RT) on Learning Trials for Single-Attribute and Holistic Learners

	Response Measure					
	Learn*		Proto†		RT‡	
Group	Mean	*SD*	Mean	*SD*	Mean	*SD*
Single-Attribute	14.59	1.14	4.00	0.00	1.61	0.60
Holistic	14.69	1.71	3.81	0.63	2.23	1.23

*Maximum possible value is 16. †Maximum possible value is 4. ‡Reaction times are in seconds.

responses shown by rapid responders have typically been judged as more primitive than those shown by slow responders, an important implication of the finding is that a holistic mode of learning concepts of the type presented here is not necessarily more primitive than an analytic, attribute-plus-exception mode. If anything, it appears that the attribute-plus-exception mode may be the more primitive one.

The results of Study 1 raise questions about previous demonstrations of holistic modes of learning both in young children and in adults operating under incidental learning conditions (e.g., Kemler Nelson, 1984). It is possible that some of the individuals thought to be exhibiting a holistic mode were actually using an attribute-plus-exception approach. The question regarding young children is explored in Study 2, and that regarding incidental learning is explored in Study 3.

STUDY 2

Kemler Nelson (1984, Experiment 4) found that kindergartners learned concepts of the type depicted in Table 1 as quickly as did fifth-graders. Those same kindergartners performed much more poorly on criterial attribute problems that required a focus on a single experimenter-designated attribute. The interpretation of these results that was favored by Kemler Nelson is that, because of their generally more holistic mode of processing, young children are attuned to similarity-based family-resemblance structure of the former concepts. Alternatively, since an attribute-plus-exception approach is characteristic of rapid responders and since the performance of adults who are rapid responders often mimics that of young children (J. D. Smith & Kemler Nelson, 1984; Ward, 1983; Ward et al., 1986), the good performance of kindergartners on the family-resemblance problems may be due to an analytic approach rather than a holistic one. Given the structure of the family-resemblance categories, as shown in Table 1, the attribute-plus-exception rule is extraordinarily simple in that regardless of which attribute the child notices first, the rule will work; such a rule may have been used by many children. Since Kemler Nelson did not include transfer items in her study with kindergartners, it is impossible to determine which type of approach they adopted.

The second study examined the performance of 5-year-olds and adults on problems of the type used in Study 1. Of interest was the proportion of individuals in each age group exhibiting an attribute-plus-exception pattern and the relative rate of learning shown by analytic versus holistic learners.

Method

Stimuli. The materials were the four clusters of faces described previously. Additional materials were a toy fire truck and a toy police car, which were used with the 5-year-olds as concrete reminders of the categories.

Participants. The participants were 24 children (mean age = 5 years, 2 months) recruited from local preschools and 40 college students enrolled in introductory psychology classes.

Procedure. The procedures were identical to those described for Study 1 with the following exceptions. There were 48 rather than 32 learning trials. These trials consisted of six random orders of the eight learning faces. In addition, the toy fire truck and police car were placed on a small table in front of the children, who were asked to point to the appropriate vehicle as well as to give the verbal label "policeman" or "fireman."

Results and Discussion

Using the criterion described in Study 1, all of the adults and 21 of the 24 children were identified as learners. Of those individuals, 26 of the adults and 11 of the children were identified as single-attribute learners based on the procedures described in Study 1. The proportion of such learners is somewhat higher for adults, but assignment to the different learning groups was found to be independent of age group ($\chi^2 = .91$, $p > .25$).

For the adults, the number of individuals identified as using the attributes of hair, mustache, ears, and nose was 4, 11, 3, and 8, respectively, whereas the comparable numbers for children were 0, 8, 0, and 3. In contrast to the adult group in which some individuals focused on each of the four attributes, the children exhibited attribute learning only with the more central features (nose and mustache) of the faces.

Reaction times and errors for the adult single-attribute learners replicate the major findings of Study 2. Eighteen of the 26 individuals made their last error during the learning trials on one of the two ambiguous faces, and of the 13 who made errors on the original learning faces during transfer, 9 made those errors only on the ambiguous faces. Mean correct reaction times and standard deviations to the ambiguous learning faces and to the other faces are presented in Table 5. As can be seen, correct reaction time to the ambiguous faces was longer than reaction time to the other faces, and the difference was statistically significant [$F(1,24) = 13.49$, $p < .01$]. Table 5 also shows the mean reaction times and standard deviations for critical test items and other test items. As can be seen, reaction time to the critical test faces was longer and the difference was statistically significant [$F(1,24) = 4.28$, $p < .05$].

As in Study 1, adults who performed perfectly on the original learning items presented during transfer were compared to the other idividuals. Of the 23 individuals who performed perfectly, 13 fit the single-attribute pattern and 10 did not. Of the 17 individuals who made errors during transfer, 13 showed a single-attribute pattern and 4 did not. A chi-square test confirmed that assignment to the single-attribute or the holistic group was independent of performance (perfect vs. not perfect) on the original learning items presented during transfer ($\chi^2 = 1.71$, $p > .20$). Also, as found in Study 1, the analysis on reaction times of the attribute learners to the ambiguous learning items versus the other items did not reveal a group (perfect vs. not perfect) effect [$F(1,24) = 1.39$, $p > .25$] or a group $\times$ item interaction ($F < 1$). The analysis on reaction times to the critical test items also failed to reveal a significant group effect ($F < 1$) or a significant group $\times$ item type interaction [$F(1,24) = 1.51$, $p > .23$].

Table 5
Mean Reaction Times and Standard Deviations (*SD*) for Adult Single-Attribute Learners in Study 2 to the Ambiguous Learning Items and Other Learning Items and to the Critical Test Items and Other Test Items

	Items							
	Ambiguous Learning		Other Learning		Critical Test		Other Test	
Group	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
Complete-Knowledge	1.69	0.38	1.32	0.55	1.59	1.06	1.14	0.39
Partial-Knowledge	1.92	0.75	1.51	0.26	1.61	0.83	1.49	0.72
Combined	1.80	0.59	1.42	0.44	1.60	0.93	1.32	0.60

Note—Means are shown separately for those who achieved perfect performance on the learning items presented during transfer (complete knowledge) and for those who made errors (partial knowledge) as well as for the groups combined.

As indicated by the means in Table 5 and as confirmed by the results of these statistical analyses, the reaction time patterns of those who showed complete knowledge of the concept were comparable to those of individuals who only showed partial knowledge. Finally, 10 of the 13 analytic individuals who were perfect responders and 8 of the 13 who were not made their last error on a learning trial to one of the ambiguous faces.

The pattern for the children identified as single-attribute learners was similar to that shown by adults. Ten out of the 11 made their last learning trial error on one of the ambiguous faces, and 10 out of 11 made errors only on the ambiguous faces during transfer trials. Mean correct reaction time to the ambiguous faces (3.03 sec, $SD = .51$) was significantly longer than to the other faces (2.36 sec, $SD = .29$) [$t(10) = 4.05, p < .01$]. The only difference between the pattern shown by adults and children is that the children did not have longer reaction times for the critical test items (2.52 sec, $SD = .86$) than for the other test items (2.36 sec, $SD = .82$) [$t(10) = 1.10, p > .20$]. Thus, for the children identified as single-attribute learners, there is no evidence that their performance was influenced by any of the other attributes.

Only 1 child performed perfectly on the learning items presented during transfer; thus no meaningful comparisons among children are possible. However, the presence of single-attribute approaches in young children poses problems for Kemler Nelson's (1984) analysis of children's performance whether those approaches led to complete knowledge of the concept or not. Children should presumably show little or no evidence of an attempt (successful or otherwise) to learn the category structure on the basis of single attributes.

Analyses of variance were conducted on the number of correct responses to the learning items presented during transfer and on correct reaction times during learning. Both analyses included age and grouping (single-attribute vs. holistic learner) as between-subjects variables. The means relevant to those analyses are presented in Table 6. Consistent with the results of Study 1, there were no differences between single-attribute and holistic learners in terms of accuracy in categorizing the original learning faces during transfer trials ($F < 1$). Reaction time differences between single-attribute and holistic learners are in the same direction as in Study 1, but the effect falls just short of significance [$F(1,57) = 3.15, p = .08$]. The adults performed somewhat better than the children on the learning items [$F(1,57) = 12.87, p < .01$], and they also had shorter reaction times [$F(1,57) = 37.08, p < .01$].

Taken together, the results both confirm and extend those of Study 1. Roughly comparable proportions of children and adults exhibit a pattern of responding consistent with the use of either single-attribute or attribute-plus-exceptions rules. In addition, the children identified as single-attribute learners gave no evidence of having processed any of the other three attributes. Apparently then, at least some young children attempt to learn concepts of the type depicted in Table 1 by adopting an analytic mode of processing rather than the holistic mode implied in Kemler Nelson's (1984, Experiment 4) study.

STUDY 3

The third study examined the implications of the preceding results for studies of incidental learning of concepts. Since much of our learning of real-world concepts may occur incidentally as a result of day-to-day experiences, incidental learning is a crucial topic to consider. The possibility that incidental learning conditions lead the in-

Table 6
Mean Number and Standard Deviations (*SD*) of Correct Classifications of Learning (Learn) and Prototype (Proto) Items on Transfer Trials and Correct Reaction Time (RT) on Learning Trials for the Age Groups and Single-Attribute and Holistic Learners

	Response Measure					
	Learn*		Proto†		RT‡	
Group	Mean	*SD*	Mean	*SD*	Mean	*SD*
	Adult					
Single-Attribute	15.15	1.08	3.96	0.19	1.52	0.43
Holistic	15.43	1.09	4.00	0.00	1.73	0.48
	Child					
Single-Attribute	14.09	0.94	3.91	0.30	2.53	0.27
Holistic	14.20	1.62	3.90	0.32	2.98	1.41

*Maximum possible value is 16. †Maximum possible value is 4. ‡Reaction times are given in seconds.

dividual to be attuned to the holistic properties of objects is particularly intriguing in that it suggests a perfect match between the structure of many natural categories and the manner in which those categories may be learned.

Kemler Nelson (1984) presented concepts structured in such a way that they could be learned by way of a single attribute or by way of a family-resemblance structure. Adults given explicit instructions to learn the concepts were much more likely to learn by criterial attributes, whereas those in incidental learning conditions appeared more likely to learn holistically. One problem, especially in Kemler Nelson's Experiment 2, is that the procedure for assigning adults to the holistic learner group makes it possible that some of the "holistic" adults had actually learned by way of one of the other "noncriterial" attributes. To illustrate, the learning materials used in Kemler Nelson's Experiment 2 can be mimicked by eliminating one pair of faces in Table 1. For example, eliminating Faces 4 and 8 makes it possible for an individual to learn by the critical attribute of hair or by a family-resemblance structure. Given the structure of those categories, the test items used by Kemler Nelson were 1333 and 3111. Although a criterial attribute (hair) learner would classify 1333 in Category A, and a holistic learner would classify it in Category B, an individual who learned by way of another, noncriterial attribute (e.g., ears) plus exceptions would also put that face in Category B. Since Studies 1 and 2 of the present series revealed that people do use attribute-plus-exception rules, it seems likely that at least some of the holistic learners in Kemler Nelson's study were learning by way of one of the noncriterial attributes. Thus, instead of shifting the individual to a holistic mode of processing, incidental learning conditions may simply make the individual less likely to find the specific attribute that the experimenter has designated as criterial. This possibility was tested in Study 3. The procedures were nearly identical to those of Kemler Nelson (1984, Experiment 2) except for the transfer items used.

Method

Participants. Eighty college students enrolled in introductory psychology classes participated.

Stimuli. The faces used in previous studies were also used in Study 3. Other materials used were a fireman's uniform and a doctor's uniform, each of which was drawn on white poster board.

Procedure. Forty-eight participants were tested in incidental learning conditions and 32 were tested in intentional learning conditions. Within each of those groups, participants were evenly divided among the four clusters. The structure of the categories for the learning phase can be described by reference to Table 1. Depending on which attribute was to serve as the criterial attribute, one pair of faces was eliminated from the set depicted. For example, when hair was the criterial attribute, Faces 4 and 8 were not presented; when the nose was the criterial attribute, Faces 1 and 5 were not presented; and so on. Each attribute served equally often as the criterial attribute for each cluster.

Six random orderings of the six learning faces were presented for a total of 36 trials. Immediately following the 36 learning trials, the 36 transfer trials described in Study 1 were presented.

For participants in the intentional condition, learning trials were as described in Study 1. For participants in the incidental condition, the learning trials were presented as a study of stereotypes. On each trial, these subjects were shown a pair of faces from the same category placed above one of the uniforms and were asked to choose which face best fit their stereotype of a doctor or a fireman, depending on the uniform shown. They were not explicitly told to try to learn who were the doctors and who were the firemen and they were given no feedback, but the two faces were always placed above the appropriate uniform for the concept being presented so that participants were in a position to learn the categories incidentally to the task they were performing. Across the 36 learning trials, the two categories were presented equally often. During transfer trials all participants were asked to indicate whether the face presented was a fireman or a doctor, and no feedback was given.

Results and Discussion

Each of the six learning faces was presented twice during the transfer phase, and participants were classified as learners if they correctly categorized the faces on 9 of those 12 presentations. Of the 48 participants in the incidental condition, 28 were learners, and of the 32 in the intentional condition, 27 were learners. The proportions are comparable to those reported by Kemler Nelson (1984, Experiment 2).

Using only those four presentations of the test items that correspond to the type used by Kemler Nelson (1984), of the learners in the incidental conditions, the number of criterial attribute, holistic, and unclassifiable individuals was found to be 2, 17, and 9, respectively. The respective numers for those in the intentional conditions were 12, 13, and 2. All four responses had to be consistent with either a single-attribute or holistic approach for the individual to be assigned to one of those groups. Otherwise, the person was judged to be unclassifiable. The proportions for both conditions are roughly comparable to those reported by Kemler Nelson (1984), and a chi-square test confirmed that assignment to the analytic versus holistic groups was not independent of experimental condition (incidental vs. intentional) ($\chi^2 = 6.98$, $p < .05$). On the surface then, it would appear that incidental learning conditions shift adults away from analytic modes and toward holistic modes of processing. Further tests, however, reveal that this conclusion is erroneous.

Using the same criteria for identifying attribute learning as described in Study 1, 11 of the 17 holistic learners in the incidental condition and 7 of the 13 holistic learners in the intentional condition gave evidence of learning by way of one of the noncriterial attributes. As shown in Table 7, this means that there were only 6 truly holistic

Table 7
Distribution of Types of Learners Based on Only the Critical Test Items Used by Kemler Nelson (1984) and on the Full Set of Transfer Items as Used in Studies 1 and 2

		Type of Learner		
Condition	Classification Procedure	Single-Attribute	Holistic	Unclassifiable
Intentional	Critical Test Items	12	13	2
Incidental	Critical Test Items	2	17	9
Intentional	All Test Items	19	6	2
Incidental	All Test Items	13	6	9

learners in the incidental condition and 6 in the intentional condition. Stated differently, 12 individuals in the intentional condition responded on the basis of the criterial attribute and 7 responded on the basis of some other attribute. The comparable numbers for those in the incidental conditions were 2 and 11. Apparently then, with the materials and procedures used in the present study (and presumably in Kemler Nelson's Experiment 2), incidental learning conditions do not lead adults to adopt more holistic modes (χ^2 = .39, p < .30), but rather make them less likely to discover the specific attribute designated as "criterial" by the experimenter (χ^2 = 7.16, p < .05).

Twenty individuals in the intentional condition and 5 in the incidental condition showed perfect peformance on the original learning items presented during transfer. Of the former group, 15 showed analytic, single-attribute patterns, 3 showed holistic patterns, and 2 were unclassifiable. Of those in the latter group, the respective numbers were 2, 1, and 2. A low proportion of complete learners in incidental conditions seems to be the norm (see, e.g., Kemler Nelson, 1984), and the present results are consistent with that trend. As with the data from children, however, the results from the incidental learning conditions pose problems for Kemler Nelson's (1984) analysis, with or without a large number of complete learners. Presumably, the incidental learners should have shown little or no tendency to analyze the faces in terms of single-component attributes whether that tendency led to complete or only partial category knowledge. This follows from the claim that incidental learning conditions should have led to a more primitive nonanalytic approach to processing the stimuli.

GENERAL DISCUSSION

The results of the present studies indicate that analytic, single-attribute modes are used at least as often as are holistic modes by people learning family-resemblance concepts of the type depicted in Table 1. In that sense, the results are consistent with those of previous reports of analytic approaches to learning family-resemblance concepts (see, e.g., Martin & Caramazza, 1980). Apparently then, the mere presence of a family-resemblance category structure in a set of objects is not in itself a factor that leads a large majority of individuals to adopt as their primary approach the holistic mode, which might facilitate learning of the concept. It is possible that some individuals initially approach the concept-learning task with an analytic, single-attribute strategy and then shift to a holistic one upon realizing that the analytic rule does not work for all stimuli. However, the results of the present studies indicate that many individuals maintain an analytic approach and use an attribute-plus-exception rule (see also Martin & Caramazza, 1980).

The present results also bear on the contrast between incidental and intentional learning situations. Since much of our knowledge about the world may be acquired incidentally, and since most laboratory studies of concept learning have occurred under intentional conditions, it becomes important to determine the extent to which learning under the two different types of conditions differs. To the extent that incidental learning and intentional learning operate according to different principles, laboratory studies of intentional learning may have limited implications for understanding how a large amount of real-world knowledge is acquired. Previous investigators (e.g., Kemler Nelson, 1984) have noted the differences in learning under the two conditions. In contrast, the most notable findings of the present studies are the similarities. When appropriate transfer items were used, it was found that people in the incidental learning conditions were no more likely to show holistic approaches than were individuals in the intentional conditions. The incidental learners acquired less information than the intentional learners, but the information that they acquired was no less likely to be about single attributes.

One intriguing difference between the intentional and incidental conditions is that participants in the incidental condition were less likely to learn about the criterial attribute and more likely to learn about one of the noncriterial attributes. If such a phenomenon also operates in real-life incidental learning situations, it may help to account for at least some of the overgeneralizations and undergeneralizations that occur in the beginning stages of acquiring some concepts. In that sense, the present results are more consistent with earlier featural or component views of the acquisition of word meanings (e.g., Clark, 1973) than with more recent similarity-based interpretations (see, e.g., Kemler, 1983a).

The present results suggest that the interesting parallel often drawn between children's holistic styles and the structure of natural categories may be exaggerated. That is, it is often suggested that the child's holistic style of processing may be advantageous in learning natural categories that have a family-resemblance structure (e.g., Kemler, 1983b). The present results indicate that many young children adopt analytic concept-learning approaches. As with incidental learners, the children acquire less information, but the information that they do acquire indicates that many of them were attending to single attributes.

Implied in the observation that both adults operating under incidental conditions and young children were no more likely to be holistic than were adults operating under intentional conditions is the idea that, in contrast to previous theorizing (e.g., Brooks, 1978; Kemler Nelson, 1984), a holistic mode is not necessarily more primitive than an analytic mode. An additional bit of evidence in support of this claim is that fast responding, which is normally associated with more primitive modes (J. D. Smith & Kemler Nelson, 1984; Ward, 1983; Ward et al., 1986), was associated with an analytic, single-attribute mode of learning. The effect was significant in Study 1 and marginally significant in Study 2.

There were some differences between children and adults, but the differences were not in the direction of children being more holistic. For example, as measured by a difference in reaction times to critical test items and those to other test items, children identified as single-attribute learners were less likely than adult single-attribute learners to be influenced by the levels of the other attributes. One interpretation of this latter finding is that the young children were even more analytic than adults with respect to the particular attributes on which they focused.

Again, it should be noted that Kemler Nelson (1984) found little evidence of learning by way of the noncriterial attributes in her first incidental learning study. The major difference between that first study and the present approach (modeled after Kemler Nelson's second and fourth studies) is that in the former experiment, characteristic values of the opposing category were substituted into the prototype to create the family-resemblance structure for the learning items, whereas in the latter study, only intermediate values were substituted. It may be the case, then, that the amount of holistic processing observed depends on whether the conflicting or intermediate attributes approach is taken (see, however, Martin & Caramazza, 1980). Likewise, it may be the case that predicted age and learning condition effects (Brooks, 1978; Kemler Nelson, 1984) will be most evident for concepts with a conflicting attribute structure. That is, we do not claim that there are no category structures for which children and incidental learners will exhibit more holistic modes than adult intentional learners. However, the present results illustrate that data from concepts with an intermediate attribute structure (e.g., Kemler Nelson, 1984) should not be taken as support for such effects.

It is clear that in simple classification tasks, the extent to which analytic versus holistic processing occurs depends on an interaction between the nature of the stimulus materials, the observer, and the task demands (e.g., Ward et al., 1986). To extend those ideas to the area of concept learning, we suggest that the extent to which learners exhibit single-attribute or holistic modes will depend on a complex interaction between their characteristics (child vs. adult; slow vs. fast responder), the nature of the materials and category structure presented (e.g., conflicting attribute vs. intermediate attribute), and the nature of the task (incidental vs. intentional learning; long vs. short response deadlines).

Specifying the extent to which stimulus, task, and observer factors interact to produce analytic or holistic modes of learning is clearly an important goal for future research. The present approach, which included converging information from appropriate transfer items, reaction times, and errors, appears to be a useful one for gaining such information. Such information can be useful in assessing not only what has been learned but also what approach the participant used in acquiring category information.

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NOTES

1. It might be argued that overall similarity must be computed by separately analyzing the component features of objects and then combining the results of those separate comparisons. However, several recent studies of classification behavior are consistent with the idea that global similarity information is available earlier in processing than is information about component dimensions (J. D. Smith & Kemler Nelson, 1984; Ward, 1983; Ward et al., 1986). Thus a claim of direct access to global similarity information is not unreasonable.

2. We prefer to describe this situation as involving a focus on a single attribute rather than on the overall similarity of the faces. Certain models of concept learning (see Medin & Schaffer, 1978; E. E. Smith & Medin, 1981), however, posit that selective attention to attributes influences the similarity parameter for those attributes. Therefore, objects sharing the attributes that are selectively attended to could be considered, all other things being equal, to be more similar to one another than objects not sharing those attributes. Presumably then *similarity* would always determine responding, and attention to attributes would affect the perceived similarity of objects. Regardless of which interpretation is used, the observable response of placing Face T4 in Category A is consistent with the idea that the observer selectively directed more attention to the single attribute of hair than to the other three attributes.

3. A complete description of the study is available from the first author on request.

4. The 15-out-of-16 rule allowed for the possibility that one of the four responses to critical test items was inconsistent with an attribute rule. Using the more stringent criterion that all four presentations of the critical test items and at least 11 out of the other 12 test item presentations be consistent with a particular attribute rule resulted in 19 individuals' being identified as single-attribute learners. Analyses of data for that smaller sample produced the same results as are reported for the 22 individuals identified by the simpler 15-out-of-16 rule.

5. It should be noted that this analysis involved means calculated on different items and different numbers of responses for different individuals. This is necessarily so since the faces that are *ambiguous* depend on which attribute the individual has focused on and since individuals varied in the number of correct responses during learning.

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