Perceptual Manifestations of an Analytic Structure: The Priority of Holistic Individuation

Glenn Regehr and Lee R. Brooks

Properties that make items perceptually distinctive may not be represented in the dimensional structure used by subjects for analysis. In a classification task, a single dimensional structure, actually used by subjects when analyzing, occurred in several perceptual forms. Two types of perceptual variation were compared: (a) feature individuation, whether a feature occurs in a unique form in different items and (b) holistic individuation, the extent to which an item's features cohere into an individuated whole. These types of individuation had separate effects on exemplar-based classification. However, holistic individuation had priority in that the presence of individuated features did not produce exemplar-based transfer if the item's holistic properties were altered. This priority of holistic individuation occurred whether the subjects had been given the classification rule or had attempted to discover it.

For purposes of comparison and categorization, sets of stimuli can be described in terms of abstract features and dimensions. Evidence from the perception and categorization literature indicates that subjects are quite adept at such description. If the task set out by the experimenter requires it, subjects are both willing and able to decompose each item within a stimulus set into a collection of component parts and to evaluate each separate part on some dimension that varies systematically across the set. Even for sets in which the stimuli are said to be unitary (as opposed to “analyzable,”) Shepard, 1964), subjects will identify and make use of dimensions of systematic variation (see, e.g., Foard & Klemmer Nelson, 1984). As Lockhead (1966) stated, “almost certainly Ss can analyze any set of multidimensional stimuli” (p. 104).

Ideally, the end result of this description process will be an organized, structural representation of the stimulus set that is well suited to analytic activities such as hypothesis testing. To be economical for these purposes, the dimensions of variation that are identified in the description process should have certain properties. First, the dimension of variation itself should be easily identified using familiar verbal description (e.g., size, shape). Second, the potential values on the dimension should be described discretely (often dichotomously), again using familiar verbal descriptions (e.g., large–small, round–square). Finally, the values on a given dimension should be selected such that they are more or less equally distributed across the stimulus set (e.g., 50–50 for dichotomous dimensions). Because of these special properties, the structural representation of the stimulus set might be thought of as resembling the arrays of ones and zeros that are used to describe most stimulus sets in the literature (see, e.g., Table 1).

As we suggested, this type of structural representation is ideal for analytic categorization procedures involving hypothesis testing. Once the stimulus has been identified in terms of its component dimensions, each dimension may be assessed to isolate, across a number of stimuli, the dimensions that help to predict category membership. Subsequent categorization decisions can then be based on the presence (or relative quantity) of the stable relevant features.

However, most natural stimulus sets also provide information that is more idiosyncratic to the individual stimuli, information that certainly is not easily described in terms of a small number of evenly distributed dimensions. This idiosyncratic information is not useful in any analytic attempt to establish an abstracted, probabilistic description of the category. Yet, such idiosyncratic information is likely to be important for learning and remembering individual stimuli. Because, as argued in models of exemplar-based classification (see, e.g., Estes, 1986; Hintzman, 1984; Medin & Schaffer, 1978; Nosofsky, 1984, 1986; L. B. Smith, 1989; Whittlesea, 1987), the memory for an individual will often include information about category membership, this idiosyncratic information can be important for classification. Furthermore, the information can act not only as a basis for classification of old items but also as a basis for the generalization of categorization decisions to stimuli that are judged similar to old items.

However, as already suggested, the pervasiveness of analytic effort suggests that even the idiosyncratic stimuli of natural categories will nonetheless be susceptible to analysis. Thus, although there is reason to believe that many natural stimuli are highly amenable to being dealt with in a nonanalytic, exemplar-based manner during categorization tasks, this does not preclude the analysis of these same stimuli. As a result, there is reason to believe that two sources of information are concurrently available during the classification of many natural stimuli: systematic variations across the stimuli, which are likely to support analytic processes, and idiosyncratic variations in the stimuli, which are likely to support nonanalytic processes.

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This research was carried out under the support of the Natural Sciences and Engineering Research Council of Canada through a graduate scholarship to Glenn Regehr and a grant to Lee R. Brooks.

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PERCEPTUAL MANIFESTATIONS OF AN ANALYTIC STRUCTURE

Table 1

Analytic Structure of the Stimuli Used in Experiment 1

<table>
<thead>
<tr>
<th>Item no.</th>
<th>Body shape</th>
<th>Neck length</th>
<th>Spots</th>
<th>No. of legs</th>
<th>Leg length</th>
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<td>0</td>
<td>1</td>
<td>1</td>
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<tr>
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<td>0</td>
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<tr>
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Note. For each dimension, zeros and ones represent the following values, respectively: body shape, round and angular; neck length, short and long; spots, absent and present; number of legs, two and six; leg length, short and long. Subsets 1 and 2 alternately served as training or transfer items.

The major purpose of the research in this article is to explore the stimulus variation that controls the extent to which both analytic and nonanalytic processes contribute to categorization. Within each experiment, all of the stimuli sets have been constructed from a single analytic structure, such as that shown in Table 1. As can be seen in this table, there are five binary-valued dimensions with equal frequencies of occurrence for each value on each dimension. However, this structure is manifested in very different perceptual forms, as can be seen most clearly in the comparison of the stimuli in Cells A and D of Figure 1. The animals in Cell A appear to be little more than the perceptual analog of the analytic ones and zeros. The most striking characteristic of the set is the fact that, although any two animals chosen at random are clearly different, there is a general uniformity that seems to exist across the set of animals as a whole. By contrast, the animals in Cell D are highly varied perceptually and appear to be quite separate individuals. Although the analytic structures for this set are identical with those for Cell A, the manner in which each analytic structure manifests itself is perceptually distinctive. We predict that the systematic variations in the dimensional structure underlying each stimulus set will be the focus of subjects’ analytic activities, whereas idiosyncratic variations in the perceptual manifestations of that structure (as in the stimuli of Cell D) will control the contribution of similarity to old items as a basis of categorization.

The research presented here addresses two sources of perceptual individuation that are not captured in the analytic structure of an item: (a) feature individuation, the unique manner in which each separate feature is manifested in an individual item, and (b) holistic individuation, the manner in which the separate features composing an item cohere into an individuated whole. Each of these sources is represented as a dimension in the $2 \times 2$ format of Figure 1. Collectively, we refer to these variations as nonanalytic variation, in contrast to the analytic variation that is being kept constant across the four stimulus sets.¹

Feature Individuation: The Unique Manifestation of Separate Features

In the vast majority of laboratory-generated categories, the analytic structure is sufficient to identify uniquely a specific stimulus in the set. That is, if two items have an identical structure on dimensions that are convenient for analysis, then they are the same perceptual stimulus. For most categories outside the lab, however, a given value on an analytic dimension is likely to be realized in a wide variety of perceptual manifestations. This phenomenon is most obvious when comparing exemplars from different subordinate categories. Eagles, hummingbirds, and penguins all have wings, and in the analytic structure used for characterizing birds as opposed to other animals, each would receive a value of 1 on that dimension. Yet, one hardly gets the impression that the wings are interchangeable perceptually.

The distinction between perceptually interchangeable and perceptually unique features is reflected in the two rows of Figure 1. For the two sets in the top half of the figure, features within a set are fully interchangeable. Within either set, for example, every pair of short legs is identical. Thus, for both sets, the separate features of a given animal provide no information beyond that present in the item’s analytic structure. For the two sets in the bottom half of the figure, however, the perceptual manifestation of each separate feature is unique to an animal. Because of this, one need only look at a single feature to identify an individual.

The unique variations across items within a category are often differences that, if a person were asked, could be described verbally. In the normal course of discussion about categorization, however, they are not likely to be mentioned. When conveying information about classification to a novice, for example, one is likely to describe only the analytic structure, trusting the novice to learn, through personal experience, the wide range of perceptual variation that the analytic description was meant to capture. Obviously, any attempt to describe all these variations would make the rules hopelessly unwieldy.

Yet, these unique variations in the perceptual manifestation of the analytic features will have an important impact on the degree of similarity between items within a category. Because of these perceptual variations, two items with the identical analytic structure might nonetheless appear quite different, whereas two items with some differences in their analytic structures might appear more similar. Thus, the degree to which two items are similar in the perceptual

¹ In previous discussions by Brooks (1978, 1987, 1990), the term nonanalytic was used without understanding the value of distinguishing between feature distinctiveness and holistic properties. Either of these sources could logically support similarity to old exemplars as a basis for generalization to new items, so the current usage is generally consistent with the prior usage.
A similar point was made by Medin, Dewey, and Murphy (1983), who suggested that exemplars are composed of category-level information plus idiosyncratic information. One source of idiosyncratic information that they identified is the unique realization of category-level information in specific exemplars. Medin, Wattenmaker, and Hampson (1987) focused on this feature-level idiosyncratic information when creating a set of perceptually distinctive artificial stimuli for their studies. The stimuli in Cell C of Figure 1, in fact, are adaptations of stimuli used by Medin and his colleagues (Medin et al., 1987, Experiments 2B and 3).

In addition to effects on item similarity, however, the unique information given by the concrete features found in both the stimuli of Medin and his colleagues and the stimuli in the bottom row of Figure 1 can have cue value in themselves. It is possible that a particular pair of legs associated with an animal in one category can increase the tendency to respond with that category if those particular legs were to be incorporated into a new animal. The possibility that the concrete manifestation of an abstract stimulus value (e.g., a particular set of two legs) can acquire independent cue value can be seen as a specialization of whatever analytic structure the subject is using to investigate the stimulus. As such, this distinctive feature source of individuation can be treated in a manner compatible with the associationist and information-processing treatments of concept formation.

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**Figure 1.** Stimuli for Experiment 1 (Cells A and D) and Experiment 2 (Cells B and C). (A similar logical structure of binary-valued dimensions underlies each set of animals. However, two aspects of the perceptual manifestation of the underlying structure are varied factorially. One factor, feature individuation, is whether a feature occurs in identical form in different items. The other factor, holistic individuation, is the extent to which an item's features cohere into an individuated whole.)
Holistic Individuation: The Individuated Nature of the Item As a Whole

A second source of perceptual individuation, also likely to be lost in analytical descriptions of the stimulus, is related to the Gestalt perceptual tradition. Early Gestalt psychologists proposed that, for many stimuli, the perceived whole is different than the sum of its component parts. That is, the nature of the object as a whole cannot be captured by an analysis of its components (Kohler, 1929). In the extreme expression of this holistic form of perceptual individuation, the separate features are subsumed in the whole and have no immediate psychological status; this is referred to as strongly holistic processing by Kemler Nelson (1989). In the weaker form distinguished by Kemler Nelson and by J. D. Smith (1989; see also J. D. Smith & Kemler Nelson, 1984), there is some independent specification of the constituent stimulus properties, but the wholes are still dominant in comparisons of similarity between items.

The degree to which a holistic source of individuation is present in a stimulus set is manipulated in the columns of Figure 1. The animals in Cell B, for example, like those in Cell A, have interchangeable features. The features provide no unique information in themselves. Yet, for the animals of Cell B, each set of features seems to cohere into an individuated item. One almost gets a feeling of personality from these animals that is simply lacking in the composite animals of Cell A. By contrast, the animals in Cell C, like those of Cell D, each possess unique perceptual manifestations of the analytic features. At the level of the separate features, each animal is unique. In the animals of Cell C, however, there is a certain consistency of construction across the set. The bodies are largely the same, and the neck, tail, and legs protrude from the same place on the body in each animal. These consistencies result in an overall feeling of sameness across the set, a feeling that the items are perceptually composite in their construction. To the extent that any personality exists in these animals, it likely arises from the unique perceptual manifestation of the head rather than as a result of any coherence of the features into an individuated whole.

The notion that the holistic coherence of a stimulus is important in classification has been examined directly in a number of contexts. Using Saltz's (1972) notion of boundedness, for example, Modigliani (1971, 1974; Modigliani & Rizza, 1971) examined the effect of stimulus integration in a standard classification paradigm. In one set of studies (Modigliani, 1971), the stimuli were composed of four binary dimensions (shape of flowerpot, shape of bloom, shape of leaves, and direction of stem). However, some subjects were trained and tested on stimuli that were organized into coherent pictures of flowers in pots, whereas other subjects were trained and tested on stimuli in which the same features were scattered randomly about the card. Modigliani first trained subjects to use one of the binary dimensions to classify stimuli into one of two categories. For the test phase, he gave the subjects the possibility of using an in-between, uncertain category in addition to the two used in training. He then began altering the logically irrelevant dimensions: adding new values to the preexisting dimensions, removing one or more of the preexisting dimensions, adding new previously unseen dimensions, and so forth. Because the relevant dimension was unchanged in the new stimuli, it was possible to continue placing these stimuli into the appropriate category according to the previously induced rule. If, however, the categorically irrelevant alterations had an effect on subjects' categorization behavior, then stimuli containing these alterations could be placed into the new (gray) category, despite the presence of the defining characteristic for the previously learned categories. Modigliani found that alterations in the logically irrelevant dimensions had a far more disruptive effect on classification for subjects viewing the coherent stimuli than for subjects viewing the randomly scattered stimuli. Thus, when the stimuli were coherent, subjects became uncertain about the classification as analytically irrelevant changes were made.

Using a similar manipulation, Brooks (1976) produced an artificial alphabet that was designed such that words could be constructed in either discrete or glyphic form. A discrete construction was simply a horizontal listing of the characters that made up the word (much like the lexical constructions used here). A glyphic construction was the same set of letters presented in the same order but vertically rather than horizontally. Both at the level of the analytic structure and at the level of the separate perceptual features, therefore, the two constructions contained an equal amount of information about the word. However, the letters were designed such that the horizontal constructions appeared visually as a list of discrete symbols, whereas the vertical constructions were integrated into visually distinct wholes. When subjects were asked to respond rapidly with a unique response to each item (i.e., to pronounce each word), the glyphic constructions produced faster responding than the discrete constructions both initially and after considerable practice. These results suggest that the integrated visual organization of the glyphic stimulus set provided information at the level of whole items that was not captured by the set of discrete features alone.

Clearly, then, the holistic quality of the items within a stimulus set can have an impact on subjects' classification behavior. The point asserted by Brooks and his colleagues (Allen & Brooks, 1991; Brooks, 1978, 1987, 1990; Jacoby & Brooks, 1984; Vokey & Brooks, 1992; Whittlesea, 1987) was that this holistic, nonanalytic quality can result in sufficient individuation to create a basis for the classification of both the item itself and new items that are judged similar to it. Because this source of individuation can be a property of the item as a whole rather than a function of the independent features that compose the item, however, its presence or absence will be represented only inconsistently by the analytic structure. One of the points illustrated by Figure 1 is that simply increasing the distinctiveness of individual features does not necessarily produce items that are easily differentiated as a whole.
Coordination of Analytic and Nonanalytic Resources

We have argued to this point that the properties that make items distinct may not be well represented in the dimensional structure used by the subjects for analysis. Instead, for categories outside of the laboratory, the individuation of stimuli can arise in the specific perceptual manifestation of the analytic structure, be it through the distinctiveness of the features or of the overall item. Thus, expert classifiers may well be able to use properties in the items' analytic structures to produce a useful probabilistic or rule-based representation of the concept but also be able to use the individuating perceptual manifestations of those analytic structures for instance-based categorization procedures.

An issue raised by these considerations is whether these analytic and nonanalytic modes of processing are normally in some sort of a reciprocal relation to one another. For example, applying or discovering an analytic rule might tend to break up a stimulus so that its holistic properties would be less likely to have an effect. On the other hand, it is possible that, with practice, responding to the holistic or distinctive feature properties is faster and less effortful than is rule application. Thus, if a beginner is given a rule for categorizing unfamiliar stimuli, the featural or holistic distinctiveness of the stimuli would not be exploited until a great deal of practice had occurred, at which time the analytic processing would have less control. Another basis for expecting a reciprocal relation is implied by discussions in which holistic processing is characterized as being developmentally or cognitively more primitive than is analytic processing; younger subjects or subjects acting under heavy cognitive load would thus be more likely to respond holistically and correspondingly less likely to respond analytically (these ideas are critiqued for categorization by J. D. Smith, 1989, and J. D. Smith & Shapiro, 1989). An expectation of reciprocal relations between the two is also implied by methods in which a subject's choice of transfer stimuli is interpreted as being either analytic or holistic (Kemler Nelson, 1984; J. D. Smith & Kemler Nelson, 1984), although it is generally not asserted in accompanying discussions.

Research that demonstrated at least some conditions in which analytic and nonanalytic categorization occurred concurrently was reported by Allen and Brooks (1991). Subjects in their experiments were given an easy, perfectly predictive classification rule, followed by training in applying that rule to a set of practice items. On a subsequent transfer test, the accuracy and speed of classifying new items was strongly affected by similarity to previously seen items. New items that were similar to old items in the same category (good transfer, GT, items) were responded to approximately as rapidly and accurately as the old items themselves. New items that were similar to old items in the opposite category (bad transfer, BT, items) produced slower response times and a much higher rate of error. If classification were being done solely by a speeded application of the rule, then one would not have expected more errors to the BT items than to the GT items; in both cases the classification could have been made perfectly by attending to the relevant features. On the other hand, the rule had not simply been abandoned; the subjects made only 45% errors on the BT items rather than scoring closer to 100% as would be expected if they were relying only on similarity to prior exemplars. Thus, in these experiments knowledge of the rule clearly helped to maintain accuracy, but it did not prevent facilitation or interference from item-specific and context-specific knowledge.

In the research presented here, we use the same general method to examine how the information available in the analytic structure and in the perceptual manifestation of that structure contribute to performance on a classification task. This is done by systematically manipulating the presence or absence of each source of perceptual individuation in the stimuli presented to subjects, as depicted in Figure 1.

In addition, we vary whether the subjects are given the classification rule before training. There is good reason to believe that whether the subjects have a rule could affect the way in which they organize the stimuli. In Allen and Brooks's (1991) studies, one group of subjects was not given the rule but was given training trials with feedback on the correct category for each of the training items. These no-rule subjects made over 85% errors on the BT items, indicating that they were classifying the transfer stimuli largely by analogy to specific training items. However, in addition to responding to the holistic or distinctive feature properties of the items, these subjects also reported trying to analyze the stimuli to discover a classification rule. It is possible that comparable no-rule subjects would respond differently to the various types of stimuli used in this article than would subjects who knew the classification rule from the beginning. However, regardless of how these subjects actually do respond, the rule and the no-rule groups represent two important conditions for categorization studies. The no-rule (rule-discovery) procedure is by far the most common method used in studies of classification. As Allen and Brooks (1991) argued, however, providing individuals with a set of classification rules reflects many training conditions found in natural teaching situations. Whether subjects are provided with the rule for classification, therefore, is another manipulated variable in the following studies.

Experiment 1: Initial Demonstration

Experiment 1 was an attempt to replicate Allen and Brooks's (1991) finding of episodic transfer effects using a new set of materials and to provide a clear contrast case in which there are no episodic transfer effects. Allen and Brooks contrasted their perceptual stimuli (drawings) with a set of verbal feature lists. When the same analytic information was given during both training and test in the form of a list of verbal descriptions, there was no sign of analogy effects. Apparently, at least when the subjects were given a sufficient classification rule, there were no effects of similarity to old items unless those items were perceptually and mnemonically distinctive. Here, we were interested in producing a set of perceptual stimuli, namely, the drawings in Cell A, in which the episodic transfer effect was clearly absent. It was with this contrast in mind that we created the stimuli in Cell A and D from Figure 1.
The stimuli were line drawings of imaginary animals. The analytic structure of the stimuli included five orthogonal binary dimensions: body shape (round or angular), neck length (long or short), spots (present or absent), number of legs (two or six), and leg length (long or short). A set was composed of 16 stimuli constructed in pairs (one member for each of two groups of items). Within each pair, the 2 stimuli differed only on the analytic dimension of spots. Across the pairs, each stimulus differed from every other on at least two analytic dimensions. The analytic structure of the 16 animals that composed a set is shown in Table 1.

The stimuli in Cells A and D are the perceptual constructions resulting from the analytic structures of Subset 1 (the top half) of Table 1. The set of animals shown in Cell D was designed with the intention that both sources of perceptual distinctiveness would be present. In each animal, the perceptual manifestation of the features was intended to be unique. Furthermore, each animal was meant to cohere into an individuated whole. In contrast, the animals in Cell A were designed such that neither source of perceptual distinctiveness was present. Here, the features are completely interchangeable and, although the features clearly combine into animals, each stimulus gives the appearance of a composite structure rather than giving any strong sense of individuality.

Our preliminary step is to determine if in adding perceptual distinctiveness to the animals of Cell D, we have fundamentally changed their analytic affordances. Our intent in the experiments in this article is to determine the effect of different perceptual manifestations of the same analytic structure. However, it is possible that the most natural analytic contrasts among the animals of Cell D are not the analytic dimensions that we intended but rather some new dimension. Alternatively, we might have changed the extent to which people rely on any consistent dimensions. With these stimuli, the subjects might use some family resemblance structure involving overall similarity that does not consistently use any dimensions. In Experiment 1A, we told the subjects that the animals they were presented with could be divided into two categories and asked the subjects to give any potential bases that they could see on which this classification could be made. In Experiment 1B, following Mechin et al. (1987), we asked the subjects to group the stimuli into whatever categories seemed natural to them. Mechin et al., using stimuli similar to those in Cell C, found that subjects tended to center idiosyncratically on one analytic dimension to form their categories, a strategy we call analytic simplification. Our question in Experiments 1A and 1B is whether the addition of the perceptually distinctive information in Cell D changed the dimensions available to the subjects or their tendency to use any one dimension. In other words, we want to discover if the analytic dimensions that we think are apparent in the stimuli are also the ones used by the subjects. Subsequently, we test a group that is not given the classification rule (Experiment 1C) and a group that is given the rule (Experiment 1D) to see if there is a difference between the stimuli in Cells A and D in the extent to which the nonanalytic properties of the items contribute to classification performance.

Experiment 1A

Method

Subjects. The subjects were 16 undergraduate students from McMaster University participating for course credit.

Procedure. Each of 16 stimuli (the 8 shown in Cell A of Figure 1 and the 8 shown in Cell D of Figure 1) was placed on a separate 3 X 5-in. file card. Each subject received either the eight animals from Set A or the eight animals from Set B. The eight cards were laid in front of a subject in a random arrangement and the subject was told the following:

The eight animals in front of you can be divided into two groups. If you were told that you had to figure out how the animals divided into the two categories, what would you do? What would you test as potential reasons for dividing the animals? Please name anything you can think of.

During responding, subjects were repeatedly prompted to name any additional methods that they could think of for dividing the animals. Subjects' responses were recorded.

Results

The responses from subjects viewing the percutually uniform set of animals were extremely consistent. Six of the 8 subjects identified the five dimensions present in the analytic structure of the stimuli and no others. The remaining 2 subjects identified the five dimensions but in addition identified the shape of body and shape of head separately (these two dimensions are perfectly confounded). One of these 2 subjects subsequently recognized the confound and indicated that it would not be worthwhile checking the head and body separately.

Of the 8 subjects viewing the percutually distinctive set of animals, 7 identified all five dimensions of variation from the analytic structure; the 8th subject failed to identify the length of neck as a potential dimension. Three subjects also identified shape of head (again, subjects' descriptions of this dimension were fully confounded with angularity of body). Two additional sources of systematic variation were identified (each by 1 subject): the presence or absence of a mouth and whether or not the eye was filled.

Discussion

Generally, the two sets of stimuli did not seem to differ radically in their analytic affordances. For both sets, all five of the original dimensions seemed apparent to subjects. Furthermore, the tendency for subjects to find additional sources of systematic variance in the percutually distinctive stimuli was small. In this experiment, however, subjects were not actually asked to classify the stimuli. Instead, subjects were simply encouraged to treat the items as analytically as possible. It would be worthwhile, therefore, to explore whether subjects continue to use these dimensions when instructions to analyze the stimuli are replaced with instructions to classify the stimuli.
Experiment 1B

The design of this experiment was consistent with the general design presented by Medin et al. (1987). That is, subjects were presented with a set of stimuli and were asked to divide them into two categories in whatever way seemed natural to them. Medin et al. found that subjects tended to focus on a single analytic dimension when forming their categories. If subjects viewing our stimuli also engage in this kind of analytic simplification, the free-sorting technique should reveal the dimensions that subjects actually use for the purposes of classification.

Method

Subjects. The subjects were 32 undergraduate students from McMaster University participating for course credit.

Procedure. Each of 16 stimuli (the 8 shown in Cell A of Figure 1 and the 8 shown in Cell D of Figure 1) was placed on a separate 3 × 5-in. file card. Subjects received either Set A or Set D in a randomly scrambled order. Subjects were asked to lay out the examples, look them over carefully, and place the animals into two categories in any way that seemed appropriate. No restriction was placed on the number of animals that were in each category. Following the categorizations, subjects were asked to describe the criteria by which they classified the stimuli.

Results

In both sets of animals, 15 of 16 subjects reported using a single analytic dimension to classify the animals into the two categories. The breakdown of features reported for both the perceptually uniform animals of Cell A and the perceptually distinctive animals of Cell D is shown in Table 2. The remaining subject viewing the perceptually uniform animals reported using a conjunctive combination of body shape and spots such that one category was defined as requiring both a round body and no spots. The remaining subject viewing the perceptually distinctive set reported using a combination of the number of legs and the length of neck, although the exact instantiation of this combination was unclear. With the exception of one stimulus, this subject placed all stimuli into groups consistent with number of legs. Similarly, one of the subjects who viewed the perceptually uniform animals and who reported using neck length as the criterion placed one stimulus with a long neck in the inappropriate category. With the exception of these 2 subjects, the rest of the subjects categorized all items in a manner consistent with the verbal reports they gave.

Discussion

Consistent with Medin et al. (1987), the results indicate that subjects who are asked to classify a set of items without the benefit of feedback tend to use strongly analytic strategies. That is, the tendency is to use a single analytic dimension as the criterion for classification. Furthermore, this analytic strategy is maintained despite the presence of perceptually idiosyncratic properties. What is more relevant to the present discussion, however, is the fact that the subjects viewing the perceptually distinctive items nonetheless used only dimensions that were present in the original analytic structure. It would appear that no new analytic dimensions emerged in these stimuli during actual classification.

Experiment 1C

Although subjects tend to use only the analytic affordances of the stimuli during a classification task in which they create the categories, in many natural (and experimental) situations the subject’s job is not to create the categories but to learn them. In the majority of experimental designs, this learning arises by way of feedback about subjects’ decisions. The following experiment was conducted to determine the degree to which this category-learning procedure induces subjects to make use of the nonanalytic information to support generalization to new items. As in the experiments by Allen and Brooks (1991), the transfer phase included items that were similar to old items in the same category (GT items) and new items that were similar to old items in the opposite category (BT items). Because these items were balanced for all of the analytic dimensions, differential accuracy on these items can serve as an index of whether the subjects were using similarity to old items, whether on the basis of distinctive individual features or holistic properties, to support categorization.

Method

Subjects and design. The subjects were 32 undergraduate students from McMaster University participating for course credit. The 16 animals comprising a set were divided into two categories (builders and diggers) on the basis of a three-feature additive rule. That is, three of the five dimensions were designated as categorically relevant dimensions, and two of the dimensions were designated as categorically irrelevant dimensions. For the three categorically relevant dimensions, one of the values was designated a builder feature, and the other value was designated a digger feature. If an animal possessed a majority of builder features, it was a member of the builder category. If it possessed a majority of digger features, it was a member of the digger category. All eight possible combinations of the binary values for the relevant features were present within each subset of eight animals, so a given feature classification was consistent with the classification of the animal in 75% of the cases. The values of the two irrelevant dimensions appeared equally often in animals of each category and therefore were definitionally nondiagnostic.

Table 2
Number of Subjects Naming Each Feature as the Sole Criterion for Classification When No Feedback Was Provided (Experiment 1B)

<table>
<thead>
<tr>
<th></th>
<th>Perceptual form</th>
<th>Body shape</th>
<th>Neck length</th>
<th>Spots</th>
<th>No. of legs</th>
<th>Leg length</th>
<th>Multiple features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uniform</td>
<td>7</td>
<td>2</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Distinctive</td>
<td>5</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Note. Perceptually uniform and perceptually distinctive conditions refer to Cells A and D of Figure 1.
Four different rules were used to categorize the animals. The features associated with builders for each of these four rules were as follows:

1. Long legs, angular body, and spots present.
2. Short legs, long neck, and spots present.
3. Six legs, angular body, and spots present.
4. Two legs, long neck, and spots present.

These rules were chosen to counterbalance four of the five dimensions across relevance to classification. However, the presence or absence of spots (the only dimension that separated the two members of a stimulus pair) was always a relevant dimension. This created four critical conditions:

1. Good old (GO)—A training item with a twin transfer item that will be in the same category.
2. Bad old (BO)—A training item with a twin transfer item that will be in the opposite category.
3. GT—A transfer item seen for the first time in the test phase that (according to the three-feature additive rule) is in the same category as its twin training item.
4. BT—A transfer item seen for the first time in the test phase that (according to the three-feature additive rule) is in the opposite category to its twin training item.

Examples of the four conditions for each set of animals are shown in Figure 2. The four rules and the counterbalancing of training and transfer subsets ensured that each of the 16 stimuli appeared equally often in each of the four critical conditions. For the purposes of analyses, the GO and BO items were treated as a single set of eight old items.

As argued by Allen and Brooks (1991), differences in performance on GT and BT items can shed light on the nature of the information that subjects acquire and make use of during classification training. The GT items operate largely as a baseline condition. Perceptually, each of these items is very similar to an old item that, according to the analytic rule, is in the same category. If the GT items are classified as rapidly and as accurately as the old items, then we have some indication that subjects can generalize their classification knowledge from the old items, on which they have had training, to new items, with which they have had no prior experience. The rapid and accurate classification of GT items, however, indicates little about the type of classification knowledge being generalized. For GT items, as for old items, the analytic and nonanalytic sources of information lead to the same category decision. Thus, the use of either analytic or nonanalytic sources of information will result in accurate classification.

By contrast, BT items are designed such that the analytic and nonanalytic sources of information are in opposition. Perceptually, each of the BT items, like each of the GT items, is very similar to a single old item. Yet, because of the change in the analytic dimension of spots, each BT item is in the category opposite to the old item it resembles. Thus, nonanalytic categorization procedures based on perceptual similarity will lead to one decision, whereas the analytic application of the rule will lead to the opposite decision. This conflict between the analytic and nonanalytic categorization processes is likely to be manifested both in the accuracy.

---

**Figure 2.** Examples of the transfer conditions used in all of the experiments (for each of the stimulus sets used in Experiment 1). (In this example, the categorization rule is as follows: At least two of long legs, angular body, and spots indicates a builder. For good transfer pairs, the transfer item is in the same category as its training twin according to the analytic rule. For bad transfer pairs, the transfer item is in the category opposite to its training twin according to the analytic rule. A difference in errors and classification times between good and bad transfer items is interpreted as showing an effect of similarity to old items.)
with which BT items are classified (according to the analytic rule) and in the speed with which accurate decisions are made. Thus, if subjects are using analytic categorization procedures exclusively, then the BT items should be classified as rapidly and as accurately as the GT items. If subjects are using nonanalytic categorization procedures exclusively, then BT items will be placed consistently in the category opposite to that dictated by the rule (the error rates will be very high compared with GT items), but the process of categorization should be as rapid for the BT items as for the GT items. Finally, if both nonanalytic sources of information and analytic sources of information have an impact on classification behavior, then we would expect the classification of BT items to be both slower and only somewhat more error prone than the classification of GT items.

Procedure. The materials were presented on the screen of an Apple Macintosh II computer. Subjects’ categorical decisions were made by pressing one of two keys on the Macintosh keyboard, and the elapsed time from the presentation of the stimulus until the response of the subject was measured. Each subject was tested individually. Subjects were in either the perceptually uniform group or the perceptually distinctive group, which differed only in the type of items that subjects were asked to classify. Each subject was told that there were two categories of items and that the subject’s job was to try to place each item into the appropriate category. It was suggested to subjects that they would likely just be guessing to begin with but that the computer would be correcting their decisions so that, with time, they would become better at placing items in the correct categories. These instructions were meant to be as neutral as possible with respect to analytic or nonanalytic methods of classification. The subject was then presented with a set of eight training items (the GO and BO items) repeated five times. The order of items was randomized within each repetition. For each of the 40 trials, subjects were to classify the item as quickly as possible without sacrificing accuracy. Feedback was given after each classification.

The transfer phase contained the eight old items and the eight transfer items. Each item was seen once. The order of the items was random except that a transfer item was always separated from its old twin by at least two items. Subjects were informed that the eight old items would now be supplemented by eight new items and were asked to continue classifying as they had been all along. No feedback was given during this phase.

Results

Analyses were performed on both the proportion of errors and the subjects’ median response times for correct classifications made during the transfer phase of the experiment. An error in classification was identified as the failure to place the animal in the category consistent with the three-feature additive rule. These analyses involved two 2 × 3 analyses of variance (ANOVA)s with one between-subjects factor, perceptual form (Uniform vs. Distinctive), and one within-subjects factor, transfer type (Old vs. GT vs. BT). A summary of the data is presented in Table 3. A criterion p value of .05 was used for all analyses.

Errors. The pattern of errors made on the perceptually uniform and perceptually distinctive stimuli were clearly different, as evidenced by a significant interaction between perceptual form and transfer type. \( F(2, 60) = 15.67, M_S = 0.04. \) To explore these results further, two separate one-way ANOVAs were performed, one for each of the two perceptual forms. Analysis of errors in the perceptually uniform condition revealed that across transfer type, the mean error rate for subjects (0.359) was significantly below chance, \( F(1, 15) = 11.09, M_S = 0.07, \) and that the error rates for old, GT, and BT items did not differ reliably, \( F(2, 30) = 2.52, M_S = 0.04. \) By contrast, an analysis of errors made on the perceptually distinctive stimuli revealed a significant effect of transfer type, \( F(2, 30) = 53.22, M_S = 0.04. \) A subsequent set of paired t tests revealed no reliable difference between old and GT items, \( t(15) = 1.77, \) but indicated that the BT items were significantly more error prone than the GT items, \( t(15) = 6.60. \)

Response Times. Analysis revealed no reliable difference in the overall response times of subjects viewing the perceptually uniform stimuli (1,144 ms) and subjects viewing the perceptually distinctive stimuli (977 ms), \( F(1, 30) < 1. \)\(^2\) Furthermore, although the patterns of response times were different for subjects viewing the perceptually uniform stimuli and subjects viewing the perceptually distinctive stimuli (the interaction was reliable, \( F(2, 60) = 3.72, M_S = 85.387), \) subsequent one-way ANOVAs performed for each of the perceptual forms revealed no difference in the speed of responding to old, GT, and BT items either.

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* As noted by Allen and Brooks (1991), there is a confound in the comparison of good transfer and bad transfer items, in that half of the good transfer items possess all three features consistent with their category membership, whereas this is true for none of the bad transfer items. However, their findings were the same whether only items with two consistent features or all the items were included in the analysis. Analysis of data from the experiments presented throughout this article repeatedly failed to find significant differences between good transfer items possessing three features consistent with category membership and good transfer items possessing only two features consistent with category membership. Thus, the analyses presented throughout this article include all items in the interest of obtaining more stable estimates.

---

Table 3

<table>
<thead>
<tr>
<th>Measure</th>
<th>Uniform(^a)</th>
<th>Distinctive(^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion error</td>
<td>( M, SD )</td>
<td>( M, SD )</td>
</tr>
<tr>
<td>Old</td>
<td>.320, .144</td>
<td>.109, .128</td>
</tr>
<tr>
<td>GT</td>
<td>.469, .196</td>
<td>.187, .194</td>
</tr>
<tr>
<td>BT</td>
<td>.328, .220</td>
<td>.766, .232</td>
</tr>
<tr>
<td>( BT - GT )</td>
<td>-.141</td>
<td>.579*</td>
</tr>
<tr>
<td>Median response time</td>
<td>( M, SD )</td>
<td>( M, SD )</td>
</tr>
<tr>
<td>Old</td>
<td>1,173, 721</td>
<td>847, 520</td>
</tr>
<tr>
<td>GT</td>
<td>1,140, 770</td>
<td>1,123, 676</td>
</tr>
<tr>
<td>BT</td>
<td>1,091, 628</td>
<td>1,090, 480</td>
</tr>
<tr>
<td>( BT - GT )</td>
<td>-49</td>
<td>-33</td>
</tr>
</tbody>
</table>

Note. Old = old item in transfer phase; GT = good transfer item; BT = bad transfer item.

\(^a\) Stimuli from Figure 1, Cell A. \(^b\) Stimuli from Figure 1, Cell D.

\(* p < .05.\)
for the perceptually uniform condition, $F(2, 30) = 1.48$, $M_{S_e} = 48.405$, or the perceptually distinctive condition, $F(2, 30) = 2.98$, $M_{S_e} = 122.369$.

Discussion

Frequently, subjects faced with stimuli that contained no contrastive perceptual information beyond that found in an analytic description showed evidence of analytic classification behavior. That is, the accuracy rate on the 16 items in the transfer phase was reliably better than would be predicted by chance. Furthermore, these subjects seemed to apply this analytic, category-level information consistently across all items (old and new alike). These conclusions are supported by anecdotal evidence collected during postexperimental interviews. During these interviews, subjects were asked the basis for their categorical decisions during the transfer phase. All subjects reported having considered features reported during training, to establish category membership on the basis of single analytic feature. Although all subjects indicated a lack of satisfaction with any single feature, a number of subjects viewing the perceptually uniform stimuli reported using a single feature rule in the transfer phase regardless of their dissatisfaction. Consistent with these reports, a review of the data indicated that for 9 of the 16 subjects in this condition, 100% of their classification responses could be accounted for by reference to a single analytic feature. For 7 of these subjects, the feature chosen was one of the category-relevant features. Data from this condition, then, support the findings of the early literature on hypothesis testing, which indicate that when the stimuli are perceptually uniform, subjects' attempts at classification tend to be conscious and analytic (e.g., Bruner, Goodnow, & Austin, 1956).

Because of the strong tendency for subjects in the uniform stimulus condition to use analytic simplification, some discussion of the classification patterns that result from this strategy is necessary. As mentioned earlier, although no single feature is perfectly predictive, the three-feature additive rule used in this study ensures that the use of a single relevant feature in isolation result in an overall accuracy rate of 75%. It should be noted, however, that this overall accuracy rate is not consistent across the three transfer conditions. When a single relevant feature is used, the classification of old items will be 75% accurate. However, use of any one of the three relevant features in isolation results in differential accuracy rates for GT and BT items. Using spots alone, for example, results in 100% accuracy on BT items but only 50% accuracy on GT items, whereas the use of either of the other two relevant dimensions will result in 100% accuracy on GT items but only 50% accuracy on BT items. The first pattern, resulting from the exclusive use of spots, is opposite to the pattern that we would expect to see when nonanalytic categorization strategies are used. Thus, the presence of a large number of subjects using spots as the classification criterion would tend to mask the presence of any nonanalytic categorization behavior displayed by the remaining subjects. By contrast, the exclusive use of either of the other two features mimics the pattern that we would expect to see when nonanalytic classification strategies are being used. As a result, when partial learning is likely (as it is in the no-rule conditions of the experiments presented in this article), it is important to isolate subjects that used analytic simplification for classification and to examine the pattern of results displayed by the remaining subjects for evidence of nonanalytic classification strategies. When the 9 subjects using analytic simplification in the uniform stimulus condition were removed from the analysis, the difference between GT items (with a mean error rate of 0.571) and BT items (with a mean error rate of 0.607) was small and not reliable.

When stimuli possessed perceptual distinctiveness (both in the unique perceptual manifestations of the separate features and in the form of holistic individuation), this distinctiveness seemed to have a strong impact on classification behavior. First, memory for the category of old items was quite good. Furthermore, compared with the perceptually uniform condition, there was a huge rise in the error rate for BT items and a corresponding drop in the error rate for GT items. These results are consistent with the use of a nonanalytic classification strategy based on the specific similarity of the new item to a previously seen item. These conclusions are again supported by the postexperimental interview. When subjects viewing the perceptually distinctive animals were asked how they classified animals in the transfer round, the majority indicated that they classified items by placing them in the same category as the old items they resembled. When asked how old items were classified, subjects generally indicated that they simply memorized the items during training. Consistent with these postexperimental statements, none of the subjects viewing the perceptually distinctive stimuli displayed a response pattern that could be explained with reference to a single feature.

This is not to say, however, that the perceptually distinctive stimulus condition eliminated all efforts at analysis. When explicitly asked, all subjects indicated that their classification attempts in the early training rounds were characterized by attempts to establish category membership on the basis of a single analytic feature. As a result, these subjects could, when asked, identify many of the analytic features that varied and could, in many cases, identify at least one feature that was correlated with category membership.

Thus, the findings of this study are, again, consistent with those of Medin et al. (1987). First, conscious analytic decisions about category membership seem to be based not on a family resemblance principle but on very simple, single dimensional rules. In fact, these data suggest that this tendency toward analytical simplification is sometimes powerful enough to persist even when repeated feedback indicates that a single feature is insufficient for accurate classification. Furthermore, anecdotal evidence from the postexperimental interviews suggests that this tendency for analytic behavior to focus on single features in isolation is present both in perceptually uniform and perceptually distinctive stimuli. Our data also suggest, however, that when idiosyncratic perceptual information is available as an aid to clas-
sification, this information is likely to take precedence over subjects' tentative analytic information.

**Experiment 1D**

Allen and Brooks (1991) showed that the effect of similarity to prior training items also occurred when subjects’ analytic categorical information was in no way tentative. Prior to training, they provided subjects with the three-feature additive rule that would result in perfect classification. Following a fairly short training session (i.e., a short period of practice in applying the analytic rule), subjects showed evidence of nonanalytic, single-item transfer. In Experiment 1D, we attempt to replicate this finding with the perceptually distinctive animals of Cell D in Figure 1. Furthermore, we attempt to contrast this nonanalytic effect in the perceptually distinctive animals with a clear lack of the effect in the perceptually uniform stimuli of Cell A.

**Method**

Subjects. The subjects were 32 undergraduate students from McMaster University participating for course credit.

Procedure. The procedure of this experiment was identical with that of Experiment 1C except that, prior to the presentation of animals in the training round, subjects were presented with the three-feature additive rule that would result in perfect classification.

**Results**

Analyses were performed on both the proportion of errors and the subjects’ median response times for correct (rule-consistent) responses made during the transfer phase of the experiment. These analyses involved two $2 \times 3$ ANOVAs with one between-subjects factor, perceptual form (Distinctive vs. Uniform), and one within-subjects factor, transfer type (Old vs. GT vs. BT). A summary of the data is presented in Table 4.

Errors. An analysis of error data revealed that subjects viewing the perceptually distinctive stimuli were, in general, more likely to make errors in classification than subjects viewing the perceptually uniform stimuli, $F(1, 30) = 18.78, MS_e = 0.02$. Furthermore, there was a significant main effect of transfer type, $F(2, 60) = 5.00, MS_e = 0.03$. The pattern of errors, however, was different for subjects viewing the perceptually uniform stimuli and subjects viewing the perceptually distinctive stimuli; the interaction between perceptual form and transfer type was significant, $F(2, 60) = 4.30, MS_e = 0.03$. A series of one-tailed paired $t$ tests confirmed the earlier predictions. For the perceptually uniform animals, old items showed no advantage over GT items, $t(15) = 0.62$, and GT items showed no advantage over BT items, $t(15) = 0.00$. For the perceptually distinctive animals, again, there was no advantage for old items over GT items, $t(15) = 0.19$. The classification of the distinctive BT items, however, was significantly more error prone than the classification of the distinctive GT items, $t(15) = 2.11$.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Uniform$^a$</th>
<th>Distinctive$^b$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion error</td>
<td>$\begin{bmatrix} M &amp; SD \ Old &amp; .031 &amp; .056 \ GT &amp; .047 &amp; .101 \ BT &amp; .047 &amp; .136 \end{bmatrix}$</td>
<td>$\begin{bmatrix} M &amp; SD \ Old &amp; .094 &amp; .109 \ GT &amp; .109 &amp; .153 \ BT &amp; .328 &amp; .212 \end{bmatrix}$</td>
</tr>
<tr>
<td>Median response time</td>
<td>$\begin{bmatrix} M &amp; SD \ Old &amp; 863 &amp; 295 &amp; 894 &amp; 324 \ GT &amp; 894 &amp; 420 &amp; 1.018 &amp; 414 \ BT &amp; 942 &amp; 292 &amp; 1.295 &amp; 396 \ BT - GT &amp; 49 &amp; 277* \end{bmatrix}$</td>
<td>$\begin{bmatrix} M &amp; SD \ Old &amp; 863 &amp; 295 &amp; 894 &amp; 324 \ GT &amp; 894 &amp; 420 &amp; 1.018 &amp; 414 \ BT &amp; 942 &amp; 292 &amp; 1.295 &amp; 396 \ BT - GT &amp; 49 &amp; 277* \end{bmatrix}$</td>
</tr>
</tbody>
</table>

Note. Old = old item in transfer phase; GT = good transfer item; BT = bad transfer item. $^a$ Stimuli from Figure 1, Cell A. $^b$ Stimuli from Figure 1, Cell D. * $p < .05$.

Response times. Analysis of subjects’ median response times for correct responses revealed a very similar pattern to that found in the error data. Again, the pattern of response times was different for subjects viewing the perceptually uniform stimuli than for subjects viewing the perceptually distinctive stimuli, as evidenced by a significant interaction between perceptual form and transfer type, $F(2, 60) = 3.51, MS_e = 70.311$. A series of one-tailed paired $t$ tests revealed a pattern of results consistent with the error data. For the perceptually uniform animals that were correctly categorized, there was no significant difference in response times between old items and GT items, $t(15) = 0.41$, and no significant difference in response times for GT items and BT items, $t(15) = 0.52$. For perceptually distinctive animals that were classified correctly, the difference in response times between old items and GT items was not reliable, $t(15) = 1.66$. However, the correct classification of BT items was significantly slower than the correct classification of GT items, $t(15) = 1.78$.

**Discussion**

Consistent with Allen and Brooks (1991), this experiment provides evidence that, despite subjects’ awareness of a perfectly predictive analytic rule for categorization, idiosyncratic information in the perceptual manifestation of the analytic structure can lead to more nonanalytic, exemplar-based categorization. If an item was perceptually similar to a previously learned item that, according to the analytic rule, was in the opposite category, then efforts to classify the new item were slower and more error prone. As in Allen and Brooks’s data, it would appear that the rule for classification was still present and operating, because the error rate on BT items was substantially lower in this study than in Experiment 1C where no rule was provided for subjects. However, the use of the rule seems to have been modified to accom-
modate the idiosyncratic information provided in the perceptually distinctive stimuli.

These effects cannot be a function merely of items’ similarity at the level of the analytic structure. Evidence for similar effects in the perceptually uniform animals of Cell A is clearly lacking. In these animals, there were no reliable differences between GT and BT items in either classification accuracy or classification speed. In fact, there were not even any reliable differences between the transfer items and the items on which subjects had been given previous classification training.

This set of studies, then, demonstrates the importance of perceptually idiosyncratic information in classification behavior. Because the studies were designed specifically to highlight this importance, however, the perceptually distinctive stimuli were created to be perceptually individuated in both the unique manner in which the separate analytic features were manifested and the individuated manner in which the animals cohered into wholes. The perceptually uniform stimuli lacked both these sources of individuation. As a result of this confound, these studies have not addressed the relative contribution of each source of perceptual distinctiveness to the phenomenon of instance-based categorization observed.

One strong possibility is that the effect of each is mediated by the task demanded of the subject. Using pseudowords as stimuli, Whittlesea (1987) showed that if subjects are encouraged to treat stimuli holistically as pronounceable words, then later classification of new items follows a nonanalytic, exemplar-based pattern of responding. When training encourages subjects to treat the items as a series of independent cues to category membership, however, the classification of new items is far more analytic. Similarly, J. D. Smith and Shapiro (1989) used the rapid pronunciation of pseudowords presented on the left or right half of the page as an incidental learning condition. Consistent with Whittlesea, they found that these conditions resulted in categorical strategies that were less analytic.

By analogy, in the studies presented earlier, it is possible that subjects provided with an explicit rule were being encouraged to break up the stimulus in a way that subjects receiving no explicit rule were not. If this is the case, then it would suggest that the nonanalytic pattern of responding on perceptually distinctive items in the no-rule experiment was being driven by the items’ holistic distinctiveness, whereas the nonanalytic intrusions in the rule experiment were more a function of the unique manifestation of the analytically relevant features.

Experiment 2: Orthogonalizing the Two Sources of Perceptual Individuation

To examine the effect of each source of perceptual individuation on classification behavior and to explore how each source interacts with our training conditions, we attempt to look at the effect of each source of perceptual distinctiveness in isolation. We return, therefore, to the 2 × 2 matrix of Figure 1 and fill in the off-diagonal cells. These remaining two cells complete the attempt to orthogonalize the two types of nonanalytic information. In the two experiments presented here, we look at the interaction of each of these two forms of perceptual information with the two training conditions we have discussed.

Experiment 2A: The Effect of Holistic Individuation

Method

Materials. Stimuli were a single set of 16 animals constructed using the same procedure as that described in Experiment 1 except that the dimension of leg number (two vs. six) was replaced by the dimension of tail length (short vs. long). Thus, all animals had two legs that systematically varied across animals in length only. The logical combinations of features (zeros and ones), however, remained identical with those displayed in Table 1. Perceptually, these animals were designed to have interchangeable features but to nonetheless cohere into individuated wholes. One of the two subsets composing the 16 stimuli that resulted from these constraints can be seen in Cell B of Figure 1.

Subjects and design. Subjects were 32 undergraduate students at McMaster University participating for course credit. The design was identical with that of Experiment 1 except that the features associated with builders in each of the four rules were altered as follows:

1. Long legs, angular body, and spots present.
2. Short legs, angular body, and spots present.
3. Long legs, round body, and spots absent.
4. Short legs, round body, and spots absent.

Procedure. Both the presentation of stimuli and the design of the training and transfer rounds were identical with those described in Experiment 1C. Subjects were in either the rule training condition or the no-rule training condition. The groups differed only in the instructions they received prior to the training phase. As in Experiment 1C, subjects in the no-rule group were told that there were two categories of items and that they were to try to place items in the appropriate categories. It was suggested that they would likely be guessing at the beginning but that the computer would be correcting their decisions so that, with practice, they would become better at classifying items. Consistent with Experiment 1D, subjects in the rule group were presented with the three-feature additive rule that would result in perfect classification of builders and diggers and were told that they would be given practice in applying the rule to a set of training stimuli.

Results

Analyses were performed on the proportion of errors and on the median response times for correct categorizations made by subjects in the transfer phase of the experiment. These analyses involved two 2 × 3 ANOVAs with one between-subjects factor, training condition (Rule vs. No Rule), and one within-subjects factor, transfer type (Old vs. GT vs. BT). A summary of the data is presented in Table 5.

Errors. Analysis of the error data revealed that subjects in the no-rule condition were, in general, more error prone than subjects in the rule condition, \(F(1, 30) = 23.75, M_S^2 = 0.03\). Furthermore, there was a significant main effect of transfer type, \(F(2, 60) = 10.26, M_S^2 = 0.03\). These main effects, however, must be interpreted in light of a significant interaction between training condition and transfer.
Table 5
Mean Responses to the Holistically Individuated Stimuli With Perceptually Interchangeable Features
(Panel B of Figure 1) Following Rule or No-Rule Training (Experiment 2A)

<table>
<thead>
<tr>
<th>Measure</th>
<th>Training condition</th>
<th>No rule</th>
<th>Rule</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>Proportion error</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Old</td>
<td>.156</td>
<td>.132</td>
<td>.052</td>
</tr>
<tr>
<td>GT</td>
<td>.146</td>
<td>.225</td>
<td>.063</td>
</tr>
<tr>
<td>BT</td>
<td>.500</td>
<td>.261</td>
<td>.083</td>
</tr>
<tr>
<td>BT – GT</td>
<td>.454*</td>
<td>.020</td>
<td></td>
</tr>
<tr>
<td>Median response time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Old</td>
<td>802</td>
<td>273</td>
<td>909</td>
</tr>
<tr>
<td>GT</td>
<td>853</td>
<td>296</td>
<td>904</td>
</tr>
<tr>
<td>BT</td>
<td>850</td>
<td>287</td>
<td>1,136</td>
</tr>
<tr>
<td>BT – GT</td>
<td>3</td>
<td>236*</td>
<td></td>
</tr>
</tbody>
</table>

Note. Old = old item in transfer phase; GT = good transfer item; BT = bad transfer item.
*p < .05.

type, \( F(2, 60) = 7.63, MS_e = 0.03 \). A subsequent set of paired \( t \) tests indicated that, for the rule training condition, there was no significant difference in the error rates of old versus GT items, \( t(15) = 0.35 \), and no significant difference in the error rates of GT versus BT items, \( t(15) = 0.52 \). For the no-rule training condition, there was also no significant difference in the error rates of old versus GT items, \( t(15) = 0.16 \). The classification of BT items, however, was significantly more error prone than classification of GT items in the no-rule training condition, \( t(15) = 4.77 \).

Response times. As with the error rates, the pattern of response times differed for subjects receiving rule training and subjects receiving no-rule training, as evidenced by a significant interaction between training and transfer type, \( F(2, 60) = 4.66, MS_e = 19.588 \). A subsequent set of paired \( t \) tests indicated that, for the no-rule training condition, there was no reliable difference in the speed of responding to old versus GT items, \( t(15) = 1.49 \), and no reliable difference between GT and BT items, \( t(15) = 0.12 \). For the rule training condition, there was no significant difference in the speed of responding to old versus GT items, \( t(15) = 0.18 \). The classification of BT items, however, was significantly slower than the classification of GT items, \( t(15) = 3.22 \).

Discussion
Subjects viewing these holistically individuated items showed evidence of episodic effects in classification. In the no-rule condition, BT items were more prone to errors than GT items, suggesting some use of the similarity to previously learned exemplars as a source of classification information. Of the 16 subjects in the no-rule condition, 3 subjects showed patterns of responding consistent with classification on the basis of a single feature rule. This suggests a tendency in some subjects to treat these stimuli as a set of independent parts capable of being recombined. When these subjects were removed from the analysis, however, the remaining subjects showed on average an even greater discrepancy between the error rates on GT and BT items (the error rate for GT items dropped to 0.096, and the error rate for BT items rose to 0.577). Generally, then, the effects here do not seem to be as powerful as the effects seen in the stimuli that possessed both sources of idiosyncratic perceptual information, but some evidence of an effect is present.

In the rule condition, the effect is apparent in subjects’ response times. Although all items were classified with approximately equal accuracy (old, GT, and BT items alike), accurate classification of the BT items was slow in comparison with the other items. This suggests that, again, the episodic effect was present, but in a weaker form than previously seen. It would appear that the conflict between the classification rule and the holistic similarity to old items resulted in some hesitation when subjects classified the BT items. Thus, under both training conditions, similarities in the holistic quality of items seem to have affected subjects’ classification behavior, despite the lack of any unique perceptual information in the manifestations of the items’ independent features. In Experiment 3, we address the issue of whether such effects are most appropriately thought of as resulting from holistic properties from or relational properties between the features that are substantially less encompassing than suggested by the term holistic.

A tentative hypothesis that we entertained was that, with these stimuli, knowledge of the rule would eliminate the response to the holistic quality that was evident in the no-rule group. Because each feature was identical in every animal in which it occurred, it might be easy for the subjects to search for the exact perceptual appearance of the features named in the rule, thereby breaking up the overall appearance of the animal. Because the subjects in the no-rule group did not know which features to search for, they might have been more sensitive to the overall organization of the item. Although the pattern of errors indicated less analytic generalization in the rule group than in the no-rule group, the inconsistent results with the response times prevent taking this as support for the hypothesis.

Experiment 2B: The Effect of Perceptually Unique Features

Materials

The stimuli for this experiment were adapted from the stimuli of Medin et al. (1987). Consistent with the stimuli created by Medin and his colleagues, the animals in this study varied systematically on only four analytic binary dimensions: head shape (round vs. angular), body markings (stripes vs. spots), leg number (four vs. eight), and tail length (short vs. long). As before, two subsets of eight animals were used (one as the training set and one as the transfer set). For one subset (shown in Cell C of Figure 1), five animals were duplicates of the animals used by Medin et al. The remaining three animals were altered in the di-
mension of tail length to produce the appropriate analytic structure for the set. We suspected that, although each of these animals had unique manifestations of the isolated features, the features in a given animal did not cohere into a differentiated individual, so the set in general gave the impression of being composite. The matched counterpart for each of these animals in the second subset was created by altering only the analytic dimension of body markings.

Method

Subjects. Subjects were 32 undergraduate students from McMaster University participating for course credit.

Procedure. The design and procedure were identical with those of Experiment 2A except that the features associated with the builder category in each of the four rules were as follows:

1. Eight legs, angular head, and spots.
2. Four legs, angular head, and spots.
3. Eight legs, round head, and stripes.
4. Four legs, round head, and stripes.

Tail length was the single definitionally irrelevant dimension.

Results

Analyses were performed on the proportion of errors and on the median response times for categorizations made by subjects in the transfer phase of the experiment. These analyses involved two 2 x 3 ANOVAs with one between-subjects factor, training condition (rule vs. no-rule), and one within-subjects factor, transfer type (old vs. GT vs. BT). A summary of the data is presented in Table 6.

Errors. Analysis of the error data showed that the subjects in the no-rule condition were, in general, more error prone than subjects in the rule condition, F(1, 30) = 55.33, MS_e = 0.03. Furthermore, there was a significant main effect of transfer type, F(2, 60) = 21.49, MS_e = 0.04. These main effects, however, must be interpreted in light of the fact that the pattern of error rates was different for the rule and no-rule subjects; the interaction was significant, F(2, 60) = 20.32, MS_e = 0.04. A subsequent set of paired t tests indicated that, for the rule training condition, there was no significant difference in the error rates of old versus GT items, t(15) = 0.02, and no significant difference in the error rates of GT versus BT items, t(15) = 0.00. For the no-rule training condition, there was also no significant difference in the error rates of old versus GT items, t(15) = 0.01. The classification of GT items, however, was significantly more error prone than classification of GT items in the no-rule training condition, t(15) = 4.93.

Response times. Analysis of subjects' response times revealed no reliable differences in either the main effects or the interaction.

Discussion

Subjects in the no-rule condition clearly used item-specific information to classify these animals. Accuracy on old items and on GT items was quite good, whereas BT items were consistently placed in the category opposite to that predicted by the three-feature additive rule. Furthermore, none of the 16 subjects in the no-rule training condition showed a classification pattern consistent with the use of a single analytic feature in the transfer round. By contrast, when subjects were supplied with the rule that would provide perfect classification, the pattern of responding suggests that subjects were able to ignore this item-specific information and respond exclusively on the basis of the analytic structure of the stimuli. Neither the error rates nor the response times suggest that subjects experienced any difficulty in classifying animals in which the analytic rule was in conflict with the perceptual similarity to previously trained items.

Taken together, the data from Experiments 2A and 2B suggest a pattern of results opposite to that suggested as a possibility earlier. First, a number of pieces of evidence suggest that, under no-rule training conditions, the unique manifestation of individual features rather than the holistic quality of the individual items seemed to have a stronger influence on responding. A small subset of subjects viewing the holistic animals, for example, made exclusive use of the analytic affordances of the stimuli in their classification attempts, whereas no subjects viewing the featuraly individuated animals used this analytic simplification approach. Furthermore, although a post hoc analysis of the data did not reveal the difference to be statistically significant, subjects viewing the featurally distinctive animals showed, on average, a slightly stronger BT effect than subjects viewing the holistically individuated animals (even after the subjects displaying analytic simplification strategies had been removed from the holistically individuated condition).

On the other hand, under rule training conditions, the effects of our attempt at holistic individuation rather than our manipulation of unique separate features appeared more persistent. Despite the fact that subjects were told to pay attention to specific features, to treat the stimuli as a set of parts, the presence of idiosyncratic parts alone was not

<table>
<thead>
<tr>
<th>Measure</th>
<th>Training condition</th>
<th>No rule</th>
<th>Rule</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>Proportion error</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Old</td>
<td>.148</td>
<td>.131</td>
<td>.063</td>
</tr>
<tr>
<td>GT</td>
<td>.141</td>
<td>.182</td>
<td>.078</td>
</tr>
<tr>
<td>BT</td>
<td>.688</td>
<td>.255</td>
<td>.078</td>
</tr>
<tr>
<td>BT - GT</td>
<td>.547*</td>
<td></td>
<td>.000</td>
</tr>
<tr>
<td>Median response time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Old</td>
<td>926</td>
<td>307</td>
<td>903</td>
</tr>
<tr>
<td>GT</td>
<td>1.013</td>
<td>362</td>
<td>911</td>
</tr>
<tr>
<td>BT</td>
<td>1.001</td>
<td>366</td>
<td>928</td>
</tr>
<tr>
<td>BT - GT</td>
<td>-12</td>
<td></td>
<td>17</td>
</tr>
</tbody>
</table>

Note. Old = old item in transfer phase; GT = good transfer item; BT = bad transfer item.
* p < .05.
sufficient to produce similarity-based responding for this group. Instead, the stimuli designed to possess holistic individuation rather than the stimuli thought to possess only unique perceptual manifestations of the separate features seemed to show nonanalytic intrusions on purely analytic performance. Although the effect was weak in the animals designed to possess only the holistic source of perceptual individuation (in that it was only present in the response times), there was no effect at all for the animals possessing only featural individuation.

Conclusions based on the comparison of these two sets of stimuli, however, must be considered somewhat tentative. The intent for the stimuli in Cell C of Figure 1 was to produce a set of items in which there was clear featural individuation but no effective holistic differentiation. However, we cannot assume that the contrast we actually achieved was this pure. These stimuli, for example, might have had even less overall individuation if the bodies were five times larger relative to the appendages. Because the shape of the bodies was the same for all of the animals, such a change might have perceptually emphasized the commonality of the animals and perceptually isolated the legs from the tails and in turn from the heads. Under these conditions, the contrast between the legs on the different animals would not have been diminished, but there would have been less of a tendency for the particular combination of legs to cohere with the tail and for the head to produce an overall impression for the animal. Possibly with such stimuli, there would have been no effect of similarity to old items, suggesting that overall similarity rather than distinctiveness of individual features is crucial for exemplar-based transfer.

Similarly, performance with the animals of Cell B might not be a pure result of their holistic properties. One could imagine, for example, that the ratio of leg length to body length was itself a feature. If so, then this could make a distinctive feature that was not based on enough information about the item to refer to it as holistic. There was certainly no indication in subjects' reports that they were using such featural interactions in their explicit attempts to develop a rule for categorization. However, this manipulation is not sufficient to implicate the holistic structure as the unique source of less explicit, nonanalytic intrusions on strictly analytic classification behavior. At best, we can say that the perceptual distinctiveness of the features used by subjects for the purposes of analysis is insufficient to account for the signs of exemplar-based generalization that we obtained in Experiments 1C and 1D.

Experiment 3: The Priority of Holistic Individuation

The first purpose of Experiment 3 is to show that something more like the overall shape of the animal is critical to obtaining the BT effects that we use as an index of exemplar-based transfer. To accomplish this, we use the stimuli shown in Figure 3. For these stimuli, we use only the dimensions that are grouped at the center of each animal as relevant dimensions, namely, number of legs, body shape, and spots. It is then possible to substantially alter the overall impression given by the animal by changing only the categorically irrelevant dimensions, as is shown by the difference in the necks, heads, and tails between Training Set A and Training Set B. In this comparison, the perceptually individuated qualities of the relevant features remain exactly the same, which means that on these dimensions the two training sets have exactly the same relation to the transfer set to be used after both sets of training items. We assume that giving a person a rule will concentrate his or her attention on the named dimensions, which would mean that maintaining the perceptual identity on these dimensions should be especially important for the subjects in the rule group. In principle, it is possible for the rule group to concentrate on the center of the animal, as they are directed to do by the rule. If so, and if the observed effect on the BT items is due to a summation of the nonanalytic information arising from the distinctiveness of the analytic features, then there should be at least some part of this effect evident in the transfer from Training Set B to the transfer set. On the other hand, if the holistic nature of the items is particularly important for producing the BT effect, then there will be substantially less transfer from Training Set B than from Training Set A.

The second purpose of Experiment 3 is to probe the relation between featural and holistic individuation. Clearly, the subjects could be learning about the perceptually unique qualities of the features and learning that the qualities of these features could be essential to the individuated nature of the whole. However, in Experiment 3B, we show that there is no sign of a BT effect between Training Set B and the transfer set, which indicates that maintaining the holistic individuation of the stimuli is critical in obtaining this sign of exemplar-based transfer. In Experiment 3C, we show that subjects learned the categorical assignments of the distinctive features by showing an instance-based pattern of categorization when the distinctive features occur separate from one another in transfer. Thus, the lack of effect of maintaining the perceptual distinctiveness of the relevant features in Experiment 3B is not the result of subjects simply failing to learn the categorical relevance of the distinctive information of the features. Rather, it appears that whatever effect is exerted by the subjects' knowledge of individuated features depends on not experiencing conflict with the holistic identity of the animals.

Experiment 3A is a preliminary experiment to demonstrate that we have not affected the basic BT effect in creating the new set of stimuli. This is an important baseline against which to evaluate the apparent null effect of maintaining the perceptual distinctiveness of the relevant features in Experiment 3B.

Experiment 3A

Method

Materials. The stimuli are a single set of 16 animals adapted from the perceptually distinctive set used in Experiment 1. These stimuli are identical with the earlier set except that the length of the animals' legs was altered (made more consistent across the animals), and a tail was added to each animal. Thus, for this set, the dimension of leg length (long vs. short) was replaced by the
dimension of tail length (long vs. short). The analytic structure of ones and zeros remained identical with that seen in Table 1. The resulting set of 16 stimuli are those that comprise Training Set A and the transfer set of Figure 3.

Subjects. Subjects were 32 undergraduate students from McMaster University participating for course credit.

Procedure. The design and procedure for this experiment were identical with those of Experiment 2A except that the features associated with builders in each of the four rules were altered as follows:

(1) Six legs, angular body, and spots present.
(2) Two legs, angular body, and spots present.
(3) Six legs, round body, and spots absent.
(4) Two legs, round body, and spots absent.

Thus, the dimensions of neck length and tail length were definitionally irrelevant in all conditions.

Results and Discussion

A summary of the data is presented in Table 7. It is clear from these data that altering the stimuli from Cell D of Figure 1 to include a tail and altering the rules from Experiment 1 to include only legs, body, and spots did not have a fundamental impact on subjects' responses to the stimuli. The pattern of results for these animals was extremely similar to the pattern for the perceptually distinctive animals of Experiment 1 when subjects were trained under similar
Table 7
Mean Responses to the Stimuli Comprising Training Set A and the Transfer Set of Figure 3 Following Rule or No-Rule Training (Experiment 3A)

<table>
<thead>
<tr>
<th>Measure</th>
<th>Training condition</th>
<th>M</th>
<th>SD</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No rule</td>
<td></td>
<td></td>
<td>Rule</td>
<td></td>
</tr>
<tr>
<td>Proportion error</td>
<td>Old</td>
<td>.094</td>
<td>.107</td>
<td>.102</td>
<td>.131</td>
</tr>
<tr>
<td></td>
<td>GT</td>
<td>.097</td>
<td>.153</td>
<td>.125</td>
<td>.183</td>
</tr>
<tr>
<td></td>
<td>BT</td>
<td>.812</td>
<td>.194</td>
<td>.344</td>
<td>.256</td>
</tr>
<tr>
<td></td>
<td>BT – GT</td>
<td>.715</td>
<td>.219</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median response time</td>
<td>Old</td>
<td>.849</td>
<td>.375</td>
<td>.811</td>
<td>.311</td>
</tr>
<tr>
<td></td>
<td>GT</td>
<td>.897</td>
<td>.293</td>
<td>.875</td>
<td>.300</td>
</tr>
<tr>
<td></td>
<td>BT</td>
<td>.878</td>
<td>.292</td>
<td>1.300</td>
<td>369</td>
</tr>
<tr>
<td></td>
<td>BT – GT</td>
<td>.19</td>
<td>425*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. Old = old item in transfer phase; GT = good transfer item; BT = bad transfer item.

* p < .05.

Conditions. Both the error rates and the response time data replicated the findings for the perceptually distinctive stimuli of Experiments 1C and 1D.

Experiment 3B

With this set of stimuli, we are in a better position to test whether the episodic effects seen in the BT items are a function of the unique manifestation of the isolated features or a function of the more holistic individuation of the animals. To distinguish these possibilities, Training Set B of Figure 3 was given to a rule group and to a no-rule group. As indicated in the introduction to Experiment 3, on the basis of definitionally relevant features alone, which it is possible to concentrate on as a group because the features are clustered in the center of the animals, these new animals bear the same relation to the transfer set as do the animals in Training Set A, both in analytic structure and in the perceptual manifestation of these features. If the observed effect on the BT items is due to a summation of the distinctive features and the subjects are given a rule, then it should be especially important to keep the relevant features the same on the transfer items. However, alteration of the definitionally irrelevant features will have an effect if the holistic nature of the items is particularly important for producing the BT effect. Thus, if this holistic individuation is having an effect on classification, then the alteration of the irrelevant features will affect the frequency of instance-based errors in the BT items.

Method

Subjects. Subjects were 32 undergraduate students from McMaster University participating for course credit.

Procedure. The design and procedure for this experiment were identical with those of Experiment 3A.

Results

Analyses were performed on the proportion of errors and on the median response times for categorizations made by subjects in the transfer phase of the experiment. These analyses involved two 2 × 3 ANOVAs with one between-subjects factor, training condition (Rule vs. No Rule), and one within-subjects factor, transfer type (Old vs. GT vs. BT). A summary of the data is presented in Table 8.

Errors. Analysis of the error data revealed that subjects in the no-rule condition were, in general, more error prone than subjects in the rule condition, F(1, 30) = 38.01, MSε = 0.02. Furthermore, there was a significant main effect of transfer type, F(2, 60) = 5.06, MSε = 0.03. These main effects, however, must be interpreted in light of a significant interaction between training condition and transfer type, F(2, 60) = 3.80, MSε = 0.03. A subsequent set of paired t tests indicated that, for the rule training condition, there was no significant difference in the error rates of Old versus GT items, t(15) = 0.28, and no significant difference in the error rates of GT versus BT items, t(15) = 0.37. For the no-rule condition, old items were significantly less error prone than the GT items, t(15) = 3.56, and no reliable difference in error rates was found between GT items and BT items, t(15) = 0.17.

Response times. Analysis of the response times revealed a main effect for transfer type, F(2, 60) = 3.49, MSε = 50.079. There was, however, no difference in the overall response times of subjects receiving rule training and subjects receiving no-rule training, F(1, 30) < 1. Furthermore, the training instructions did not interact with the pattern of response times on the three transfer conditions, F(2, 60) = 1.33, MSε = 50.079. Collapsing across the rule and no-rule training conditions, a subsequent set of paired t tests revealed no reliable difference between GT and BT items, t(31) = 0.26, but responses to old items were significantly faster than responses to the transfer items (collapsed across GT and BT), t(31) = 2.63.

Table 8
Mean Responses to the Stimuli Comprising Training Set B and the Transfer Set of Figure 3 Following Rule or No-Rule Training (Experiment 3B)

<table>
<thead>
<tr>
<th>Measure</th>
<th>Training condition</th>
<th>M</th>
<th>SD</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No rule</td>
<td></td>
<td></td>
<td>Rule</td>
<td></td>
</tr>
<tr>
<td>Proportion error</td>
<td>Old</td>
<td>.102</td>
<td>.068</td>
<td>.039</td>
<td>.060</td>
</tr>
<tr>
<td></td>
<td>GT</td>
<td>.313</td>
<td>.233</td>
<td>.047</td>
<td>.101</td>
</tr>
<tr>
<td></td>
<td>BT</td>
<td>.297</td>
<td>.245</td>
<td>.063</td>
<td>.112</td>
</tr>
<tr>
<td></td>
<td>BT – GT</td>
<td>-.016</td>
<td>.016</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median response time</td>
<td>Old</td>
<td>1.095</td>
<td>442</td>
<td>1.194</td>
<td>404</td>
</tr>
<tr>
<td></td>
<td>GT</td>
<td>1.320</td>
<td>492</td>
<td>1.237</td>
<td>326</td>
</tr>
<tr>
<td></td>
<td>BT</td>
<td>1.258</td>
<td>409</td>
<td>1.271</td>
<td>340</td>
</tr>
<tr>
<td></td>
<td>BT – GT</td>
<td>-.62</td>
<td>34</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. Old = old item in transfer phase; GT = good transfer item; BT = bad transfer item.
Discussion

Evidence from this study suggests that for both the rule and the no-rule training conditions, the items' holistic individuation, rather than the unique manifestation of independent features, was essential for the BT effect. When the holistic individuation was changed through the alteration of definitionally irrelevant features, all evidence of exemplar-based transfer disappeared.

Subjects classifying the animals following rule training were extremely accurate in the classification of all stimuli (old, GT, and BT stimuli alike). Furthermore, response times for the rule condition were clearly slower in the transfer phase of Experiment 3B than in the transfer phase of Experiment 3A, suggesting that the perceptually altered transfer items produced a general context of unfamiliarity that resulted in more deliberate rule application in the final round.

In the no-rule condition, responding to old items was fairly accurate (at least as accurate as responding to other perceptually distinctive stimuli viewed under no-rule training conditions). Thus, for the familiar old items, the memory for specific cases appears to have been influential in classification. In the transfer items, however, GT and BT items were classified with equal accuracy. This pattern is not consistent with the pattern expected under conditions of episodic transfer. The level of accuracy for the transfer items, however, was better than the 50% accuracy predicted by chance. It was, in fact, quite similar to the level of accuracy achieved by subjects viewing the perceptually uniform stimuli under the no-rule conditions of Experiment 1C.

It appears, therefore, that although the classification of perceptually familiar old items was being aided by memory for specific exemplars, the classification of the perceptually novel transfer items was supported by some (albeit incomplete) analytic category-level information, similar to the analytic simplification observed in Experiment 1C.

Thus, when the individual as a whole became unfamiliar, subjects responded as if no similarity existed between the new individual and the earlier training items. Subjects failed to take advantage of the perceptual and analytic similarities that continued to exist despite the loss of the holistic similarity. This suggests that when the holistic similarity was present, it was this form of similarity that drove the exemplar-based responses.

Experiment 3C

Although it would appear that holistic individuation will interfere with the tendency for unique features to control responding, Experiment 3B does not shed much light on whether this interference is at the level of acquisition or response control. It is possible, for example, that in the presence of holistic individuation, subjects fail to notice the unique nature of the individual features out of which the whole is emerging. If this were true, then in the presence of holistic individuation, the specific features would have no separate association with the object. The only contribution of a feature to the individual would be in the manner in which it melds with other features to create the whole. Undoubtedly, the unique manifestation of the specific features will contribute to the holistic distinctiveness of the animal. Anecdotal evidence from everyday life, however, suggests that the uniqueness of separate features is not entirely lost in the gestalt of the whole. Children, for example, are often told that they have their mother's eyes or their father's nose. This suggests that separate features do, in fact, become recognized as belonging to the individual. Thus, it is more likely that subjects in Experiment 3B could have identified the perceptually similar features as belonging to a previous individual item. They did not, however, because the altered holistic nature of the stimulus suggested that this was a new, very different individual. To examine whether the subjects in fact learned anything about the associations of the unique features with the categories, we tested them in another condition. For this condition, stimuli in the transfer phase were composed of features scattered randomly about the screen. Consistent with Modigliani (1971, 1974), we argue that such a manipulation will destroy the holistic nature of the stimuli, while leaving the unique nature of the separate features intact.

Materials

During training, subjects viewed the stimuli from Training Set B of Figure 3 five times each. In the transfer phase, these 8 stimuli were supplemented with the 8 stimuli from the transfer set of Figure 3. In this experimental condition, however, the features comprising each of the 16 stimuli in the transfer phase were no longer arranged to create whole animals. Instead, for each stimulus, the five features were scattered randomly around the screen. Thus, the separate pieces of analytic and perceptual information were present in the stimulus, but no holistic component existed.

Method

Subjects were 8 undergraduate students from McMaster University participating for course credit. The procedure was identical with the no-rule condition of Experiment 3B.

Results

The error rates for the old, GT, and BT items are shown in Table 9. A set of paired two-tailed t tests revealed no significant difference between the error rates of old and GT items, t(7) = 0.26, but a significant increase in errors for the BT items over GT items, t(7) = 2.96.

Discussion

The disruption of the holistic nature of the animals in this no-rule training condition seemed to hurt performance on old items at least to some degree. The 20% error rate is higher than we have generally seen on perceptually distinctive stimuli. Interestingly, this manipulation, which seemed to hurt the classification of old items, also resulted in the
Table 9
Mean Responses to the Stimuli Comprising Training
Set B and the Transfer Set of Figure 3 Following
No-Rule Training When the Holistic Nature of the
Stimuli Was Disrupted at Transfer (Experiment 3C)

<table>
<thead>
<tr>
<th>Proportion error</th>
<th>No-rule training</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( M )</td>
</tr>
<tr>
<td>Old</td>
<td>.203</td>
</tr>
<tr>
<td>GT</td>
<td>.219</td>
</tr>
<tr>
<td>BT</td>
<td>.656</td>
</tr>
<tr>
<td>BT – GT</td>
<td>.437*</td>
</tr>
</tbody>
</table>

Note. Old = old transfer item in transfer phase; GT = good transfer item; BT = bad transfer item. * \( p < .05 \).

return of the episodic transfer effect. It would appear that when subjects are faced with a set of randomly scattered parts, the similarity of a few separate features is sufficient to influence responding. This suggests that the presence of holistic individuation during training does not interfere with the acquisition of knowledge about the unique perceptual manifestation of separate features. The continued presence of holistic individuation during transfer, however, appears to interfere with the use of this knowledge about unique features.

General Discussion

There are three central assertions in this article: (a) For most natural stimuli, the dimensional structure that describes the subjects’ analytic activity is not sufficient to describe the perceptual distinctiveness that supports concurrent exemplar-based categorization; (b) holistic individuation (the distinctiveness of whole items) is not generally produced by increasing the distinctiveness of individual features and even has some priority over individual feature distinctiveness in supporting exemplar-based categorization; and (c) use of the two types of nonanalytic distinctiveness, holistic individuation and featural individuation, is not necessarily in a trade-off with use of analytic knowledge. We discuss these three themes in turn.

Perceptual Manifestations of Analytic Structure

The principle manipulation in these experiments was to vary the perceptual manifestation of a single analytic structure. There were several lines of evidence demonstrating that the dimensional variation that we called analytic was in fact used by the subjects when faced by an analytic task: The explicit dimensional descriptions elicited from the subjects in Experiment 1A; the free two-category sortings produced in Experiment 1B; the single-dimension solutions (analytic simplifications) produced by subjects using the nondistinctive stimuli of Figure 1, Cell A; and the free reports of analytic activity given by subjects after the transfer phase in the relevant experiments all support our designation of the analytic structure. However, the different perceptual manifestations of this analytic structure differed widely in their tendency to support transfer based on similarity to particular training instances. Clearly, different aspects of the stimuli are important for supporting these two different types of processing.

Materials and tasks such as the current ones, in which both analytic and nonanalytic categorization processes occur, present a problem for some concept-learning models. Many models calculate similarity between two stimuli as some function of the overlap in their dimensional structure (e.g., some function of the number of ones and zeros shared in an abstract description such as that in Table 1). This same dimensional structure is also used to describe whatever analytic activity is occurring. However, on the basis of the current results, there is no reason to believe that, except for some special stimulus sets, the same aspects of stimulus variation are important for both types of processing. This is particularly evident for the holistic variation, which cannot even be nested into the same description; that is, it cannot be treated as simply a more concrete or distinctive level of the analytically useful structure. For stimuli in which such effects occur, two different descriptions of the stimuli seem to be required.

We do not believe that there is anything rare about stimuli and tasks that require two different descriptions of the stimuli. Most natural stimuli show perceptual variety and holistic integrity at least comparable to that evident in our perceptually distinctive stimuli, for example, Cell D of Figure 1. What is unusual about our perceptually distinctive stimuli is that they also show such obvious analytic variation. However, in many natural situations with less obvious analytic dimensions, people either have an established theory or have received deliberate instruction that contains a useful analytic description. Both the strengths and the limits of such analytic descriptions are shown especially in areas that require a combination of textbooks and years of practice, such as dermatology, radiology, and histology (see Allen, Norman, & Brooks, 1992; Brooks, Norman, & Allen, 1991; Norman, Brooks, Coblenz, & Babcock, 1992). Experimental models that contain the affordances for both analytic and nonanalytic processes would provide a useful tool for investigating an interesting class of natural problems.

The Priority of Holistic Individuation

The manipulations in this article distinguished between featural individuation (whether a feature occurred in identical form in different items) and holistic individuation (the extent to which the separate features of an item cohered into an individuated whole). Logically, individuated features could be sufficient to produce analogy to individual items; a new item that had several features that had been uniquely associated with a particular training item might be categorized by analogy with that item. However, the current evidence demonstrates that for the conditions in this article this is not sufficient.

Experiments 3B and 3C tested the relations between holistic and featural individuation. In the transfer phase, the two analytically irrelevant features were altered substantially. For the transfer stimuli of Experiment 3B, this meant
that the holistic quality of each stimulus was substantially altered as well. The effect of this alteration was the elimination of episodic transfer in subjects' classifications. In Experiment 3C, the same features were altered in the same way. Because the transfer stimuli were broken apart, however, the holistic nature of the stimuli was not altered, it was entirely destroyed. Under these circumstances, the episodic transfer effect returned. It would appear, therefore, that when both holistic and unique feature information are available in the training stimuli, both sources of information are acquired under no-rule training conditions. Yet, if both are present at the time of transfer, the holistic individuation of the stimulus seems to have a stronger influence on classification. If, as in Experiment 3B, the holistic nature of the stimulus is altered, the resulting stimulus is an unfamiliar individual. In this context of unfamiliarity, subjects fall back on an analytic pattern of responding. If, however, the holistic nature of the stimulus is entirely disrupted, the stimulus is no longer an individual at all, but a set of parts. Under these circumstances, the focus seems to shift to the separate features, and the perceptual similarity of some of these features to the old training items is sufficient to produce more episodic, similarity-based responding. Thus, the presence of holistic individuation in the training stimuli does not seem to interfere with the acquisition of knowledge about the items' perceptually unique features. The continued presence of holistic individuation during transfer, however, does appear to interfere with the use of this knowledge about unique features.

Perhaps this priority of the whole is not surprising in the context of no-rule training. Subjects were simply being presented with a series of individuals and asked to learn the category membership of these individuals. Although there is some evidence that subjects attempted to treat these individuals analytically, there was no specific injunction from the experimenter that they do so. This was not the case, however, under the rule training conditions. Here, subjects were given explicit instructions regarding their treatment of the stimuli. They were told to pay attention to specific features and that only those features were relevant to classification. The specific features identified by the rule remained perceptually unaltered in the transfer stimuli. Despite this strong encouragement to treat the stimuli as a set of parts, however, it was again the holistic nature of the stimuli rather than the unique perceptual manifestation of the separate features that seemed to intrude on analytic performance.

This priority of the whole is probably influenced by the way the subjects think about the stimuli. The items were presented in training as whole animals, not as sets of disassembled parts. Consequently, the subjects were likely to think of them as whole animals and fail to react to transfer animals that seemed to be essentially different for whatever reason. We expect that if we had asked the subjects to categorize the legs rather than the whole animals, holistic priority would have accrued to the legs rather than the whole animal despite the continued figural connectedness of the whole animal. That is, the holistic properties are probably at least partly relative to the way the items are framed (for a review of framing effects in concept learning, see Barsalou, 1991).

Finally, it is worth noting that although we produced holistic integration in this article entirely by manipulating the form of the stimuli, similar effects can be produced by varying the way the subjects process exactly the same stimuli. Whittlesea and his colleagues (Whittlesea, 1987; Whittlesea & Brooks, 1988; Whittlesea, Brooks, & Westcott, 1992; Whittlesea & Cantwell, 1987) showed large variations in the extent to which a stimulus supports exemplar-based generalization by varying whether the subjects treated a set of pseudowords as individuals or as data for judgments about the category as a whole.

The Nonreciprocal Relation Between Analytic and Nonanalytic Resources

The evidence in this article indicates that neither the acquisition nor the use of analytic and nonanalytic information are antagonistic to one another. In the rule conditions, subjects started the training phase with an analytic rule that was sufficient for perfect categorization. This did not prevent them from acquiring and using sufficient nonanalytic knowledge to produce a BT effect. Allen and Brooks (1991) demonstrated that this effect is robust across experimental variations, such as prompting the subjects for accuracy and warning them about the presence of "trick" BT items. The subjects in our no-rule conditions also learned about and made use of both analytic and nonanalytic knowledge. Postexperimental interviews with the no-rule subjects viewing perceptually distinctive stimuli indicated strong analytic tendencies. As with subjects viewing the perceptually uniform animals, these subjects attempted to isolate the dimensions relevant to category membership. As seen in Experiment 3B, this analytic knowledge was used by these subjects to classify perceptually novel items with a moderate level of accuracy (a level essentially equal to that achieved by subjects viewing the perceptually uniform stimuli under no-rule training conditions). Thus, it would appear that the no-rule subjects' acquisition of knowledge about the individuality of specific cases did not preclude their acquisition of knowledge about the analytic information contained in those cases. Rather, when distinctive perceptual information is available in the stimulus, subjects will use it to supplement their incomplete analytic knowledge, thereby improving their accuracy in the classification of old and perceptually similar new items. When this information is not apparent, the analytic information will be used exclusively, and accuracy in classification will be limited to the adequacy of this analytic knowledge.

This is consistent with the data reported by Vokey and Brooks (1992). They presented subjects with a set of letter strings to memorize, all of which were generated using a complicated, artificial grammar. Following this training phase, subjects were informed of the existence of the grammar and were subsequently presented with novel letter strings. The subjects' task was to indicate whether each of the new items followed the grammar. These new strings varied both on their grammaticality (whether they were
consistent with the grammar) and on their similarity to a previously studied item (one letter away vs. several letters away). Vokey and Brooks found that when grammaticality and similarity to old items were orthogonalized experimentally, they became independent, noninteracting sources of variance in subjects' classification behavior. Again, the analytic and nonanalytic sources of information were not in a trading relation. Rather, subjects learned about and made use of both sources of information during the experiment. A similar additive relation between the factors of context-free similarity (a measure of the structure of the set) and specific memorability was found for recognition memory by Vokey and Read (1992).

The hypothesis that analytic and nonanalytic sources of information are both acquired independently with experience is also being asserted in the memory literature. Jacoby (1991; see also a more general review in Jacoby, Ste-Marie, & Toth, in press) developed a technique to isolate the effects of conscious recollection and unreflective familiarity on subjects' classification of items as old or new in a recognition memory paradigm. Using the technique, Jacoby showed that more intensive processing of an item (experiencing the item as an anagram that must be solved as opposed to simply reading the item) increases not only the probability that the item will be recollected but also the probability that the item will feel familiar. That is, a manipulation that increases one source of memory does not necessarily produce a decrease in the other. The processes described by Jacoby in the framework of the memory literature may map very well onto the analytic–nonanalytic distinction being used in the categorization literature. If this is true, then Jacoby's process-dissociation technique may become a powerful tool in our attempts to isolate and examine the two processes in categorization and may provide converging evidence for their independence.

Our emphasis on methods that allow independent variation of analytic and nonanalytic information is also the major difference between the current work and that of Kemler Nelson (1989) and J. D. Smith (1989). The distinctions that we make in this article are obviously closely related to distinctions made by those authors. Kemler Nelson distinguished among three different senses in which processing can be nonselective, that is, three different ways in which judgments of similarity can depend relatively unselectively on many aspects of the stimulus. These differ in the extent to which judgments of overall similarity occur together with independent processing of constituent stimulus attributes. One extreme is analytic processing, in which the stimulus attributes are independently processed and then the similarity judgment is constructed from these already identified attributes. In this form of processing, the calculation of similarity is clearly secondary to the processing of the stimulus attributes. On the other extreme is strong holistic processing, in which processing the individual properties is not a part of the apprehension of overall similarity. The model of such strong holistic processing is the integral or configural processing discussed by Garner (1974), in which the underlying dimensions do not have psychological primacy in judging distance between two stimuli. In between is weak holistic processing, in which the overall similarity computation is clearly primary but in which specification of individual properties occurs as a part of this computation.

Using Kemler Nelson's distinctions, it seems likely that what we call holistic individuation corresponds to weak holistic processing. Because we were interested in facilitating concurrent analytic processing, we did not use stimuli that support strong holistic processing, in which the component dimensions lose all priority. Similarly, the whole point of the perceptual manipulations was to demonstrate the insufficiency of a strictly analytic computation of similarity. Because of the analytic affordances that we built into our stimuli, we cannot use the specific free and directed sorting methods used by Kemler Nelson and by J. D. Smith to diagnose these various forms of processing. However, it is clear that descriptively the distinctions are very similar to ours. Indeed, our materials provide an interesting extension of the ideas described by J. D. Smith (1989) and J. D. Smith and Shapiro (1989) on the relation between holistic and analytic processing.

We should also comment on our use of the word holistic. The stimuli were selected by our impressions of which stimuli tend to cohere as individuals and which tend to appear as collections of individual parts. We have a good deal of informal evidence that, when posed with these alternatives, a great many people, including our subjects, agree with our assessment of the stimulus sets displayed in Figure 1. What we clearly have not done is validate our use of the term holistic by means of the operations used in much of the literature that discusses the influence of holistic perceptual organization (reviewed in Kemler Nelson, 1989). The assessment of operations in that body of literature were obviously very useful for their stated purposes, but do not, in our opinion, transfer well to the current purposes. As mentioned previously, both the unspeeded classification test, proposed by Garner (1974) and used extensively by L. B. Smith (1989), J. D. Smith (1989), and Kemler Nelson (1989), and the ambiguous item test, introduced by Kemler Nelson (1984), pit analytic and holistic processing against each other. These methods are not appropriate given the current purpose of ascertaining how the two stimulus organizations can be coordinated within a single act of classification. The data in this article can be seen as an adaptation of the third method discussed by Kemler Nelson, that of comparing the relative speed of learning or use of the holistic and analytic classification schemes. Our use of the term holistic is justified on the basis of a similar conceptual purpose rather than by the same operational definitions. The coherence of the features of an item into a single organization was manipulated by perceptual variation (rather than the processing operations used by Whittlesea, e.g., 1987) and is contrasted with the features being organized as a collection of parts. This is the same means and conceptual contrast used in the literature reviewed by Kemler Nelson (1989), even if it cannot be corroborated by the same converging operations. The evidence that we achieved our intent is provided by the results of the experiments in this article, particularly Experiment 3B.
Finally, it is worth commenting on the limits of what can be inferred about analytic and nonanalytic processing with our BT method. All our methods demonstrate about analytic processing is the special availability of definitional features. For example, the restraint that we observed on errors on BT items could occur because recognition of the item cued knowledge of or facilitated the extraction of the relevant features. It certainly does not necessarily imply that there is a context-free process of rule application going on concurrent with assessment of an item’s holistic properties. Similarly, our assessment of nonanalytic, and especially holistic, processing does not imply that the subject is being totally nonselective. A subject’s assessment of what characterizes an item as a whole does not necessarily equally weight all component properties or even exhaust them.

Conclusions

This set of experiments highlights the importance of the perceptual array in the classification of items within a stimulus set. Whether faced with perceptually uniform or perceptually distinctive stimuli, subjects can induce and make use of abstract categorical information. It is interesting, however, that subjects challenged with perceptually distinctive stimuli will often make use of this item-specific information in addition to the analytic information. In fact, this tendency to make use of perceptually idiosyncratic information is sufficiently powerful that it will often persist even under circumstances in which subjects possess analytic information that is perfectly predictive of category membership.

We stress that this perceptual idiosyncrasy is not merely at the level of the item’s separate features. Clearly, the unique perceptual manifestation of an item’s separate features can affect classification behavior. Often, however, its effect on classification behavior is in its contribution to the individuated nature of the item as a whole. It is the presence of this holistic individuation that seems to affect subjects’ application of an explicit classification rule most strongly.

The finding that item classification is a function both of abstract, category-level information and of item-specific information is becoming common in the literature (see, e.g., Allen & Brooks, 1991; Brooks, 1987, 1990; Jacoby & Brooks, 1984; Medin et al., 1983; Medin & Ross, 1989; Ross, 1987; Whittlesea & Brooks, 1988). Such findings have led to the description of classification behavior as a hybrid of both rule-based and item-based knowledge. Inevitably, such descriptions lead to questions regarding the relative availability and the coordination of the two bases of classification. The point we make here is that the answer to this question is not a general one. Instead, conclusions of this sort must include a statement about the perceptual composition of the stimulus set being classified.

References


Received February 10, 1992
Revision received August 11, 1992
Accepted August 24, 1992