CATEGORICAL AND INDIVIDUAL INFORMATION IN NATURAL STIMULI: TONGUES OF FIRE AND FLUFFY CLOUDS

by

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B.A., Simon Fraser University, 1988

THESIS SUBMITTED IN PARTIAL FULFILLMENT OF

THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF ARTS

in the Department

of

Psychology

SIMON FRASER UNIVERSITY

September 1990

APPROVAL

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Degree: Master of Arts (Psychology)

Title of Thesis: Categorical and Individual Information in Natural Stimuli: Tongues of Fire and Fluffy Clouds

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Categorical and Individual Information in Natural Stimuli:

Tongues of Fire and Fluffy Clouds

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Nov 9, 1990

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Abstract

Natural stimuli could be analyzed into a large number of properties of varying degrees of detail. Because of processing limitations, the human cognitive system cannot extract all possible properties. Therefore, constraints must operate to limit the type and/or number of properties that can be extracted. A constraint examined here is that properties are extracted in a global-to-local sequence. In Experiment 1, subjects received a training phase in which they were shown White and Red Oak leaves. In the test they were asked to discriminate between old and new leaves. Four groups of subjects differed in the type of instructions received, designed to introduce a bias toward extracting either global (at the category or species level) or local (at the level of the individual leaf). Subjects in all groups remembered global information well. There was indication that they retained some individual information as well, although the effect was weak. Experiment 2 explored the hypothesis that local information about a particular leaf would be better retained if that leaf had a very distinctive property. The procedure was the same as in Experiment 1. During training, one leaf was made distinctive by having a prominent notch carved out of its margin. It was hypothesized that, in the test phase, subjects would recognize this leaf as old on the basis of the notch. Although subjects did remember that during training there was a leaf with a notch, they had difficulty remembering to which leaf the notch was attached. Overall, the results showed that, at least with these types of natural stimuli and categories, subjects could easily extract a global property that permitted them to consistently discriminate at the species level. However, they were unable to extract local properties that would have allowed them to discriminate at the level of individual leaves. The implication of these results for current models of categorization is discussed.

Acknowledgements

I wish to thank Dr. Vito Modigliani for his continued advice, encouragement, and humour throughout the entirety of this research. I would also like to thank my family and friends for their interest, patience and support during this time.

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CHAPTER 1

Introduction

Categorization is a process fundamental to human cognition. It entails the ability to form concepts and to classify objects, relationships, and events as members of a category, it allows us to organize the diversity of the perceived world, and ultimately to communicate with others. Categorization has been extensively studied by cognitive psychologists who seek to infer the internal structure of categories from the classifications people make. Since categories consist of nonidentical stimuli, classification tasks require subjects to make judgements about the relative similarity of objects. It is generally assumed that such judgements begin with the analysis of stimuli into their properties. This assumption is a natural outgrowth of the analytic tradition of Western philosophy and psychology. It has fostered the use of controllable stimuli for the investigation of categorization.

Thus, research in classification has typically employed artificial stimuli (e.g. geometric figures) which are highly structured. A significant disadvantage of such stimuli is that they greatly constrain the number of properties subjects are required to analyze. Alternatively, experimenters have tended to use overlearned stimuli (e.g. letters, words, man-made objects) involving stimulus properties with which the subjects are very familiar. Neither of these two types of investigations have been able to directly address the question of how, in the process of categorizing <u>natural</u> stimuli, people analyze stimuli into component properties.

In natural stimuli, such as the Oak leaves shown in Figures 1A & 1B, each stimulus could be analyzed into a very large number of properties, any set of which could be used for the purpose of classification. Thus, an important question that arises is:

Insert Figure 1A about here

Insert Figure 1B about here

What properties do people use when making categorical judgements of natural stimuli? The standard (although often implicit) assumption underlying theories of classification is that somehow all the properties of any stimulus are available and influence categorization, an assumption that is rarely questioned. However, issues such as cognitive economy and memory limitations make it highly unlikely that even 'nearly' all properties of natural stimuli can be processed and used for categorization tasks. Therefore it is reasonable to look for possible constraints which might guide the extraction and use of properties of natural stimuli. The purpose of the present investigation was to explore the question of what kind of information people extract when learning to distinguish between members of two natural categories, i.e., the leaves of White versus Red Oaks. The underlying issue was whether, or to what degree, people are able to extract individual item information, categorical information, or both, in the course of such learning.

With this as a focus, the following will, first, examine some definitional issues relevant to the topic of categorization. I will then briefly discuss the influence of historical perspectives on investigations of categorization. Current theoretical frameworks will be examined in Chapter 2. Chapter 3 and 4 are devoted to Experiments 1 and 2, respectively. Finally, a general discussion is presented in Chapter 5.

Definitional Issues

Categorization is often discussed under the topic of conceptual behavior. Depending on the theoretical perspective, a concept has been referred to as existing when groups of objects or events are classified on the basis of common features or properties (Bourne, 1966), as a representation of objects organized by their distance from a prototype (Rosch, 1975; 1978), as objects grouped according to their similarity expressed as a linear combination of common and distinctive features (Tversky, 1977), or as the storing of individual category exemplars in memory (Medin & Schaffer, 1978). A category is most generally defined as a grouping of objects, events or relationships; in other words, it is the instantiation of a concept. Although the literature is not precise, the term concept usually refers to the internal representation that binds together a group of objects, whereas the term category tends to refer to the actual objects, that is, to the extension of the grouping. In practice, the two terms are often used interchangeably, and this usage will continue here.

There has been much confusion in the use of the terms properties, features, attributes, and dimensions (see Treisman, 1986, for a review). Some employ very general meanings. For example, Tversky (1977) refers to features as corresponding to "...components such as eyes or mouth...concrete properties such as size or color...abstract attributes such as quality or complexity" (pp. 329). Others have more specific meanings for these terms. For example, "stimuli vary along dimensions...a dimension has, by definition, at least two and usually many more discriminably different values or attributes." (Bourne, 1966, p. 3-4). Garner (1978) proposes that component properties of a stimulus (also called attributes) consist of either dimensions or features. For Garner the meaning of dimension is similar to that given by Bourne. A feature, on the other hand, is an all-or-none characteristic that is either present or is not. In the present work, the terms properties or features will be used interchangeably to refer to any discriminable characteristic of a visual stimulus.

Historical Background

Western philosophy, and the psychology that emerged from it, have followed the Aristotilean tradition of an analytic (as opposed to synthetic) approach. This analytic tradition has been the mainstay of psychological research. Critical of the absolute realist notion of Plato, by which things were classified according to one essential characteristic or 'essence', Aristotle preferred to analyze objects into components parts. British empiricism, which has dominated much of psychological theorizing, followed the Aristotilean tradition. Current models of perception and classification follow this tradition as well. They maintain that all cognitive processes begin with feature analysis, i.e., the decomposition of a stimulus into its component parts (see Uttall, 1988, for a critical analysis). Some of the current theories of classification that adhere to this view will be considered in more detail below.

Another tradition, opposed to the analytic orientation is the global, holistic, or synthetic approach, emphasized by Gestalt psychology. In this approach, holistic or configural properties of stimuli are thought to be the psychologically important ones (Uttal, 1988). This approach has not enjoyed the same unbridled acceptance as the analytic one. However, a minority of theororists have used it as a framework for theory. Some of these will also be reviewed below. The present work addresses, in some respects, the analytic/holistic distinction in the context of two natural categories.

CHAPTER 2

Current Theoretical Frameworks

Early studies of concepts and classification behavior used artificial concepts and conformed to a theoretical orientation that has been referred to as the classical view (Smith & Medin, 1981). The classical view holds that concepts can be defined on the basis of necessary and sufficient properties. That is, all members of a category share a set of properties that are necessary and sufficient to define the category. Smith and Medin (1981) summarize the three main assumptions of the classical view as follows: (1) there is a single summary representation resulting from an abstraction process. The representation may not correspond to a specific instance, but applies to all possible members of a category, (2) a concept representation includes features which are singly necessary and jointly sufficient to define the concept and, (3) the defining features of a concept are nested in its subsets.

The classical view has been criticized on the basis that there seem to be many instances of concepts for which it does not account. For example, the structure of an apparently simple category such as "cup" is difficult to account for in a classical way (Labov, 1973), nor can the classical view account for some disjunctive concepts (e.g., a strike in baseball), or unclear cases (e.g., tomato as a fruit). There are also a number of empirical results which are inconsistent with the assumptions of the classical view. One of the most pervasive finding, the so-called typicality effect, indicates that some members of a category are considered to be better or more typical examples than others (Rosch, 1973; Rosch, 1975; Rosch & Mervis, 1975; Rosch, 1978; Rips, Shoben & Smith, 1973). This is inconsistent with the classical view. For these reasons, more recent models of categorization have taken a probabilistic or exemplar view approach. Three classes of such models will be discussed here.

Eleanor Rosch

Perhaps the work that has been most influential to the development of alternatives to the classical model of categorization is that of Eleanor Rosch and her colleagues (Rosch, 1975; Rosch & Mervis, 1975; Rosch, Mervis, Gray, Johnson, Boyes-Braem, 1976; Rosch, 1978). According to Rosch (1978) the two basic principles that govern categorization are *cognitive economy* and *perceived world structure*. Cognitive economy is concerned with the hierarchical organization of categories. The perceived world structure principle claims that " the perceived world is not an unstructured total set equiprobable co-occurring attributes" (Rosch 1978, p. 29). Rather, unlike the highly contrived types of stimuli used in most laboratory settings, concrete objects in the world are seen as having a high correlational structure among their attributes. The claim is that this structure is readily perceived by an observer.

Rosch (1978) views category systems as having a vertical dimension, varying in the level of category inclusiveness (e.g., Persian, cat, mammal, living thing), and a horizontal dimension, which segments categories at the same level of inclusiveness (e.g., cat, dog). The two principles of cognitive economy and perceived world structure have important implications for these dimensions. The major implication for the vertical dimension is that the various levels of category inclusiveness are not equally useful. Similar to the generic level of taxa of folk biologies (Berlin, Breedlove, & Raven, 1966, 1973; Berlin, 1978), Rosch et al (1976), proposed that there is a basic level of categorization. This basic level is said to be the most inclusive level at which the correlational structure of attributes in the perceived world is best mirrored, and is thus the most useful level. According to Rosch et al (1976), "...the basic level of abstraction in a taxonomy is the level at which categories carry the most information, possess the highest cue validity, and are thus, the most differentiated from one another" (p. 383). For the horizontal dimension, the implication is that categories tend to become defined in terms of prototypes. Prototypes, or best examples, are assumed to contain properties most representative of category members and least representative of non-members.

Rosch's idea of prototype is similar to Wittgenstein's (1954) notion of family resemblance. She views each category member (item) as a set of elements and maintains that "each item has at least one, and probably several, elements in common with one or more other items, but no, or few, elements are common to all items" (Rosch and Mervis, 1975, p. 575). The degree of family resemblance depends on the degree of attribute overlap between each item and all other items in a category. (Rosch has also attempted to define family resemblance in terms of "cue validity", e.g., Rosch and Mervis, 1975, but this notion has been criticized by Murphy, 1982).

The family resemblance model is based on the assumption that each stimulus can be decomposed into a set of features. Most of the data supporting a family resemblance model have been obtained by having subjects list features for each of a number of so-called natural categories. It should be realized, however, that features are given in response to the names (e.g., oak, cat) of natural categories, not the actual stimuli representing those categories. The implicit assumption of much of this research, therefore, has been that the features listed by subjects in reponse to the name of a category are indeed those that are functional in classifications of actual exemplars of that category. This assumption may be true, but should not be accepted uncritically. In any case, the question of which features a person would actually use in true natural classification is left unanswered.

Prototype Models

Prototype models propose that some form of summary statistic is calculated which describes the category as a whole (Reed, 1972; Posner & Keele, 1970). Stimuli are then classified in terms of their relationship to such statistics.

Modal prototype models are based on feature counts (Hayes-Roth & Hayes-Roth, 1977; Neumann, 1974, 1977). In these models, the prototype includes the most frequent properties. It is clear that, in order to be able to count them, a subject must know the features in advance. Modal prototype models are therefore an instance of the analytic approach. That is, such models assume that the identification and extraction of the set of features in the stimulus is an unambiguous and automatic process. This leaves open the question of <u>which</u> properties of stimuli, if not all, are abstracted and on what basis this is determined. It should be noted that research based on these models has used artificial stimuli which often contain a limited number of properties. Such stimuli are not representative of natural stimuli, since the latter are likely to contain far larger numbers of possible properties. Thus, the question of which properties are used in a task using well-defined artificial stimuli may not be important. This question seems crucial, however, with natural stimuli.

In the average prototype model, the summary statistics includes an average of all stimuli encountered during learning as well as a measure of variability (Posner & Keele, 1970). The average prototype model is intuitively appealing, although its acceptance would depend on the exact mechanism by which the average is computed. If the mechanism requires an initial process of feature extraction (as it would seem to in the case of Posner & Keele's dot patterns), then the model would be another instance of the analytic approach, and could be criticized in the same way as are modal prototype models.

Exemplar Models

Most recently, exemplar models of categorization have been proposed. They assume that the representation of a concept consists of the separate memories of individual category exemplars (Brooks, 1978; Medin & Schaffer, 1978, Smith & Medin, 1981; Medin, 1983). The Context Model (Medin & Schaffer, 1978), in particular, proposes that classification judgements are based on the retrieval of stored exemplar information. Medin and Schaffer (1978) assume that a new (probe) stimulus serves as a retrieval cue to access information stored with stimuli similar to the probe. It is proposed that the cue, context, and event are all stored together in memory, such that simultaneous activation of both the cue and context is required in order to retrieve information about the event. As well, a particular stimulus property has two functions: one as a cue and the other as context for other cues.

Perhaps the most important aspect of the context model is that overall similarity between stimuli is determined in a multiplicative manner. The various dimensions of stimuli are represented by similarity parameters which can range from 0 to 1, with 1 representing maximum similarity. If two stimuli were comprised of two dimensions each (A and B), then their overall similarity would be equal to AB. The attractive aspect of this multiplicative rule is that it allows for the effects of the various dimensions to be overcome by those of some dimensions, even a single one. For example, the difference between a person and a mannequin on the dimension of 'animacy' effectively overshadows the many similarities that may otherwise exist between them (this would be the result of the animacy dimension being effectively equal to zero).

Exemplar models are attractive because of their parsimony. In these models there does not appear to be any need for summary statistics of categorical information. Rather, all that is required is for each stimulus to be stored as a set of features, including context and category membership, and for any new stimulus to be compared with previously stored exemplars. The parsimony is only apparent, however. These models do not address the question of which features are stored on any given occasion. The assumption that a stimulus is stored as a set of features requires that these features be known. As pointed out in the previous section, this may well be true in experimental situations which use geometric stimuli whose composition is carefully explained to the subject (cf. Hovland, 1952). It is doubtful, however, that subjects would automatically know which features to extract when faced with natural stimuli, such as those shown in Figure 1A & 1B, that consist of a potentially large number of features of varying degrees of detail.

In summary, most current models of categorization share an analytic orientation. They assume that the first step in categorization consists of decomposing a stimulus into a set of features. As was repeatedly pointed out, the question of <u>which</u> features are extracted in the case of (natural) stimuli that contain a potentially large number of features is left unanswered.

Holistic Approaches

In contrast to the analytic tradition, some theorists have utilized a holistic approach to perception and categorization. Lockhead (1972) suggested a 'blob' model in which objects are processed as unified wholes according to integral dimensions, and where specific local features are ignored (see also Shepard, 1964; Garner, 1974).

Garner (1978) has distinguished three types of holistic components: simple wholes, templates, and configurations. Simple wholes are defined as the sum of the parts. A template according to Garner, is best considered as a 'schema' or modal stimulus defined by relevant attributes. Configurations are considered to be something other than the sum of the parts and are defined by properties such as symmetry and repetition. These properties are considered 'emergent' in that they cannot be considered independently of other stimulus components.

Palmer (1975), among others, has argued for the importance of global information in visual perception. He refers to real-world object schemas in which higher-order concepts, such as location and orientation, provide a 'frame of reference' for the subparts. The important part of a visual scene is captured by a high level of representation which is relatively simple and comprehensible; people rarely perceive or remember visual information in fine detail. This is consistent with his view that in everyday life people usually ignore a great deal of information unless there is a specific reason to attend to it.

Navon (1977, 1981) has been one of the strongest proponents of the view that perception proceeds from the global to the specific. This refers to the temporal development of a percept according to which the global aspects of a stimulus are processed before the local ones. In a series of experiments using compound letters (i.e., large letters made up of smaller ones) he found evidence of 'global precedence'. Subsequent research using compound letters as stimuli, however, has cast considerable doubt on whether there really is global precedence with this type of stimuli (Pomerantz,1983). Regardless of its status with respect to results obtained using overlearned stimuli such as alphabetic letters, it is quite possible that global precedence may affect the processing of unfamiliar natural stimuli.

Eleanor Gibson's theory of perceptual learning and development is relevant to the present discussion. Gibson (1969; 1987) maintains that perceptual learning entails an active process of differentiation such that, as the human infant develops, he or she must learn to extract the order and the invariant structures available in the environment. Although the present thesis was not concerned with perceptual development in young children, it is possible that processes similar to those envisaged by Gibson apply to adults who must learn to discriminate between unfamiliar stimuli such as those shown in Figure 1A and 1B. One might expect in this case that their learning would also entail an active process of differentiation. From this perspective, Navon's hypothesis of global precedence in the development of a percept has many points of similarity with Gibson's theory of perceptual development.

Overall, the theories examined in this section do not assume that all properties of a stimulus are immediately available after a single presentation. Rather, they share the view that processing proceeds from the relatively more global to the relatively more local aspects of stimuli. In this sense, these theories provide a constraint on the processing of natural stimuli that is missing in the more analytically oriented approaches discussed previously. The present thesis explores the possibility of a global-to-local constraint in the classification of stimuli from two natural categories.

CHAPTER 3

Experiment 1

The brief review in Chapter 2 has shown that most models of classification share the analytic assumption that categorization begins with the decomposition of each stimulus into a set of properties. It was argued that, with regard to many natural stimuli, this assumption is problematic because such stimuli can be decomposed into a large number of possible features and, given the limited capacity of the human cognitive system to process information, it is likely that, in a single exposure to a stimulus, subjects could extract but a few of those features. The question of constraints in the categorization of natural stimuli was then raised.

One possible constraint may be due to a global-to-local direction of feature processing (Palmer, 1975; Navon, 1977, 1981). If limitations of information processing prohibit the processing of <u>all</u> properties of natural stimuli at once, then, perhaps as Palmer (1975) suggested, global properties may be the ones that are extracted first, with processing continuing toward more detailed features only as the necessity for finer and finer discriminations arise.

A second possible constraint may arise from evidence that people often categorize items on the basis of a single characteristic property (e.g., Medin, Wattenmaker & Hampson, 1987; Cook & Odom, 1988). They tend to approach a categorization task by looking for a defining property in a manner that is consistent with the classical view. It should be noted that this 'distinctive feature' approach to categorization is compatible with a global-to-local direction of processing. That is, people may begin looking for a distinctive feature at the global level of analysis and proceed to more local levels only if no satisfactory global feature can be found.

These considerations lead to a third and related point. Different categorization tasks may require stimulus analysis to different degrees of detail. For example, the hierarchy of the plant kingdom includes Families, Genera, and Species. Classification at the family level would require attention to more global properties than classification at the genus or species level. Furthermore, classification at the species level would require more global properties than those needed to identify a particular member of a species. Thus, the purpose of classification is likely to affect the level of detail to which a stimulus is analyzed.

As mentioned at the outset, the main purpose of the present research was to investigate some aspects of categorization involving natural stimuli. The stimuli were (tracings of) actual leaves of two species of Oaks, i.e., White and Red Oaks. Although most people know Oaks, very few know how to distinguish between the leaves of White and Red Oaks. Subjects who are asked to learn to discriminate between White and Red Oak leaves are in the position of naive botanists. They are confronted with stimuli that possess a large number of properties. The question addressed here concerned the property (or properties) that they would use when learning to discriminate between leaves of different species as compared to leaves of the same species.

Drawing from the foregoing discussion, one would predict that the discrimination between leaves with respect to whether they belonged to the White or Red Oak species would require the extraction of categorical information which might entail one or more global properties. On the other hand, discrimination between leaves of the same species would require the extraction of individual leaf information which might entail one or more local or detailed properties.

Experiment 1 was designed to explore the extent to which people are able to extract and remember relatively more global (categorical) information as compared to more detailed (individual) information under different task instructions. Thus, if the task emphasized discrimination at the species level, and if the order of processing proceeds from the global to the more detailed levels, then it should be easier to extract and remember global as opposed to detailed information. Operationally this means that it would be easier to distinguish between the leaves of Red and White Oaks than between same-species leaves. It is possible, however, that, should the task emphasize discrimination at the level of individual leaves, detailed information may be extracted at the expense of more global information. In Experiment 1, four groups of subjects received different instructions. In one group, instructions emphasized the extraction of global (categorical) level information. In another group, they emphasized the extraction of detailed (individual leaf) information. The remaining two groups received a combination of these instructions. The specific hypotheses were that:

(1) When instructions emphasize discrimination at the species level, subjects will extract predominantly categorical information.

(2) When instructions emphasize discrimination at the individual leaf level, subjects will extract detailed information. The extraction of such information may or may not preclude the extraction of more global information. If the global-to-local order of processing is mandatory, as suggested by Navon (1977; 1981), then global information must always be processed first before more detailed information can be processed. On the other hand, it may be possible to process individual item information without having to process the stimulus at the more global level. The

test phase of Experiment 1 was designed to allow a decision between these possibilities.

Method

Subjects

The subjects were 64 volunteer undergraduate students enrolled in psychology courses at Simon Fraser University, randomly assigned to each of four conditions.

Stimuli

Each stimulus included a black line tracing of a leaf on standard (8.5" x 11") white paper. Tracings were obtained from actual leaves collected from two species of trees (White and Red Oaks) in the Lower Mainland area of British Columbia. Leaves were photocopied and the photocopies enlarged or reduced until approximately equal sizes, as judged by the experimenter, were achieved. The final photocopies were then traced using a .01 graphic pigment liner on fine tracing paper with bottom illumination to maintain accuracy. The leaf margins, stem and portions of the veins were traced. Each tracing was finally photocopied onto standard white paper so that it was centered slightly above the midline. Tracings of 10 White Oak leaves and 10 Red Oak leaves were obtained in this way. Hereafter these tracings will be referred to as leaves. The 20 leaves were randomly divided into two sets (Set 1 and Set 2) of five White Oak and five Red Oak leaves each as shown in Figures 1A and 1B.

Training Stimuli. All training stimuli included black line tracings as described above. In the No-Name condition, the training stimuli showed only the leaf. In the

Individual condition, each leaf had a unique, randomly obtained two-digit number (e.g., #67) written below it. This number identified each leaf as a unique stimulus. In the Category condition the words "White Oak" or "Red Oak" were written below each leaf, as appropriate. In the Category/Individual condition, both the type of Oak leaf (White or Red) and its individual number (e.g., #67) were written below each leaf. Examples of training stimuli can be seen in Figure 2. For one-half of the subjects, the 10 leaves in Set 1 were used for training, whereas the leaves in Set 2 were used for the other half. Two random presentation orders were used for each set of stimuli, the second order being the reverse of the first.

Insert Figure 2 about here

Test Stimuli. All test stimuli included black line tracings as described above. Leaves were placed on the page exactly as with the training stimuli. Space was provided underneath each leaf for subjects to indicate (a) whether the leaf was OLD or NEW (in the No-Name condition), (b) the NUMBER of the leaf and whether the leaf was OLD or NEW (Individual condition), (c) the category NAME of the leaf (White or Red Oak) and whether it was OLD or NEW (Category condition), or (d) the category NAME, the NUMBER of the leaf, and whether the leaf was OLD or NEW (Category/Individual condition). Examples of test stimuli are shown in Figure 3. There were 20 test stimuli, which included all the original 10 White Oak leaves and 10 Red Oak leaves. Ten of the test stimuli were OLD, having previously been seen in the training phase (either as Set 1 or Set 2), and 10 were NEW (either Set 2 or Set 1, respectively).

Insert Figure 3 about here

Design

The experiment included four groups of subjects each of which received a training phase followed by a test phase. The groups differed in the type of instructions and stimuli received.

Procedure

Training. Subjects were run in groups of 6 - 16 subjects. Each subject received one of 32 different booklets at random. The booklets differed in terms of the instructions, set of training and test stimuli used, training order, and test order. The top page of each booklet contained instructions for the training phase. Subjects in all groups were informed that they would be shown a series of 10 leaves and that they were to learn as much as possible about each of them because later they would be asked to recognize the leaves again. These were the only instructions given to subjects in the No-Name condition. Subjects in the Individual condition were informed, in addition, that they should try and learn the number (e.g., #67) associated with each leaf because later they would be asked to recall each leaf's NUMBER. Those in the Category condition were informed, in addition, that they should also try and learn the category names associated with the leaves (White or Red Oak) because later they would be asked to recall the NAMES of the leaves. Finally, those in the Category/Individual condition were informed that they should also try and learn both the name of each leaf (White or Red Oak) and the number (#67) associated with it, because later they would be asked to recall both the NAME and the NUMBER.

After the instructions were understood, subjects were paced through two blank practice pages in order to familiarize them with the pace at which pages would be turned. They were then paced through the next 10 pages of the booklet, each of which showed a training stimulus. Subjects were instructed to turn each page upon a cue from the experimenter (the word TURN) which was said every 4 s, as timed by a stopwatch. One-half of the subjects received one randomly determined presentation order, while the other half received the reverse order.

Test Procedure 1. The material for the test phase was contained in the same booklet received by each subject at the beginning of the experiment. For all groups, the test phase began with a page of instructions followed by one blank page (so subjects could not see the first test stimulus), and then by the 20 test stimuli. The instruction page informed subjects that they would be seeing 20 leaves, that 10 of these would be OLD (leaves they had just seen), and that 10 would be NEW (leaves not seen before). As well, subjects in the No-Name condition were asked to indicate in the space provided whether the leaf was OLD or NEW (see Figure 3). Those in the Individual condition were asked to indicate whether the leaf was OLD or NEW and to write down the leaf's NUMBER. They were also informed that in order to aid their recall, the leaf numbers of all the OLD leaves would be listed at the bottom of each page. Those in the Category condition were asked to indicate the leaf's category NAME and whether it was OLD or NEW. Finally those in the Category/Individual condition were asked to indicate the leaf's category NAME, whether the drawing was OLD or NEW, and to write down its NUMBER. They were also informed that in order to aid their recall, the numbers of all the OLD leaves would be listed at the bottom of each page.

Subjects were instructed to turn each page upon the cue from the experimenter (the word TURN) which was said every 8 s, as timed by a stopwatch. Subjects had approximately 5-6 s to record their responses underneath each leaf. Test stimuli were presented in two different random orders (the second being the reverse of the first), each for one-half of the subjects in each of the groups.

Subjective Reports. Following the test phase, the next page of the booklet asked subjects to respond in writing to the following three questions:

1. Describe all that you have learned about the leaves.
2. Did you see any different <u>kinds</u> of leaves? If so, how many kinds?
3. If you answered yes to the previous question, describe on what basis you saw the kinds of leaves.

The written answers to these questions are referred to as the subjective reports. The subjective reports completed the experiment for subjects in the Category and Category/Individual conditions.

Test Procedure 2. Upon completion of the subjective reports, subjects in the No-Name and Individual conditions were asked to examine all 20 test stimuli again, one at a time, with the instruction to write on each stimulus page whether the leaf was of

Kind 1, Kind 2, etc., in accordance with the kinds of leaves they had just described. This task completed the experiment for these subjects.

Results

Individual Item Information: Old/New Identification Task

The data were first analyzed to determine whether subjects were able to remember individual information about OLD stimuli, that is, whether they could discriminate, in the test phase, between OLD and NEW stimuli. Mean proportion of Hits and False Alarms are shown in Table 1. To determine whether discrimination was a function of training conditions, a d' score was calculated for each subject. Mean d' scores are shown in the bottom row of Table 1. An Analysis of Variance (ANOVA) carried out on d' showed that mean d' scores were not significantly different from one another, $F\,(3, 60) = 1.76$, $p > .10$.

Insert Table 1 about here

A planned comparison test, however, showed that the No-Name and Individual groups combined ($M = .48$) differed significantly from the Category and Category/Individual groups combined ($M = .07$), $t\,(62) = 2.27$, $p < .05$. Subsequent analyses showed that the combined mean of the No-Name and Individual groups was significantly different from zero, $t\,(31) = 4.27$, $p < .01$, whereas the combined mean of the Category and Category/Individual groups combined was not, $t\,(31) = .52$, $p > .05$.

In the test phase, subjects in the Individual and Category/Individual conditions were asked to recall the number associated with each OLD leaf. A count of all responses (of all subjects to all OLD leaves) in the Individual condition indicates that there were only 17 correct responses out of 149 (there were 11 omissions). Of the 120 responses (excluding omissions) made by subjects in the Category/Individual condition, only 9 were correct. These performances are not significantly different from chance expectation (1 out of 10 correct).

Categorical Information

Category and Category/Individual Conditions. The data were then analyzed to determine whether subjects could remember categorical information. During the test phase, subjects in the Category and Category/Individual conditions indicated, in addition to whether each leaf was OLD or NEW, whether it was a White or a Red Oak type. Across all stimuli and subjects in both groups, 95.5 % (611/640) of the responses were correct, 3.3% (21/640) were omissions, and only 1.2% (8/640) were incorrect. As well, all subjects in these conditions, without exception, indicated in their subjective reports that they had learned to distinguish Red Oaks and White Oaks on the basis of the shape of the leaf lobes. The adjectives used by different subjects varied between pointed, jagged, or sharp (for Red Oak leaves) and rounded, smooth, or curved (for White Oak leaves).

Individual and No-Name Conditions. Subjects in these two groups were not given nor were they asked to learn any categorical information during training. Similarly, they were not asked to give any categorical information during the initial test. The question remains, however, whether these subjects had learned any categorical information, despite not being explicitly asked to do so. The purpose of the subjective reports, and of the second administration of the test stimuli, was to assess the degree of categorical information remembered by the No-Name and Individual subjects. Both the subjective reports and the second categorization of test stimuli showed that all but one subject had formed at least two groups of leaves, the principal distinction being whether the lobes of the leaves were rounded or pointed.

More specifically, 56% of the subjects categorized the leaves into 2 kinds only, on the basis of the 'rounded' vs. 'pointed' distinction. All other subjects (except one), also used the rounded-pointed distinction, but added other criteria as well. These included one or more of the following: size, width, length and overall shape.

Discussion Experiment 1

Categorical Information

Subjects who were instructed to focus on categorical information (Category and Category/Individual conditions) were able to remember this type of information well, as indicated by their 95.5% accuracy in naming the species of each leaf regardless of whether it was OLD or NEW. Their subjective reports also indicate that it was easy for them to distinguish between Red and White Oaks. Subjects who were <u>not</u> specifically instructed to focus on categorical information (No-Name and Individual conditions), were nevertheless also able to remember such information well, as indicated by their subjective reports and performance on the second categorization test.

Individual Information

The results of the d′ analysis shows that subjects in the Category and Category/Individual conditions were unable to remember any information about individual leaves, since their average d′ score was .07. Subjects in the No-Name and Individual conditions, however, did remember some individual leaf information, since their average d′ was .48, which was significantly different from zero. From the point of view of signal detection theory, a d′ of .48 indicates an overlap of about 80% between the signal (OLD item) and the noise (NEW item) distributions. Thus the effect, though significant, is small.

In summary, the data show that, under the present conditions, categorical, but not individual, information was easily extracted and remembered. Subjects remembered a modicum of individual information only when instructed to do so, and in the absence of instructions to remember categorical information. This raises the question of why it was relatively difficult to remember individual information. One possibility is that the ability to remember an OLD item depends on whether the subject extracted a detail that was unique to that item (Loftus & Kallman, 1979). This possibility is addressed in Experiment 2.

CHAPTER 4

Experiment 2

The data of Experiment 1 indicated that subjects remembered categorical information well, but that their retention of information about individual leaves was relatively poor. An examination of same-species leaves used in Experiment 1 (see Figures 1A & B) shows that, despite apparent differences between them, these differences may not have been sufficient to make each leaf memorably distinct from the others. The purpose of Experiment 2 was to determine whether an added property that made a leaf distinctive would allow subjects to remember that particular leaf. Thus, if a subject's ability to remember an individual leaf depends on it possessing a distinctive property, then, in a test similar to that of Experiment 1, subjects should be able to remember that leaf as OLD.

This hypothesis, however, is less straight forward than it seems. The issue is whether subjects would remember that a distinctive property was attached to a particular leaf, or only that the distinctive property was attached to one of the leaves. In Experiment 2, the added property was a prominent notch in the margin of one of the leaves used in training. The issue can then be expressed as follows: How much detail would subjects remember after seeing a notched leaf. One possibility is that they do remember much detail. If this is the case, not only would they remember that there was a leaf with a notch, but they would also remember the particular leaf in which the notch was embedded. Under this hypothesis, therefore, a subject should be able to discriminate the OLD leaf with a notch from a NEW leaf that had the same notch carved out of its margin. However, as suggested by the results of Experiment 1, subjects may not be able to remember much detail. In this case they might remember only that a leaf had a notch, but not which leaf had the notch. Under this hypothesis, subjects should not be able to discriminate between the OLD notched and a NEW notched leaf.

In summary, if subjects do remember much detail, then the following predictions would follow: They should be able to discriminate between OLD and NEW notched leaves; they should also be able to select the particular training leaf that had a notch in it; as well, they should be able to discriminate between the OLD regular (nonnotched) leaves and NEW regular leaves. However, if subjects do not remember much detail, then they would not be able to discriminate between the OLD notched and the NEW notched leaves; they would also be unable to select the particular training leaf that had a notch in it; as well, they would be unable to discriminate between OLD regular (nonnotched) and NEW regular leaves.

Under the second alternative (inability to remember fine detail) performance might be determined by response strategies. With respect to notched leaves (OLD and NEW), one strategy could be guessing. A second strategy, that would apply to the first (or only) notched leaf seen in the test phase, could be to call this leaf OLD, regardless of whether it was in fact OLD or NEW. This hypothesis is based on the notion that, when subjects see a notched leaf, they would remember that they saw one such leaf during training , but, being unable to remember any other detail, they would tend to assume that it was the OLD leaf. This strategy would affect responses to the only notched leaf shown in the test phase in Groups A and B below, and to the first notched leaf shown in the test phase of Group C.

When two notched leaves are shown, the response to the second leaf may depend on what response was made to the first, and whether subjects can remember what that first response was. More precisely, if subjects remember how they responded to the first notched leaf, then there may be a tendency for them to give the alternative response to the second notched leaf. However, if subjects do not remember how they responded to the first notched leaf, then they will be likely to guess in response to the second one.

Method

Subjects

The subjects were 90 volunteer undergraduate students enrolled in undergraduate courses at Simon Fraser University.

Design

This experiment included three groups, A, B, and C, that differed in the test they received. It should be noted (see below) that all groups were variants of the No-Name group of Experiment 1. There were 18 subjects in each of groups A and B whereas there were 54 subjects in group C. The relative large number of subjects in Group C was needed in order to have reasonable power in the statistical tests planned for that group.

Stimuli

Training Stimuli. All stimuli were similar to those used in Experiment 1. Only Red Oak leaves were used. A subset of five from the original 10 Red Oak leaves was randomly chosen to constitute the training stimuli (see Figure 4). Of these, one leaf was randomly chosen to become the distinctive leaf. Using photocopies of other Red Oak leaves with actual worm-eaten margins, the experimenter constructed a realistic worm-eaten notch in the margin of the distinctive leaf (see Figure 5). This leaf will be hereafter referred to as the OLD notched leaf.

Insert Figure 4 about here

Insert Figure 5 about here

Pretest of the distinctiveness of the old-notched leaf. A pretest was conducted in order to determine whether the OLD notched leaf was indeed distinctive, as hypothesized. Twenty-five subjects were shown the five training Red Oak leaves, one at a time. Three random orders were used, with the distinctive leaf appearing in the first, third, or last position. Subjects examined each leaf at their own pace. Afterwards they were asked to describe in writing the ways in which each leaf differed from the others. The descriptions indicated that all 25 subjects indeed noted that one of the leaves had a notch in its margin.

Test Stimuli. Each of three groups was tested with 10 test stimuli.

Group A: The test stimuli for this group consisted of all five training stimuli (including the OLD notched leaf), and the five Red Oak leaves remaining from the original set used in Experiment 1. (It should be noted that in this group the notched leaf is the only distinctive leaf throughout the experiment. In the test phase, this is an OLD leaf.)

Group B: The test stimuli for this group were obtained by replacing the OLD notched leaf with a NEW notched leaf (see Figure 5). This test set, therefore, consisted of four regular training (OLD) leaves, five regular NEW leaves, and one NEW notched leaf. In this group subjects saw an OLD notched leaf during training and a NEW one during testing. The question was whether subjects would be able to detect that the notched leaf in the test was NEW.

Group C: The 10 test stimuli for this group consisted of the five training stimuli (including the OLD notched leaf), four NEW regular leaves, and one NEW notched leaf (the same as for Group B). The question here was whether subjects would be able to discriminate the OLD notched from the NEW notched leaf when both occurred during testing. For one-half of the subjects (Group C1) the OLD notched leaf preceded the NEW one whereas for the other half (Group C2) the order was reversed.

Forced Choice Test Stimuli. The test stimuli in the forced choice test consisted of five regular leaves. Four were the regular training leaves. The fifth was the notched training leaf restored to its original form, i.e., without the distinctive notch carved out of it (i.e., as seen in Figure 4).

Procedure

Training Procedure. Subjects were run in groups of 7-18 subjects. Each subject received a booklet at random in which the top page contained the instructions for the training phase. Subjects in all groups were informed that they would be shown a series of five leaves and that they were to learn as much as possible about each of them because later they would be asked to recognize them again. All subjects received the same training stimuli: four regular leaves and one notched leaf. Three different orders were used: In Order 1, the notched leaf was in Position 1, in Order 2 it was in Position 3, and in Order 3 it was in Position 5. Within each order, the 4 regular leaves were placed randomly in the available positions. As in Experiment 1, pages were turned at a pace controlled by the experimenter, who said the word TURN every 4 s, as timed by a stopwatch.

Test Procedure. The material for the test phase was contained in the same booklet that each subject received at the beginning of the experiment. For all groups the test phase began with a page of instructions followed by a blank page and 10 test stimuli. Subjects were informed that they would be seeing 10 leaves and that one-half of these would be OLD, that is, ones they had just seen, while one-half would be NEW, ones that they had never seen before. The experimental groups differed on the test they received, as outlined above. For all subjects, the task was to identify in writing whether each leaf they saw was OLD or NEW. Pages were turned at a pace controlled by the experimenter, the same as in Experiment 1. For Group A, two random orders were used. In the first, the OLD notched leaf was in Position 3. The second random order was the reverse of the first, so that the notched leaf was in Position 8. For Group B, the test was identical to that of Group A, except that the NEW notched leaf was substituted for the OLD one. For Group C, one-half of the subjects (Group C1) received a random order which was the same as for Group A, except that a NEW notched leaf replaced the new regular leaf that occupied Position 8. In this order, therefore, the OLD notched leaf was in Position 3 and the NEW notched leaf in Position 8. The other half of the subjects (Group C2) received a random order which was the reverse of the first.

Forced Choice Test Procedure. Following the OLD/NEW recognition task all subjects were given a five-item forced choice test in which they were asked to pick the leaf which, in the training phase, had a notch carved out of its top right margin. The five leaves appeared sequentially in three random orders which were the same as those described for the training procedure. These three random orders were crossed with the three training orders. The test was self-paced so that subjects could look through the five leaves at a pace they chose and mark an X on the leaf that they thought was the one from which a notch had been carved out in the first part of the experiment.

Results

Identification of Regular Leaves

Although the focus of Experiment 2 was on the notched leaf, a first analysis was carried out to determine whether subjects were able to discriminate regular OLD from regular New leaves. Mean proportion of Hits and False Alarms and mean d' are shown in Table 2. An ANOVA carried out on d' scores showed that the groups differed significantly from one another, $F(2, 87) = 3.55$. $p = .03$. A t-test showed that the overall mean d' ($M = .15$, all groups combined) was not significantly different from zero, $t(89) = 1.005$, $p = .31$.

Insert Table 2 about here

Identification of Distinctive Leaves

Binomial tests were conducted to assess the subjects' ability to remember specific information about the "notched" leaf under various test conditions.

Groups A & B. In the test phase, 11 of the 18 subjects in Group A correctly called the OLD notched leaf OLD. However, 14 of the 18 subjects in Group B incorrectly called the NEW notched leaf, OLD. These two proportions did not differ significantly from one another, $z = 1.09$, $p > .10$. Combining Groups A & B together, 25 of 36 subjects called the only notched leaf they saw during testing OLD, a proportion which is significantly greater than .5, $z = 2.53$, $p < .05$.

Group C. This group of subjects consisted of two subgroups , C1 and C2. Group C1 saw the OLD notched leaf in Position 3 and the NEW notched leaf in Position 8. Group C2 saw the NEW notched leaf in Position 3 and the OLD one in Position 8. Consistent with the previous analyses, there was a significant tendency for subjects to call the first notched leaf they saw OLD. Eighteen of 27 subjects in Group C1 did so (correctly), whereas 16/27 in Group C2 did so (incorrectly). These two proportions did not differ significantly from one another, $z = .56$, $p > .10$. Thus, a total of 34/54 subjects called the first notched leaf they saw OLD, a proportion which is significantly greater than .5, $z = 1.97$, $p = .05$.

Responses to the second notched leaf depended strongly on whether the first was OLD or NEW for subgroup C1 but not for subgroup C2. The number of subjects in Group C1 who (correctly) called the first notched leaf OLD and the second NEW was 15. The number of those who (incorrectly) called the first notched leaf NEW and the second OLD was 0, a highly significant difference, $z = 3.87$, $p < .01$ (see McNemar, 1969). In Group C2, the number of subjects who (correctly) called the first notched leaf NEW and the second OLD was 6. The number of those who (incorrectly) called them OLD and NEW, respectively, was also 6, a nonsignificant difference, $z = 0$.

Forced Choice Test. Across all Groups, 21/87 subjects (there were three omissions) correctly chose the leaf which originally had the notch carved out of its margin. This does not differ significantly from 1/5, which is expected by chance ($z = 0.93$, $p > .10$).

Discussion Experiment 2

The results of Experiment 2 support the conclusion that subjects could remember that there was a leaf with a notch, but could not remember much else. During the pretest, all subjects (25/25) noticed that one of the leaves had a notch, supporting the hypothesis that the notch was distinctive. Responses to the notched leaf in Groups A and B, and to the first notched leaf in subgroups C1 and C2, however, shows that subjects were unable to discriminate between OLD and NEW notched leaves. Their responses were seemingly determined by a tendency to call the first notched leaf they saw, OLD, regardless of whether it was in fact OLD or NEW. Subjects were also unable, in the forced choice test, to correctly select the leaf which originally had the notch carved out of its margin. These results support the conclusion that subjects could not remember details associated with the notched leaf, i.e., to which particular training leaf the notch was attached. That subjects could not remember much detail is also supported by their responses to the regular leaves since, across all subjects, mean d' was not significantly different from zero. (It should be noted that because the overall d' was not significantly different from zero, and there being no reason to expect significant differences in performance on the regular leaves between the groups, the significant result of the Analysis of Variance obtained between groups was probably due to Type I error.)

Given the subjects' inability to remember much detail, their pattern of responses to the second notched leaf in Group C is likely due to whatever response strategies were adopted. The results show that, for some subjects (Group C1) responses to the second notched leaf depended on their responses to the first, whereas for others (Group C2) it did not. Subjects in Group C1 who saw the OLD notched leaf first and the NEW notched leaf second, were were better able to discriminate between these leaves than subjects in Group C2 who saw the leaves in the reverse order. A possible explanation for this pattern of responses is that eight of the 15 subjects in Group C1 who correctly discriminated between the OLD and NEW notched leaves, had received training order two in which the OLD notched leaf appeared in fifth and last position. Thus these subjects saw only two intervening leaves between the training presentation of the OLD notched leaf and its appearance in the test phase, whereas for other subjects there was a minimum of five intervening leaves. This explanation is highly speculative and the replication of Groups C1 and C2 would be required in order to clarify the obtained pattern of responses.

CHAPTER 5

General Discussion

The present work was concerned with the properties that people use when making categorical judgements of natural stimuli. An important aspect of such stimuli is that they can be analyzed into a very large number of properties, any number of which can be used for the purpose of categorization. Processing limitations of the cognitive system suggest that constraints must operate to delimit the type and/or number of properties that are extracted from natural stimuli in any given situation.

One type of constraint may be provided by assuming that stimulus analysis proceeds from relatively more global to relatively more local properties. Thus, for natural categories arranged hierarchically, such as those in the plant kingdom, it is possible that, at each level of the hierarchy, properties of differing degrees of detail become relevant. The present thesis was concerned with the two lowest levels of this hierarchy, that of the species and that of individual members of a species. The two species were White and Red Oaks. The individual members were leaves of each species. The hypothesis explored was that the kind of properties needed to discriminate leaves at the categorical level would be relatively more global, and therefore more easily extracted, than those needed to discriminate at the individual level, i.e., between leaves of the same species.

The above hypothesis was tested and supported in Experiment 1. In Experiment 1, subjects instructed to focus on categorical information (Category and Category/Individual groups) showed over 95% accuracy in their classification of (old and new) leaves according to their species. These subjects however, were unable to discriminate old leaves from new ones, indicating no retention of individual information. Subjects who were explicitly instructed to focus on individual information (No-Name and Individual groups) did remember a modicum of such information. However, they were also able to extract categorical information, as indicated by their subjective reports and their performance on the second classification test.

The asymmetry of these results is in accord with the proposal that visual information processing proceeds from the global to the local, and that the processing of global information is mandatory (Navon, 1977). Thus, subjects instructed to process leaves at the categorical level, extracted only categorical (presumably global), but not individual (local) information. However, subjects instructed to process individual information did so to some extent, but, importantly, were also able to remember categorical information, thus supporting the notion that processing of global information is obligatory.

Experiment 2 was concerned with one issue raised by the results of Experiment 1, namely, the reason for the relatively poor retention of individual information. The specific hypothesis explored in Experiment 2 was that, if a leaf had a property (a notch) which made it distinctive, then perhaps subjects would be able to remember that particular leaf. The results showed that, although subjects could remember that there was a notch, they were unable to remember the particular leaf which possessed it. In general, it would appear that, if a stimulus has a unique property, then subjects may remember that there was such a property, but do not remember other details, so that they are unable to individuate the stimulus to which the property was attached.

In Experiment 2, the inability to remember detail was confirmed by the analysis on the regular leaves. Based on 90 subjects, mean d' was not significantly greater than zero. In this context, it should be noted that all groups in Experiment 2 were a replication of the No-Name group in Experiment 1. In Experiment 1, the d′ associated with this group was .42, significantly greater than zero. This value, however, was based on only 16 subjects, each of whom classified 20 test stimuli (10 old and 10 new). The mean d′ of Experiment 2 was not only based on a much greater number of subjects, but, in addition, these subjects saw only 10 test stimuli (5 old and 5 new), not 20. Discrimination should therefore have been easier in Experiment 2 than in Experiment 1. For these reasons, the result of the d′ analysis obtained in Experiment 2 carries more weight than the result obtained with the No-Name group in Experiment 1. Thus, it is reasonable to conclude that, under the conditions of the present experiments, subjects are unable to remember much detail.

This raises the question of why so little detailed information was remembered. One possibility is that the procedure used in the present investigation, a single brief exposure of stimuli (entailing exposures of less than 2 s per leaf), may have allowed for the extraction of categorical, but not individual information. If subjects were given more exposure time or more trials, there is reason to expect that they would be better able to extract individual information. An examination of same-species leaves in Figures 1A and 1B, reveals that they differ in many and, in some cases, fairly distinct ways. These differences are such that, given sufficient time and practice, subjects should be able to remember one or more properties of individual leaves that would allow them to discriminate successfully between leaves of the same-species. Another possible factor that may have affected the relatively poor retention of individual information was the use of two-digit numbers to emphasize that each leaf was unique. It may be that numbers are not as useful in this respect, as some other labeling method, such as letters, or even proper names, might have been. An even better method might be to name each leaf with its most distinctive property. For example, "left-leaning" or "four-lobed", and so on. These hypotheses will be tested in future studies.

In conclusion, the present results indicate that, at least in the case of the natural stimuli used in the present work, subjects are able to extract very few, if any, individual properties from each of the stimuli. What they are able to do very easily, however, is to extract (categorical) information that allows them to make the distinction at the species level. From the subjective reports, the distinction between Red and White Oak leaves was made on the basis of whether the lobes were pointed or rounded, respectively. One poetic version of this was to describe the Red Oaks as 'tongues of fire' and the White Oaks as 'fluffy clouds'.

What is a Global Property?

Throughout the present work "categorical", has been implicitly or explicitly equated with the term global. A question that arises from the foregoing is whether the properties used by subjects to distinguish between the two categories, namely, the shape of the lobes, is, in fact, global. The issue of what constitutes a global property is not simple because there is no objective or formal way to operationally define, a priori, what constitutes such a property. It is also possible that any given stimulus may have more than one global property. In the present context, both the overall shape of the leaf and the shape of the lobes could be considered global properties, in the sense that they pertain to the whole leaf. Of these two, overall shape does not allow for the Red/White Oak distinction to be made with any consistency (compare Figure 1A with 1B), whereas the shape of the lobe does. This latter property was, in fact, the one used by subjects to make the discrimination at the species level.

Relation to Current Models of Categorization

It is of interest to attempt to account for the results of the present work within the frameworks of the major theoretical models of categorization outlined in Chapter 2. Average prototype models propose that a category is described by summary statistics calculated from all stimuli encountered. In Posner and Keele's (1968) model, for example, these statistics include a composite average and a measure of variability. In such models, specific individual item information is lost. The present data are consistent with models of this type if one assumes that the average prototype includes the global property of lobe shape. A feature of the Posner and Keele model is that the prototype is thought to be more resistant to memory decay than individual instances (Posner & Keele, 1970). The present data are consistent with this view if it is assumed that individual information was extracted during training, but had decayed by the time of testing. Under the conditions of the present study, the time elapsing between the training phase and the test phase was approximately 2 minutes. If individual information was extracted, it would have to have decayed rapidly within this time interval.

Modal prototype models would not easily account for the present data. These models are based on feature counts which result in a prototype that includes only the most frequent properties (Hayes-Roth & Hayes-Roth, 1977; Neumann, 1974, 1977). As previously discussed, the main problem with such models is that they require that the features be known in advance so they they may be counted. It is difficult to imagine, with respect to the kind of stimuli used here, how the list of relevant properties would be constructed. The model could be invoked post hoc by supposing that, after seeing the stimuli, only one relevant property, the shape of the lobes, was extracted and that it necessarily became the modal feature. This account obviously stretches the model beyond the scope for which it was intended.

The present data also pose a problem for the family resemblance model (e.g., Rosch & Mervis,1975). According to the family resemblance notion, category members are related to one another on the basis of the degree of feature overlap between them. The difficulty faced by this approach is similar to that discussed with respect to the modal prototype model, namely, that it presupposes the extraction of a population of known features. As was the case with the modal prototype model, the family resemblance model could account for the present data in a post hoc manner, but this would be contrary to the spirit of the model.

The exemplar models (e.g., Medin & Schaffer, 1978) may have the most difficulty in accounting for the present data because they presuppose that each stimulus is encoded as a set of properties, and that each incoming stimulus is classified by having its properties compared with those of all previously stored exemplars. One way this model could account, again post hoc, for the present data would be to assume that the global properties of natural stimuli overshadow all other properties. However, such an assumption would strain the model in that, if the extraction of global properties lead to the retention of only categorical information, then people might remember only categorical, and not individual information, contrary to the very notion of exemplar storage.

At this point it may be worthwhile to reconsider the classical model. This model was rejected because of its difficulty in accounting for the fuzzy nature of some categories. In the present situation, however, the classical model may be more successful than the ones discussed above. Subjects in the present study seem to have extracted a single relevant property (the shape of the lobes) which could be considered defining, in the classical sense. Recent evidence also suggest that people approach categorization learning tasks in a manner that is consistent with the classical view (Medin, Wattenmaker, & Hampson,1987; Cook & Odom, 1988).

Summary and Conclusion

The two experiments in this thesis explored the issue of what type of properties are extracted and used in one instance of classification of natural stimuli. The results indicate that subjects easily extract a property relevant to discriminating between two species of leaves, but have difficulty in extracting properties relevant to discriminating between individual leaves of the same species. The property that subjects used to distinguish between the species appears to be more global than any of the properties that could be used to distinguish between individual leaves. The above results are consistent with a view according to which the extraction of relatively more global properties precedes and is easier than the extraction of relatively more local ones. This may be related to the hierarchical structure of natural categories such that, as one moves from the most to the least inclusive level of a hierarchy, relevant properties change from relatively more global to relatively more local. Thus, different categories at different levels of inclusiveness would be characterized by properties of differing degrees of globality. A common weakness of most current theories of classification, including the classical view, appears to be that they have largely ignored the possibility that different types of properties are relevant at different levels of categorization.

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Table 1

Mean Proportion of Hits, False Alarms, and Mean d′ as a Function of Experimental Instruction in Experiment 1.

	Experimental Instruction			
	No-Name	Individual	Category	Category/ Individual
Hits	.57	.63	.58	.61
False Alarms	.42	.43	.56	.53
d′	.42[a]	.55[a]	.10[b]	.05[b]

[a]The mean d' of the No-Name and Individual groups combined was significantly differently from zero.

[b]The mean d' of the Category and Category/Individual groups combined was not significantly different from zero.

Table 2

Mean Proportion of Hits, False Alarms, and Mean d' in Experiment 2.

	Test Group		
	Group A (n = 18)	Group B (n = 18)	Group C (n = 54)
Hits	.60	.56	.52
False Alarms	.36	.42	.52
d'	.88[a]	.28[a]	-.13[a]

[a]The mean d' of all groups combined was not significantly different from zero.

Figure Captions

Figure 1A. White Oak leaves. (Top row: Set 1; bottom row: Set 2).

Figure 1B. Red Oak leaves. (Top row: Set 1; bottom row: Set 2).

Figure 2. Examples of training stimuli used in Experiment 1. The top left stimulus is an example of those seen in the No-Name condition. The top right stimulus is an example of those seen in the Individual condition. The bottom left stimulus is an example of those seen in the Category condition. The bottom right stimulus is an example of those seen in the Category/Individual condition.

Figure 3. Examples of test stimuli used in Experiment 1. The top left stimulus is an example of those seen in the No-Name condition. The top right stimulus is an example of those seen in the Individual condition. The bottom left stimulus is an example of those seen in the Category condition. The bottom right stimulus is an example of those seen in the Category/Individual condition.

Figure 4. Red Oak leaves used in the training phase of Experiment 2.

Figure 5. Notched and New leaves used in Experiment 2. The leftmost stimulus is the OLD notched leaf (#66). The middle stimulus is the NEW notched leaf (#72). The rightmost stimulus is a new Red Oak leaf used for testing in Group B.

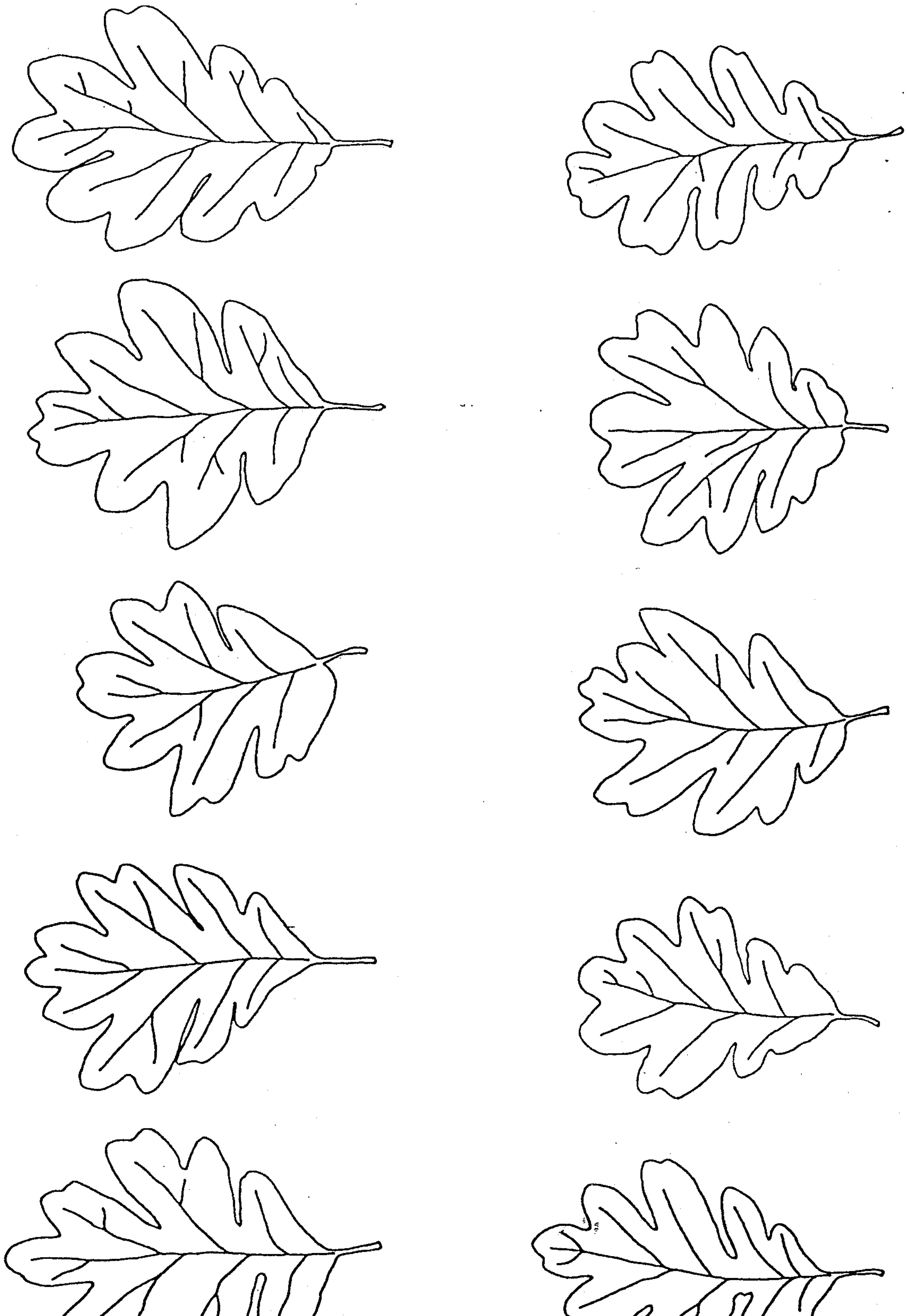


Figure 1A

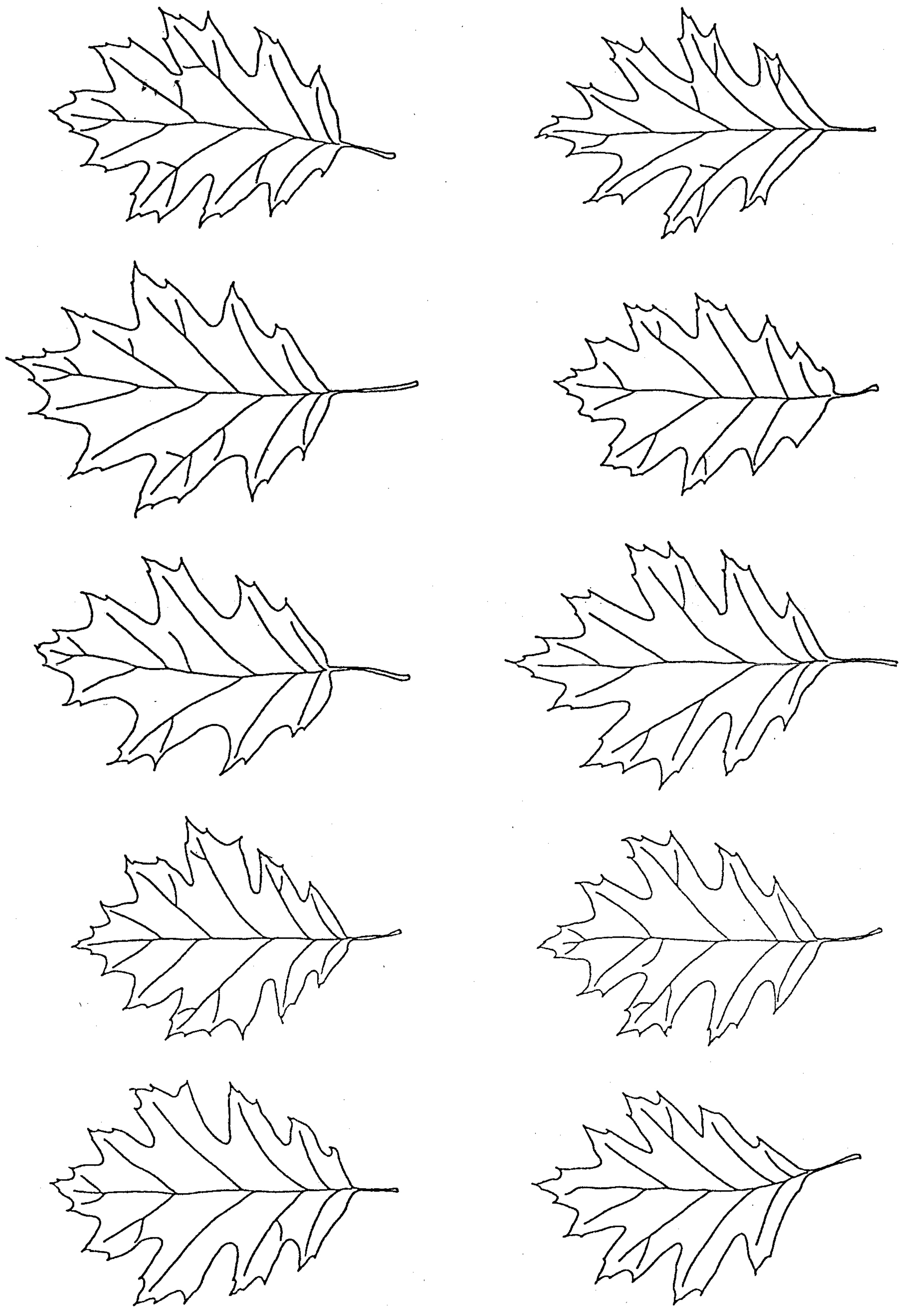


Figure 1B

Figure 2

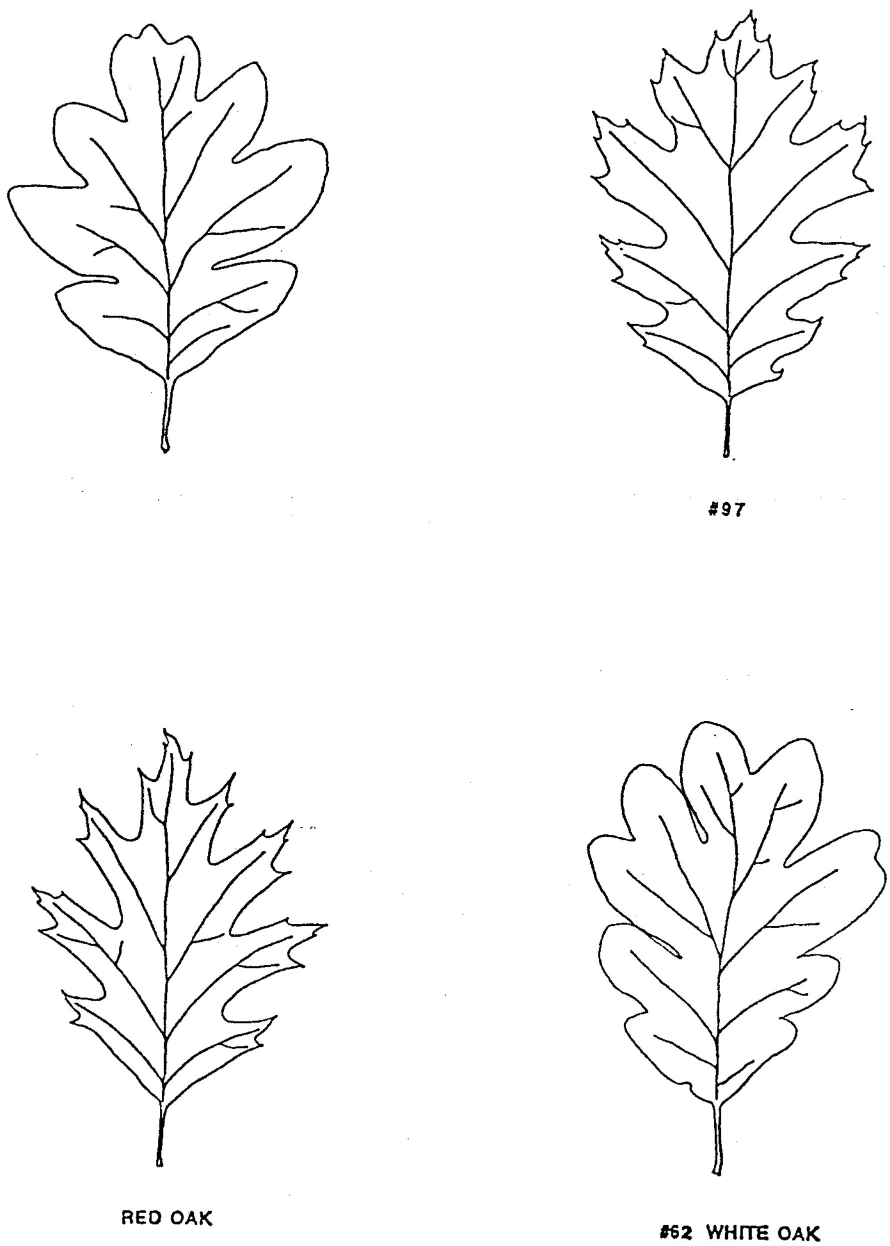
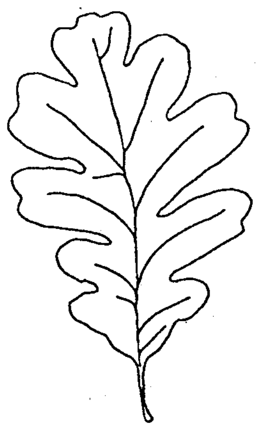
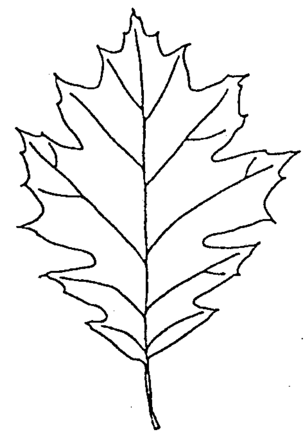


Figure 3

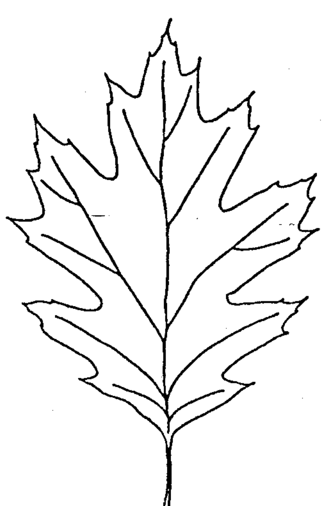


OLD ____
NEW ____

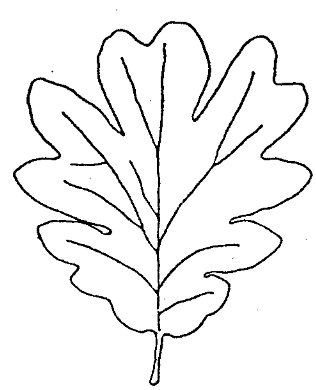


OLD ____
NEW ____
NUMBER ____

#66	#97	#48	#62	#15
#67	#34	#95	#78	#12



NAME ______________
OLD ____
NEW ____



NAME ______________
OLD ____
NEW ____
NUMBER ____

#91	#21	#38	#35	#72
#93	#22	#83	#30	#58

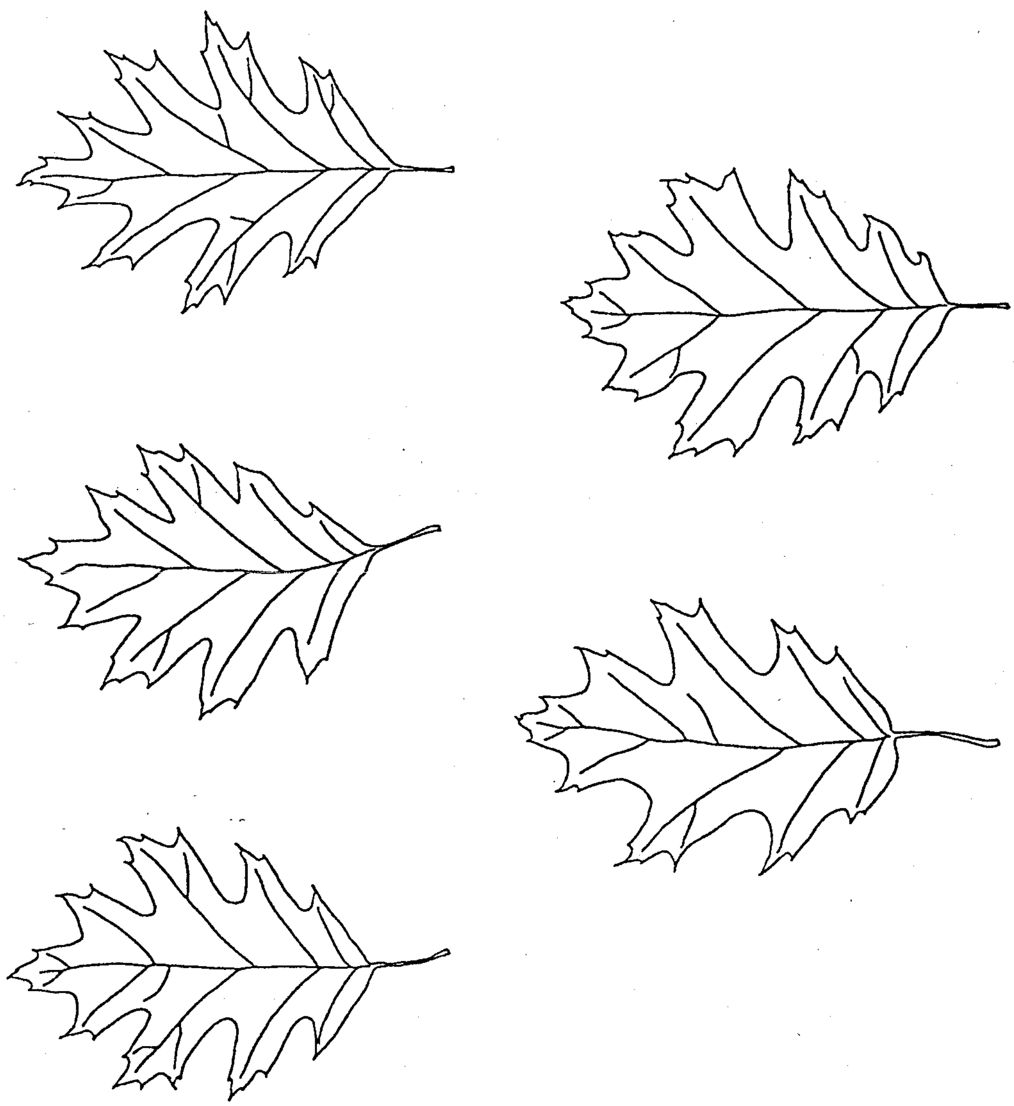


Figure 4

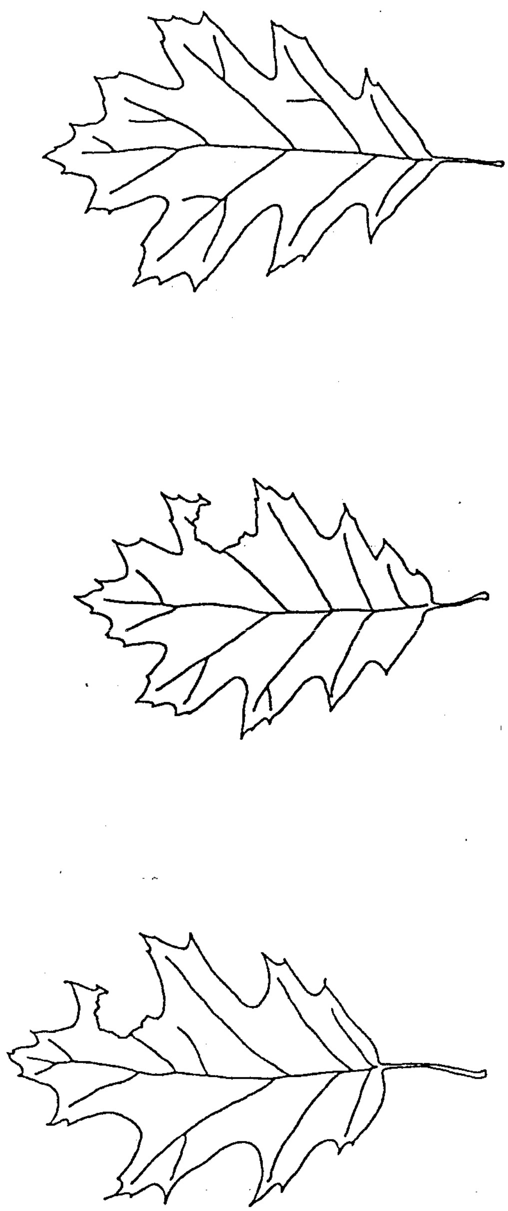


Figure 5