

**ACQUISITION AND RETENTION OF GLOBAL AND LOCAL ASPECTS
OF COMPLEX AND UNFAMILIAR STIMULI**

by

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Acquisition and Retention of Global and Local Aspects of

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Abstract

The global/local hypothesis claims that properties of visual stimuli are extracted in a global-to-local order. This hypothesis has typically been studied by using a search task, in which subjects determine whether a certain known feature is present in a briefly presented (40 - 200 ms) simple and familiar compound stimulus. In contrast, the present work used an encoding task in which subjects attempted to remember initially unknown features of a complex and unfamiliar stimulus. Moreover, the concern here was with much longer stimulus presentations (5 - 60 s). Experiment 1 investigated the extent to which subjects were able to encode and remember global as opposed to local feature information as a function of exposure time, under normal and directed attention conditions. Directed attention conditions are situations wherein attention is explicitly directed to a particular portion of the stimulus. Normal attention conditions are situations wherein attention is not explicitly directed. Subjects were first shown a single stimulus for either 5 or 60 seconds. They were then immediately tested with two test stimuli, one of which was the original. The difference between the original and the new stimulus

involved a single feature (shape) at one of two levels of globality. The task was (1) to detect the difference between the test stimuli, latency being the response measure, and (2) to choose the original stimulus. The data failed to support the global/local hypothesis. Experiment 2 varied globality over three levels. Globality affected performance significantly in both the difference-detection and the recognition tasks. In the recognition task, a significant globality level x exposure interaction was also obtained. Discussion emphasized that the results of Experiment 2 were consistent with the global/local hypothesis.

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Table of Contents

Approval Page.....	ii
Abstract.....	iii
Acknowledgements.....	v
List of Tables.....	viii
List of Figures.....	ix
CHAPTER 1.....	1
Introduction.....	1
Global Precedence in Search Tasks.....	3
Size.....	6
Sparsity.....	7
Retinal Location.....	8
Spatial Uncertainty.....	9
Attention Allocation.....	10
Relative Discriminability.....	10
Summary and Conclusion.....	12
Global and Local: Definitional Issues.....	13
Undifferentiated Wholes.....	14
Spatial Distribution.....	15
Aspects of a Stimulus.....	15
Levels of Stimulus Structure.....	18
Geometrical vs. Perceptual Structure.....	20
Conclusion.....	21
Global Dominance in the Encoding of Properties of Complex and Unfamiliar Stimuli.....	22
Oak Leaves as Stimuli.....	23
Information Encoded from Complex and Unfamiliar Stimuli.....	26
CHAPTER 2.....	29
Experiment 1.....	29
Normal Attention Conditions.....	30
Directed Attention Conditions.....	33
Method.....	35
Subjects.....	35
Stimuli.....	35
Training Stimulus.....	38
Test Stimuli.....	38
Design.....	39
Procedure.....	39
Normal Attention Condition.....	40

Directed Attention Condition.....	42
Results.....	44
Difference-detection.....	44
Normal Attention Condition.....	45
Directed Attention Condition.....	45
Recognition Memory.....	45
Normal Attention Condition.....	46
Directed Attention Condition.....	46
Discussion.....	47
Conclusion.....	49
CHAPTER 3.....	50
Experiment 2.....	50
Method.....	52
Subjects.....	52
Stimuli.....	52
Design.....	52
Procedure.....	54
Results.....	55
Difference-detection.....	55
Recognition Memory.....	56
Discussion.....	57
CHAPTER 4.....	60
General Discussion.....	60
Global Properties Reconsidered.....	62
Conclusion.....	64
References.....	66
Footnote.....	73
Figure Captions.....	79

List of Tables

Table		Page
1	Mean Response Latency (seconds) in the Difference-Detection Task as a Function of Condition, Property, Exposure Duration, and Locus of Change in Experiment 1	74
2	Percent Correct Recognition in the Memory Task as a Function of Condition, Property, Exposure Duration, and Locus of Change in Experiment 1	75
3	Mean Response Latency (seconds) in the Difference-Detection Task as a Function of Property, Exposure Duration, and Species in Experiment 2	76
4	Percent Correct Recognition in the Memory Task as a Function of Property, Exposure Duration, and Species in Experiment 2	77
5	Examples of Properties That Could be Used to Describe an Oak Leaf	78

List of Figures

Figure		Page
1	Examples of the Types of Stimuli Used in Navon's (1977) Study	81
2	Examples of Stimuli Used in Kimchi and Merhav's (1991) Study	82
3	Examples of Navon and Norman's (1983) Compound Stimuli	83
4	Examples of Martin's (1979) Many-element and Few-element Compound Stimuli	84
5	Marginal Configuration Changes. Original Stimulus and Stimuli that Instantiate M1 & M2	85
6	Venation Changes. Original Stimulus and Stimuli that Instantiate V1 & V2	86
7	Stimuli that Instantiate Conditions P0 - P2	87
8	Recognition Memory Performance as a Function of Exposure Time in Experiment 2	88

CHAPTER 1

Introduction

In the early 1900s, the Gestalt psychologists addressed the issue of wholistic perceptual dominance. Using the method of phenomenology, they attempted to identify the wholistic properties of the percept (e.g., closure, symmetry, etc.) that dominated or obscured the components of a stimulus (Lasaga, 1989). In spite of the early successes of the Gestalt psychologists in this regard, the majority of perceptual psychologists embraced analytic rather than wholistic (or synthetic) models of perception (Uttal, 1988). As a result, Gestalt psychology suffered a period of neglect, and the analytically oriented British empiricist tradition, which emphasizes atomism and the role of learning in perception, dominated the study of perception for most of the 20th century. Recently, however, a growing minority of researchers have begun to adopt a wholistic view of perception similar to that originally advocated by the Gestalt psychologists. In particular, the Gestalt assertion of the primacy of wholistic properties has once again begun to inform theory and experimentation into the nature of form perception.

In most contemporary studies of what is now referred to as the global/local issue, however, the emphasis has shifted from a concern with direct perceptual experience to a concern with the underlying microgenetic processes that produce that experience. These studies have been primarily concerned with the properties that are extracted from the visual stimulus in the very early stages of visual perception; i.e., they are concerned with the formation, or microgenesis, of the percept (see reviews by Kimchi, 1992; Lasaga, 1989).

The microgenetic approach has been concerned with global precedence, that is, whether the global properties of a stimulus are perceived earlier (and/or faster) than the local properties. The paradigm of choice has been the search (or speeded identification) task in which a subject determines, as quickly as possible, whether a known target is present in a visual display.

The present concern is with how the global aspects of a stimulus may affect visual information processing at stages well beyond the early ones. The issue is not so much one of global precedence, but one of global dominance (cf. Navon, 1981; Ward, 1982, 1983); namely,

whether or not the global aspects of complex and unfamiliar stimuli dominate the extraction of information after the percept has been fully formed. The process of interest might be called macrogenetic. The main hypothesis tested in the present thesis was that, under normal circumstances, the global aspects of a stimulus would dominate the extraction of information, even when there has been ample time (up to 60 s) to examine the stimulus. These notions are elaborated in the following sections.

Global Precedence in Search Tasks

The global precedence hypothesis, originally formulated by Navon (1977), concerns the temporal development of a percept. It claims that during the microgenesis of a percept, the relatively more global properties of a visual stimulus are extracted earlier, or faster, than are the relatively more local properties (Kimchi, 1992; Navon, 1977, 1981; Ward, 1983). It does not necessarily imply what is salient in the final percept (Navon, 1977, 1981). To investigate this hypothesis, the majority of studies have used a target search (or speeded identification) task in which subjects determine whether a certain known visual feature or pattern is present in a briefly

(less than one second: typically 40 - 200 ms) presented simple or familiar stimulus (Grice, Canham, & Boroughs, 1983; Kinchla & Wolfe, 1979; Martin, 1979; Miller, 1981; Navon, 1977; Navon & Norman, 1983; Pomerantz, 1983, Experiments 1 & 2; Ward, 1982).

Navon's (1977, Experiment 3) study illustrates the search task approach. He used compound letter stimuli that consisted of large letters (the global unit) made up of smaller letters (local elements) to test the hypothesis of global precedence (see Figure 1). There were two types of stimuli: (1) consistent - global and local letters were identical; and (2) inconsistent - global and local letters were different. Subjects were instructed to attend to either the global or the local

Insert Figure 1 about here

level of a tachistoscopically presented stimulus (40 ms exposure). In the global-directed condition the subject was instructed to indicate whether the global character was H or S. Similarly, in the local-directed condition the subject was instructed to indicate whether the local character was H or S. Subjects were asked to respond as quickly as possible while avoiding

errors. Navon found that identification of the global characters was always faster than that of the local characters. Further, in the global-directed condition, identifications (as measured by reaction time [RT]) did not depend on consistency level, whereas, in the local-directed condition, identifications were significantly slower when conflicting rather than consistent stimuli were used. This pattern of results was interpreted as showing that the global letters could not be ignored when responding to the local letters. Navon (1977) wrote "the finding that attention cannot be efficiently diverted from the whole may be interpreted as a support to the notion that global processing is a necessary stage of perception prior to more fine-grained analysis" (p. 371). Thus, Navon's results seemed to indicate that there is an inevitable "global precedence" in visual perception. Following Navon's (1977) seminal work, numerous studies have tested the hypothesis of global precedence. Most have used compound letter stimuli, while others have used simple geometric figures (e.g., Kimchi & Merhav, 1991: see Figure 2). Many studies have found that global

Insert Figure 2 about here

information appears to be processed prior to local information (e.g., Miller, 1981; Navon, 1977; Navon & Norman, 1983; Ward, 1982). However, several others have shown that the type of precedence (global vs. local) that is obtained depends on a number of experimental variables (e.g., Grice et al., 1983; Kinchla & Wolfe, 1979; Martin, 1979; Navon & Norman, 1983; Ward, 1982). The following variables have been shown to affect the type of information precedence (global vs. local) that is obtained in search tasks.

Size. Kinchla and Wolfe (1979) varied the visual angle of compound letters and found that the type of advantage (global vs. local) that was obtained depended on the size of the visual angle subtended by the stimuli. At small visual angles (less than about 7°), a global advantage in reaction time was obtained, but at large visual angles, a local advantage was obtained. Navon and Norman (1983) argued that level of globality and eccentricity (distance from the fovea) were confounded in Kinchla and Wolfe's study. That is, when a compound letter such as a large H made up of small

E's is enlarged, features of the stimulus that yield information about the global form are displaced laterally into relatively low-resolution regions of the retina. In contrast, features of one or more of the local forms fall on high-acuity regions near the fovea. Thus, these local letter(s) would be expected to benefit from greater acuity, leading to a local advantage. To control for this confound, Navon and Norman used global C's and circles so that all the local elements (also C's and circles) were located along the perimeter of each stimulus (see Figure 3).

Insert Figure 3 about here

They found a global advantage for both small (2^0) and large (17.25^0) visual angles. Navon and Norman's study suggests that if eccentricity is controlled, then a global advantage will be obtained over a wide range of visual angles. Kinchla and Wolfe's study suggests, however, that if eccentricity is not controlled, then the type of advantage (global vs. local) that is obtained will depend on the size of the visual angle.

Sparsity. Martin (1979) varied the number of elements in compound letters to examine the effect of

sparsity (i.e., the spacing between local units) on global/local advantage. The stimuli consisted of many-elements (dense) and few-elements (sparse). The overall size of the global letters was not manipulated; only the local letters differed in size: the local letters in many-element patterns were smaller than the local letters in few-element patterns (see Figure 4).

Insert Figure 4 about here

She found that the type of advantage that was obtained depended on sparsity: with many-element patterns, a global advantage was obtained; with few-element patterns, a local advantage was obtained. Martin concluded that either global or local aspects of a compound stimulus may be processed more quickly depending on the sparsity of the local elements making up the global stimulus. Podrouzek, Modigliani, and DiLollo (1992) have also shown that performance in a global/local task is affected by the density of the small letters. They attributed the effect to lateral masking.

Retinal location (foveal vs. peripheral).

Pomerantz (1983) and Grice et al. (1983) examined the

role of retinal location on global/local processing by varying the location (foveal vs. peripheral) at which stimuli were presented. Compound stimuli were presented either at an uncertain peripheral or at a certain (fixed) central location. With uncertain peripheral presentation, a global advantage was obtained; with fixed central presentation, no global advantage was obtained (similar findings were obtained in both studies). Pomerantz (1983) and Grice et al. (1983) reached a similar conclusion: a global advantage is produced with peripheral presentations because acuity falls off rapidly with distance from the fovea thereby affecting the local aspect more than the global aspect of a compound stimulus.

Spatial uncertainty. Lamb and Robertson (1988, Experiments 1 & 3) challenged the above conclusion by arguing that retinal location and spatial uncertainty were confounded in these studies in that central presentations were fixed while peripheral presentations were uncertain. When spatial uncertainty was controlled by using uncertain central and peripheral presentations, however, Lamb and Robertson obtained evidence that was consistent with the previous conclusion; i.e., with central presentations, the local

aspect benefitted from an increase in acuity independent of spatial uncertainty.

Attention allocation. Ward (1982) examined how the prior allocation of attention to the global or the local level can affect the speed with which a subsequently presented stimulus is processed. He used sequential presentation of pairs of compound stimuli (each pair of stimuli constituted a trial) and asked subjects to identify either the global or local aspect of each stimulus in each pair. Ward found that identifications were faster at a given level (global or local) if previous processing had just been at that same level. Thus, either a global or a local advantage was obtained depending on where attention was allocated for the preceding stimulus.

Relative discriminability. In addition to the foregoing factors, the issue of relative discriminability must also be considered. It has been argued that discriminability differences between the global and local levels of stimuli, rather than global precedence per se, might account for global advantage effects (e.g., Pomerantz, 1983). This alternative account of global advantage is based on some of the previously reviewed findings that have indicated that

factors affecting the perceptual quality of information at the global and local levels seem to determine whether or not a global advantage will be obtained (e.g., Grice et al., 1983; Kinchla & Wolfe, 1979; Pomerantz, 1983). For example, size is correlated with level of globality such that global properties are associated with (or dependent on) a relatively larger portion of a stimulus than local properties are (regardless of the overall visual angle of the form). According to a discriminability explanation, a global advantage in RT is found with stimuli subtending less than about 7° of visual angle (Kinchla & Wolfe, 1979) because the relatively larger parts of the stimulus are easier to see. Therefore, it would be expected that the global unit should enjoy an RT advantage compared with the local elements, which are harder to see. This example suggests the need to provide a discriminability control in studies of global/local issues. However, it should be noted that none of the factors affecting the perceptual quality of information at the global and local levels has been shown to constitute a necessary and sufficient condition for obtaining global advantage (cf. Kimchi, 1992).

Summary and conclusion. From this brief review (see Kimchi, 1992, for a complete review) it seems apparent that studies of the global/local issue have not yielded clear answers. Size, sparsity, retinal location, spatial uncertainty, and level of prior attentional allocation can all affect the type of advantage (global vs. local) that is obtained. Further, the issue of relative discriminability has often been neglected.

Part of the problem is that (1) these studies have subscribed to a narrow definition of the terms global and local, and (2) the paradigm of choice has been a search task wherein a subject searches the stimulus for the presence of a well-known feature or pattern. The next section examines a number of different conceptualizations of the terms global and local in order to place these notions within a wider context than has typically been used. The final section examines the appropriateness of the search task, and of the use of compound letter stimuli, for the study of global/local issues. I will suggest that a much better way to study such issues is by using an encoding task with complex and unfamiliar stimuli.

Global and Local: Definitional Issues

Psychologists have had little success in precisely defining or quantifying stimulus form, either verbally or mathematically (Uttal, 1988). As a result, it is difficult to precisely specify the attributes - either global or local - of a form that regulate its detectability, discriminability, or recognizability. Another reason for this difficulty is that manipulating the forms of continuous figures usually leads to confounded outcomes (e.g., varying area also covaries perimeter). Nonetheless, perceptual psychologists have proposed a number of useful conceptualizations of the structural or psychophysical aspects of form.

Of particular interest within the global/local paradigm are the different conceptualizations of the terms global and local. Thus far I have repeatedly made reference to these terms without clearly distinguishing the different senses in which each of them may be used. These related concepts have been used to refer to (1) the degree of differentiation of a percept (e.g., Lockhead, 1972), (2) regions of the visual field (e.g., Pomerantz & Kubovy, 1981; Pomerantz, Pristach, & Carson, 1989), (3) properties of a stimulus (e.g., Kimchi, 1992), (4) levels in a

hierarchical system (e.g., Navon, 1977; Palmer, 1975), or (5) levels of geometric as opposed to perceptual structure (e.g., Kimchi & Palmer, 1982). I will consider each of these in turn.

Undifferentiated wholes. According to early theories of microgenesis, there is a temporal development of each percept of a visual stimulus that is characterized by a growing clarity over the first few hundred milliseconds after the onset of stimulation (e.g., Flavell & Draguns, 1957; Kaswan, 1958; Kaswan & Young, 1969). The claim was that microgenesis begins with diffuse, undifferentiated whole percepts that subsequently become sharpened and internally differentiated. Thus, one sense of the term global is 'undifferentiated whole.' Lockhead (1972) presented a similar conceptualization. He claimed that integral dimensions of stimuli are processed as unified, undifferentiated wholes and specific local features are ignored. (Integral dimensions are dimensions that jointly define a stimulus and cannot be analyzed separately by a perceiver [Garner, 1974; Uttal, 1988]. For example, hue and saturation are difficult to perceive separately - perceivers see colors, not independent hues and saturations [Uttal, 1988].)

Spatial distribution. The terms global and local can also refer to regions of the visual field (e.g., Pomerantz & Kubovy, 1981; Pomerantz et al., 1989). In this usage, global refers to a distributed region of the visual field whereas local refers to some limited region. For example, symmetry is a relational property that is distributed throughout a form. That is, the symmetry of a form is not localizable to a particular position within the form. In contrast, a discrete part of a form can be localized to a particular position.

Aspects of a stimulus. Garner (1978) distinguished between two major classes of stimulus properties: component properties and wholistic properties. Component properties consist of two subtypes: dimensions and features. Dimensions are variables for which mutually exclusive levels exist. As an example, size is one dimension of a visual stimulus. Although a particular visual stimulus could be represented at any one of an infinite number of different sizes, it cannot be two or more sizes simultaneously. Other examples of dimensions include color, form, brightness, and linearity. Garner defines features as variables that exist or do not exist - if a particular feature exists it has only one level. A

feature can be removed from a stimulus without affecting the rest of the stimulus. For example, the vertical line segment in the capital letter T is a feature of that stimulus that can be removed from the rest of the stimulus.

Wholistic properties are the second major subclass of properties. Garner (1978) distinguished three types of wholistic properties: simple wholes, templates, and configurations. Simple wholes and templates are primarily information-processing concepts that connote parallel as opposed to serial processing. These terms are not well defined, and Garner notes that in purely stimulus terms they may not have any real meaning. Simple wholes are defined as the sum of the parts of a stimulus. A template is a schema, or modal stimulus, that is defined by relevant attributes. According to Garner, the third type of wholistic properties, configural properties, do have positive stimulus properties, which means that they can be defined independently of a processing outcome, and they can be manipulated in an experiment. Configural properties are emergent properties that depend on the interrelations between the component parts. Two examples of emergent configural properties are symmetry

and closure. These properties are considered emergent because they do not inhere in the component parts and cannot be predicted by considering only the component parts (Kimchi, 1992).

This classification scheme can be related to the terms global and local as follows. A visual object, viewed as a whole, can have global dimensions (e.g., size, shape), global features (e.g., jagged vs. smooth contour), and global (configural) properties (e.g., symmetry). Thus, global properties include both relational (configural) and non-relational (dimensions, features) properties. A part, or localized component, of a visual object can also have dimensions (e.g., size, shape), features (e.g., jagged vs. smooth contour), and (configural) properties (e.g., symmetry). Note that with respect to global aspects of stimuli, different authors vary in the degree of emphasis that they place on dimensions vs. features vs. configurations. For example, whereas some authors have emphasized the importance of size, color, and form (global dimensions) in perception (e.g., Palmer, 1975), others have primarily emphasized wholistic configural properties (e.g., Kimchi, 1992). In fact, configural properties seem to be the most commonly referenced type

of global property. It should also be noted that there is disagreement in the literature in the way in which different authors conceptualize global properties. For example, some authors (Rock, 1986) refer to shape as depending on the geometrical spatial relationships among points or contour demarcations (i.e., a configural property in Garner's scheme). Others, refer to shape as a global dimension (Treisman, 1986). Similarly, there is disagreement in the way in which different authors conceptualize features. 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" (p. 329). In contrast, many authors have adopted Garner's scheme, and refer to features as binary attributes of stimuli (Treisman, 1986).

Levels of stimulus structure. The global precedence hypothesis was formulated within a framework that was strongly influenced by work on computer pattern recognition, particularly the concept of image structure employed in syntactic scene analysis (Fu, 1974; Quinlan, 1991). The idea is that an object (or scene) can be parsed into hierarchical levels of form

(Kimchi, 1992; Navon, 1977; Palmer, 1975; Quinlan, 1991; Venturino & Gagnon, 1992). Thus, an object as a whole consists of parts which in turn may consist of other parts. The object as a whole represents a higher level in the hierarchy than does a part, which in turn represents a higher level than does a part of a part, i.e., parts, and parts of parts are logical constituents of whole objects. The object as a whole has properties, the parts have properties, and the parts of parts (if they exist) have properties. Thus, visual properties can be instantiated at different levels within a hierarchy. Within this framework, properties at a higher hierarchical level are more global than those at a lower level, which in turn are more local. At each level of form, properties may be continuous dimensions, binary features, or configural properties.

To illustrate these points, consider a person's face. The highest-order form in the scene, the face, has properties (size, shape, symmetry), the eyes each have a set of properties (size, shape, symmetry), and parts of the eyes (lens, iris, sclera) have properties. It should be apparent that in this conceptualization, the global and local levels are defined only in

relation to one another and within the context of a particular visual object or scene. It should also be apparent that a given stimulus might be represented by a series of different levels of stimulus structure, limited only by visual acuity. Thus, in the previous example, if the stimulus was a newspaper photograph of a face, the lowest-order forms in the hierarchy would be the individual dots that make up the photograph. It is important to point out that within the global/local paradigm, level of globality is defined in terms of levels of form, or stimulus structure (Navon, 1977). The hypothesis that is tested using hierarchical forms is that processing of properties of higher level units precedes processing of properties of lower level units (Kimchi, 1992; Navon, 1981; Ward, 1982). Another way of saying this is that properties of the whole are processed before properties of the parts, which in turn are processed before properties of the parts of parts, and so on. This is the theoretical framework that will guide the present work.

Geometrical vs. perceptual structure. Researchers concerned with issues of global and local processing typically assume that there are perceptual levels that correspond to the geometrical global and local levels

in a hierarchical system (Kimchi, 1992). However, research has shown that this is only sometimes true (Kimchi & Palmer, 1982, 1985). It was for this reason that Kimchi and Palmer (1982) argued that the terms "global and local be reserved for referring to levels of geometrical structure in the stimulus...and that form (or shape) and texture (or material) be used to refer to perceptual levels of subjective structure" (p. 535).

Conclusion. In the present work, it is assumed that a stimulus consists of a whole and its parts. Properties that pertain to the whole stimulus are considered global. Properties of parts and the parts themselves are considered local. Global properties include both relational and non-relational properties. Relational properties are properties (e.g., symmetry, closure, etc.) that depend on the interrelations between the component parts (Garner, 1978; Kimchi, 1992; Navon, 1977; Rock, 1986; Uttal, 1988). Non-relational global properties are properties that are distributed over a form (e.g., color, size, shape, etc.) but that do not necessarily depend on interrelations between parts. This definition will serve only as a working definition here, since it must

be acknowledged that there is no objective or formal way to define, a priori, what constitutes a global property (Kirson, 1990; Uttal, 1988). It should also be re-emphasized that global and local are relative terms within the 'levels of structure' context. Thus, in the case of an oak leaf stimulus, although a major lobe is local relative to the whole leaf, it is global relative to the smaller lobes (and parts) that are constituents of the lobe. In the following, the context will make clear the sense in which the terms global and local are being used.

Global Dominance in the Encoding of Properties of Complex and Unfamiliar Stimuli

Most research on the global/local issue has employed compound letters as typical stimuli, and the search task as the typical paradigm. It is dubious whether either of these are well-suited for the study of this issue. A compound letter is a simple stimulus, consisting of only two letters, a large one and a small one. The small letter is repeated at many locations to make up the large one. A compound letter is not representative of most real life stimuli. The latter typically are complex patterns, consisting of many levels (not just two). Also, they are rarely (if ever)

made up of virtually identical copies of a particular lower order feature. Further, letters of the alphabet are extremely well-known patterns, at least for adult native speakers of the language, and the typical global/local task has been one in which a subject searches the stimulus for the presence of such patterns. In contrast, in daily life we encounter many novel stimuli consisting of unknown features. It is possible that global properties may dominate the process of encoding features of such complex and unfamiliar stimuli. To illustrate this point, consider the type of stimulus used in the present research, the oak leaf.

Oak leaves as stimuli. Oak leaves can be distinguished from typical laboratory stimuli, which are familiar stimuli consisting of overlearned features, in two fundamental ways. First, oak leaves are generally unfamiliar stimuli. Although most people are familiar with the word oak (or with oak furniture), very few people are familiar with oak leaves. It is true that oak trees may be frequently encountered, particularly in the Lower Mainland near Vancouver, B. C., where there are extensive plantings of a wide variety of oaks. Therefore, one might be led to

conclude that these are familiar stimuli. However, it is dubious whether most individuals know these objects are oak trees and it is even more dubious whether, if asked, most people could describe the architectural characteristics associated with the leaves of a given oak tree without carefully inspecting them (gardeners and botany/horticulture students are notable exceptions). The point is that in the absence of an explicit need to study oak leaves, or in the absence of a meaningful association between these stimuli and goal-directed behaviour, these stimuli will remain on the periphery of awareness and experience. Thus, the typical urban dweller has little if any need to study oak leaves, nor are these stimuli tied to his or her goal-directed behaviour. It is safe to assume that oak leaves are unfamiliar to most individuals who participate in psychology experiments.

Second, unlike the types of laboratory stimulus considered previously, oak leaf stimuli are complex. Oak leaves (and leaves in general) are so variable and complex that they cannot be precisely defined by a priori sets of features (it is for this reason that botanists have traditionally relied on qualitative descriptions for purposes of communication). In order

to bring this point out, it may be useful to examine a drawing of a red oak leaf (see Figure 5A). The leaf conforms to the pinnately lobed design that is characteristic of several oak species. To be more specific, the oak leaf stimulus has the following architectural features: (1) lobed margination; (2) pointed lobes; (3) rounded sinuses (incisions between lobes); (4) short stem; and (5) pinnate venation, i.e., a single primary vein (midvein) serves as the origin for secondary venation. It is notable that this set of properties normally applies to all red oak leaves. Yet, red oak leaves display a tremendous diversification of detail within the frame of this pinnately lobed architectural design (cf. Goldstein & Chance, 1970, for a similar point).

It is readily apparent that the red oak stimulus displays a complexity that is not found in compound letters or simple geometric figures. It is also apparent that, geometrically, the stimulus consists of a hierarchical organization of whole and parts. First, there is the whole leaf. Second, major lobes are arranged in a certain configuration. Third, each major lobe consists of a unique configuration of smaller lobes, and so on. Similarly, there is a primary vein,

there are secondary veins, and so on. Although all red oak leaves have this structure, the exact number and shape of component parts vary from leaf to leaf, so that no two leaves are ever identical.

In sum, oak leaf stimuli have the following attributes: (1) they are unfamiliar to many people; (2) they cannot be uniquely defined in terms of a small number of properties; (3) they are more complex than typical laboratory stimuli; and (4) they consist of hierarchically organized arrangements of parts and their associated properties.

Information encoded from complex and unfamiliar stimuli. Suppose a person is shown one or a series of oak leaf stimuli with instructions to remember as much as possible about the single leaf or about each leaf in the series. Since these are complex and unfamiliar stimuli, it is hypothesized that the person would attempt, in the absence of more specific directions, to encode the more global aspects of each stimulus, and disregard the details, even though these may be perfectly visible. Thus, one might attempt to memorize the overall shape of a leaf, its degree of symmetry (in the case of an asymmetrical leaf, one might try to remember how symmetry was violated), its size, the

number of major lobes that make up the leaf, and so on. A person is not likely, under normal circumstances, to memorize the shapes of very small lobes, or the shapes or locations of tertiary veins.

Kirson (1990) provided some support for these claims. In her Experiment 1, subjects were shown a series of 10 oak leaves and were told that they were to learn as much as possible about each of them because later they would be asked to recognize the leaves again. Five of the leaves were white oak leaves (which have round lobes), the other five were red oak leaves (which have pointed lobes). Thus, the round vs. pointed lobe distinction was a major global aspect of these stimuli. Each leaf stimulus was presented for 4 seconds. Memory was tested using an old/new recognition test. Kirson's results showed that subjects learned the pointed vs. smooth lobe distinction. They subsequently used that criterion to correctly classify new instances of red and white oaks. Kirson also found that retention of local information about individual leaves was very poor. Kirson concluded that this pattern of results was in accord with the hypothesis that properties of visual stimuli are encoded in a global-to-local order.

The present investigation extended the work of Kirson (1990) by testing the acquisition and retention of experimentally manipulated features. Subjects were shown a single oak leaf stimulus for either 5 or 60 seconds. They were then immediately presented with two test stimuli, one of which was the leaf shown initially. The original and the new stimulus differed in a single feature that was experimentally controlled. Features of varying degrees of globality were examined. The task was (1) to detect as quickly as possible the difference between the test stimuli, and (2) to recognize the original stimulus. Experiment 1 varied the critical feature at two levels of globality. Experiment 2 varied it at three levels.

CHAPTER 2

Experiment 1

As discussed in Chapter 1, the global/local issue has been studied by using a search task, in which subjects determine whether a certain known feature or pattern is present in a simple and familiar stimulus that is very briefly presented, usually for a fraction of a second. In contrast, the present study is concerned with global dominance in tasks that involve a complex and unfamiliar stimulus that cannot be readily decomposed into a set of predetermined features. Moreover, the concern here is with much longer stimulus presentations than have typically been used. Rather than following the traditional approach of presenting stimuli for a fraction of a second, the present research used presentations of 5 - 60 seconds.

The primary purpose of Experiment 1 was to investigate the extent to which subjects are able to encode and remember global as opposed to local information as a function of exposure time, under normal attention conditions. Normal conditions are defined as situations in which attention is not explicitly directed to a particular portion of a complex and unfamiliar stimulus. In this case, it is

assumed that global/local constraints will influence the type of stimulus information that will be extracted. More specifically, it is assumed that global properties will be extracted first, with local ones being extracted only if time permits. Normal conditions are contrasted with directed attention conditions, defined as situations in which an individual receives explicit instructions to attend to a distinctive part of a complex, unfamiliar stimulus. In this case, it is assumed that global/local constraints will not influence the type of stimulus information that will be extracted. The relevant information will always be extracted because of the explicit instructions to do so. Further details regarding the normal and directed attention conditions are presented below.

Normal attention conditions. It is hypothesized that, under normal attention conditions, the properties of complex forms are extracted and/or compared in a global-to-local order. This hypothesis assumes that when an individual examines a stimulus for a given amount of time, only a finite number of properties can be extracted. One can therefore expect that the number of encoded properties is proportional to the amount of

time spent examining the stimulus. For relatively short exposure durations, only a small number of properties will be extracted. According to the hypothesis of global dominance, these will primarily be global properties. For relatively longer exposure durations, a larger number of properties will be extracted. These may include both global and local properties (Loftus & Bell, 1974; Loftus, Nelson, & Kallman, 1983).

These assumptions lead to the following predictions regarding performance on a difference-detection task and a memory task, as a function of exposure duration, under normal attention conditions. In a difference-detection task, an individual is instructed to compare simultaneously two complex stimuli that differ in a single property, in order to discern the difference between them. If the global properties of complex forms are noticed first, then it should take less time to detect the difference between stimuli when they differ in terms of a global rather than a local property.

In a memory task, an individual examines a single complex stimulus for a period of time in order to try to commit it to memory. The person is subsequently

presented with two test stimuli that differ in a single property, the task being to choose the stimulus that was seen previously. If only a small number of properties are extracted at short exposure durations, and these are global ones, then he/she should demonstrate superior recognition performance on test stimuli that differ at the global (as opposed to the local) level of stimulus structure. At relatively longer exposure durations, the disadvantage associated with test stimuli differing at the local level should be diminished since the probability of extracting the relevant local property should increase with exposure duration. Thus, under normal attention conditions, an interaction between property level and exposure duration would be predicted. It should be noted that an interaction between these variables would not be expected in the difference-detection task. It was theorized that the amount and type of information that is extracted from the training stimulus should not affect the order in which the two test stimuli are compared. Thus, since it was posited that properties of the test stimuli would be compared in a global-to-local order until the difference was found, it was expected that less time would be required to discover

the difference between stimuli that differ in a global rather than a local property, regardless of exposure duration.

Directed attention conditions. Whereas under normal conditions it is more likely that a global rather than a local property will be encoded in a given amount of time, under directed attention conditions this is no longer necessarily true. When an easily discriminable part of a complex stimulus has been made distinctive (e.g., by highlighting it) and an individual is instructed to attend to it, it may be assumed that that part will be encoded, regardless of whether or not it exists at the global or the local level of stimulus structure and regardless of exposure duration, at least above some minimum value. Under conditions of directed attention, therefore, whether the highlighted property is global or local should make little difference. More specifically, in the difference-detection task, when an individual compares two stimuli that differ in a single property (that was previously made distinctive), the amount of time required to detect the difference should be independent of whether the differential property was global or local. It should also be independent of exposure time.

Further, relatively short response latencies would be expected. In the memory task, performance should be equally good, regardless of whether the highlighted property was global or local, and regardless of exposure time. In the directed attention condition, an individual would be expected to complete the difference-detection task significantly faster than in the normal attention condition.

It should be noted that if the described pattern of results is obtained, the results of the directed attention condition would rule out a discriminability explanation of the normal attention condition results. Recall that global properties are often confounded with size (Navon, 1981), such that they are associated with (or dependent on) relatively larger portions of a stimulus than local properties are, and that it has been argued that relatively larger parts of the training stimulus are easier to see and discriminate (Pomerantz, 1983). On this account, it could be argued that if differences in recognition due to level of globality were found in the present experiment, they could be due to discriminability differences due to size rather than to the different levels of globality. However, if, as hypothesized, performance in the

directed attention condition was independent of property level and exposure time, then the discriminability hypothesis would be ruled out, since discriminability should affect performance in both normal and directed attention conditions.

Method

Subjects

One hundred and ninety-two male and female Simon Fraser University students participated in the study. Subjects had normal or corrected-to-normal vision. All subjects were randomly assigned to experimental conditions. There were 12 subjects in each cell of the factorial design.

Stimuli

A single leaf was randomly selected from a red oak tree. The leaf was photocopied and the major anatomical features (leaf margin, venation pattern, and stem) were traced on fine tracing paper using bottom illumination to ensure accuracy. The tracing was then photocopied onto standard 8.5" x 11" white paper. Finally, it was reduced in size to allow for two copies of the stimulus to be placed side-by-side on a single page. The final size of the original figure was 9 cm x 5.5 cm (see Figure 5A).

Two relatively independent aspects of the leaf's structure were then manipulated: marginal configuration and venation. Botanists clearly separate these as independent aspects of leaf structure, each of which is hierarchically organized (Hickey, 1973). Two independent structural aspects were manipulated in order to increase the generality of results. Within each aspect, two different types of structural change were made. One of these was designed to represent a relatively more global level of stimulus structure, the other, a relatively more local level. All changes were produced by altering the same red oak leaf; henceforth this leaf will be referred to as the original leaf.

With regard to marginal configuration, an (assumed relatively more) global level change, referred to as M1, was produced by eliminating a sinus from one side of the original leaf. As a result, two adjacent lobes of the leaf were merged to produce a single large lobe. Comparison of the altered leaf with the original reveals a conspicuous difference in terms of overall shape (compare Figures 5A & 5B). Note that the number of major lobes is reduced by one in the altered leaf. Also, the altered leaf is not nearly as symmetrical as the original one. An (assumed relatively more) local

level change, M2, was produced by smoothing out two protrusions on one of the primary lobes of the original leaf (compare Figures 5A & 5C). One of these protrusions was relatively small in size and appeared on the apical surface of the lobe; the other was comparatively larger and appeared on the basal surface. Inspection reveals that M2 affected a much smaller portion of the leaf than did M1. Also, M2 appears to be a less conspicuous change than M1. With respect to

Insert Figure 5 about here

venation, an (assumed relatively more) global level change, V1, consisted of a change to the shape of the midvein of the leaf, from straight to wavy (compare Figures 6A & 6B). Inspection reveals that this appears to be a conspicuous change to the overall venation pattern. Not only does it affect the appearance of the main axis of the leaf (while holding the shape of the margin constant), it also incurs small changes in the length of some of the secondary veins. That is, some veins must be lengthened slightly to accommodate the change, others must be shortened. An (assumed relatively more) local level change, V2, consisted of

an alteration to the shape of one of the secondary veins that branches off the midvein (compare Figure 6A & 6C). Inspection reveals that V2 affected a much smaller portion of the venation pattern than did V1 and appears to be a less conspicuous change.

Insert Figure 6 about here

Training stimulus. At the beginning of the experiment, each subject was shown a single training stimulus that consisted of a red oak leaf figure centered at the midline of a sheet of white paper. In the directed attention condition, a portion of the training stimulus that was critical to the subsequent tests was made distinctive by highlighting it (using a fluorescent yellow text liner). In the normal attention condition, training stimuli were not highlighted.

Test stimuli. Regardless of condition, each subject received two test stimuli: the original red oak leaf stimulus and an altered version of the original. One of these stimuli was identical to the training stimulus. These stimuli were placed 9 cm apart at the

midline of a sheet of white paper. Test stimuli were not highlighted.

Design

A four-factor independent groups design was used. The design was a 2 (property level: P1 [M1/V1] vs. P2 [M2/V2]) x 2 (locus of change: margin vs. vein) x 2 (exposure duration: 5 vs. 60 seconds) x 2 (condition: normal vs. directed attention) factorial.

Procedure

All subjects were run individually. Each subject was randomly assigned to one of 96 different four page booklets. Each booklet contained the training stimulus and two test stimuli. The booklets were constructed so that the four possible training/test stimulus combinations were counterbalanced across subjects and conditions. Thus, the original leaf and altered versions of the original appeared equally often as training stimuli. Also, the target figure appeared equally often on the left and right side of the test sheet. All subjects performed a difference-detection task and a memory task. The response measure for the former was latency (i.e., the amount of time required to discover the difference between test stimuli). The

response measure for the latter was an old/new forced-choice recognition measure.

Individuals were approached in the Simon Fraser University library and asked if they would like to participate in a short visual perception study. Those who were interested were then provided with a brief overview of the procedure. The purpose of this was to provide subjects with enough information so that they knew what was expected to occur in the experiment. Also, it allowed the experimenter to make sure that subjects understood instructions. When the procedure was understood, subjects were then asked for their informed consent to participate in the study. They were told that their participation in the experiment was entirely voluntary and that they could withdraw at any time, for any reason. All subjects were required to sign a voluntary agreement form.

Normal attention condition. Subjects assigned to the normal attention condition were given the following instructions: "In this experiment you will be shown a line drawing of a leaf, for (5 or 60) seconds. Your task will be to examine the leaf and to try to remember as much about it as you can. Following this, your memory for the leaf will be tested." Subjects were

then instructed to wait until they were told to turn the page. When the subject had read and understood the instructions, he/she was then told to turn the page and begin. The training stimulus appeared on the second page. The experimenter started a stopwatch and allowed the subject to examine the training stimulus for either 5 or 60 seconds, depending on exposure condition. Pilot work had shown that an exposure time of 5 seconds was ample for encoding any of the features manipulated in the directed attention condition. This was therefore chosen as the shorter of the two exposure durations. Note that the longer exposure, 60 seconds, was much greater (12 times) than the shorter one. The subject was then instructed to turn the page (only the word "turn" was spoken). Page three informed subjects that "Two leaf figures appear on the next page. One of these is identical to the one you just saw. Your first task is to discover the difference between the two figures. Please use the marker to highlight the exact location where the figures differ [subjects were supplied with a text liner]. I will be recording the time it takes for you to complete this task, up to a maximum of two minutes. Your next task is to select the leaf that is identical to the one that you just saw

on the previous page. Please indicate your choice by drawing a circle around the appropriate figure." At the bottom of this instruction page subjects were instructed to wait until they were told to turn the page. The experimenter allowed 20 seconds to pass before instructing subjects to turn the page (this provided subjects with enough time to read the instructions). The two test stimuli appeared on page four. The experimenter recorded the amount of time that elapsed between the moment page three was turned and the moment each subject highlighted the correct difference between the two test stimuli. If a part that did not correspond to the actual (and only) difference between the test stimuli was highlighted, the subject was asked to double check the accuracy of his/her response. Subjects then completed the memory task.

Directed attention condition. The same procedure was used in the directed attention condition. However, subjects received different instructions on pages one and three of the stimulus booklets. Page one informed subjects that "In this experiment you will be shown a line drawing of a leaf, for (5 or 60) seconds. A portion of the leaf will be highlighted in yellow.

Your task is to examine the leaf and to pay particular attention to the part that is highlighted. This part of the leaf will be critical to the memory test that follows." Page three informed subjects that "Two leaf figures appear on the next page. One of these is identical to the one you just saw. The two leaves differ at the location marked on the leaf you have just seen. Please use the marker to highlight that location again. As I will be recording the time it takes for you to complete this task, please work as quickly as possible, while avoiding errors. Your next task is to select the leaf that is identical to the one you just saw on the previous page. Please indicate your choice by drawing a circle around the appropriate figure." The rest of the procedure was identical to that for the normal attention condition.

Once subjects circled the figure that they thought was identical to the training stimulus, they were debriefed, informed of the accuracy of their performance, and thanked for their participation. During the debriefing, subjects were asked if each aspect of the procedure was perfectly clear. In addition, the experimenter provided a general description of the problem under investigation,

answered any questions, and finally, asked the subject not to discuss the experiment with others.

Results

Mean latency in the difference-detection task and percent correct recognition in the memory task are presented in Tables 1 and 2, respectively.

Difference-detection

As can be seen from Table 1, the overall mean latency score in the normal attention condition ($M = 48.7$ s) was much greater than that in the directed attention condition ($M = 6.7$ s), $t(97.1) = 12.33$, $p < .0001$. The variance in the normal condition (1102.9)

Insert Table 1 about here

was also much larger than that in the directed attention condition (12.2), $F(1, 188) = 158.72$, $p < .0001$ (Levene's F). The data were transformed to logarithms and once again tested for heterogeneity. Levene's test still revealed a highly significant difference in variability, $F(1, 188) = 12.16$, $p < .001$. Since a large difference in variance remained after the log transformation, separate analyses of variance

(ANOVAs) were conducted for the normal and directed attention conditions.

Normal attention condition. A 2 x 2 x 2 (property level [P1 vs. P2] x exposure duration [5 s vs. 60 s] x locus [margin vs. vein]) ANOVA was performed on the log transformed latencies for the normal condition. The ANOVA yielded no significant main effects or interactions (all $p > .05$).

Directed attention condition. A 2 x 2 x 2 (property level [P1 vs. P2] x exposure duration [5 s vs. 60 s] x locus [margin vs. vein]) ANOVA was performed on the log transformed latencies for the directed attention condition. The ANOVA yielded no significant main effects or interactions (all $p > .05$).

Recognition Memory

As can be seen from Table 2, the overall mean percent correct for the directed attention condition ($M = 95.8\%$) was larger than that for the normal condition ($M = 60.4\%$), $z = 5.94$, $p < .0001$, one-tailed. Also, the variance for the normal condition (.24) was larger than that for the directed attention condition (.04).

Insert Table 2 about here

A Levene's test revealed a highly significant difference in variability, $F(1, 190) = 343.29$, $p < .0001$. Since there were large differences in means and variances, separate weighted least squares analyses of proportions (Cox, 1970; Grizzle, Starmer, & Koch, 1969) were conducted for the normal and directed attention conditions.

Normal attention condition. A $2 \times 2 \times 2$ (property level [P1 vs. P2] x exposure duration [5 s vs. 60 s] x locus [margin vs. vein]) weighted least squares analysis was performed on the recognition data for the normal condition. The analysis revealed a significant main effect of exposure duration [$X^2(1, N = 96) = 4.96$, $p < .05$]. Recognition performance was significantly more accurate when subjects studied the training stimulus for 60 seconds ($M = 71\%$) as opposed to 5 seconds ($M = 50\%$). There were no other significant main effects or interactions (all $p > .05$).

Directed attention condition. A $2 \times 2 \times 2$ (property level [P1 vs. P2] x exposure duration [5 s vs. 60 s] x locus [margin vs. vein]) weighted least squares analysis was performed on the recognition data for the directed attention condition. There were no significant main effects or interactions (all $p > .05$).

Recognition performance was highly accurate (i.e., 100% in 5 out of 8 cells; overall $M = 95.8\%$) regardless of whether subjects examined the training stimulus for 5 seconds or for 60 seconds and regardless of whether test stimuli differed in terms of P1 (M1/V1) or P2 (M2/V2).

Discussion

The main hypothesis of the present experiment was that, under normal attention conditions, the properties of complex, unfamiliar forms would be extracted and/or compared in a global-to-local order. In general, the data did not support the hypothesis. There were no main effects due to the global/local manipulation in either the normal or directed attention conditions, in either latency or recognition scores. Thus, the latency data in the normal condition did not support the a priori assumption that P1 and P2 reflected different levels of stimulus structure. Regarding the recognition data, it is notable that level of globality did not interact with exposure time in the normal condition. It will be recalled that such an interaction would be expected if global properties were extracted first, and local properties second. These data might be explained by a two stage model that

entails encoding of features of the whole stimulus followed by attention to (and encoding of) the parts (see Wright, Katz, & Hughes, 1993). This model would not predict task performance differences between P1 and P2 since these both involved localized parts of the stimulus.

As might be expected, increased exposure to the training stimulus lead to better recognition performance in the normal condition. It is notable that an exposure time of 5 seconds resulted in chance recognition (.5 probability of success), suggesting that, with the kind of stimulus used in the study, 5 seconds was not sufficient to extract the property (either P1 or P2) that was critical for later recognition.

As expected, there were large differences in both latency and recognition between the normal and directed attention conditions. Mean latency was 6.7 seconds in the directed attention condition, but 48.7 seconds in the normal condition. Recall that subjects in the directed attention condition were told in advance that the highlighted portion of the training stimulus corresponded to the location of the difference between test stimuli. In contrast, subjects in the normal

condition were not provided with advance information regarding the location of the difference. Thus, in the directed attention condition, knowing where to look obviously simplified the task.

The lack of significant effects in the directed attention condition indicates that discriminability is not a factor affecting performance in this type of situation.

Conclusion

The most striking result of this experiment was the lack of support for the global/local hypothesis. Under normal attention conditions, properties that were assumed, a priori, to be relatively more global (P1), were not more likely to be extracted and/or compared faster than properties that were assumed to be relatively more local (P2). Two possibilities arise. Either there is no fundamental distinction between global and local properties, as some of the research on the global/local issue that used compound letters might suggest, or, the difference between P1 and P2 was not sufficient to be detected given the power of the present tests. Experiment 2 addressed this issue.

CHAPTER 3

Experiment 2

The data of Experiment 1 were not consistent with the hypothesis of global dominance. It was suggested that this may have been due to an unsuccessful property manipulation. The primary purpose of Experiment 2 was to test the hypothesis of global dominance (1) by increasing the magnitude of the difference between P1 and P2, and (2) by incorporating a yet more global level of stimulus structure, referred to as P0, into the design of the experiment. In this experiment, P0 was instantiated by the difference between white and red oak leaves, chosen for the following reason. Recall that Kirson (1990) investigated the degree to which subjects would extract global vs. local information when they were presented with unfamiliar red and white oak leaf stimuli. Each stimulus was presented for 4 seconds. She found that subjects typically reported that they had learned a smooth vs. pointed lobe distinction, which is the main feature botanists use to distinguish between white and red oak leaves (Hickey, 1973). Therefore, it would seem that the difference between red and white oak leaves represents a truly global difference.

Since in Experiment 1 performance in the directed attention condition was at ceiling and was independent of stimulus manipulations, the present study used only a normal attention condition. As in Experiment 1, exposures of 5 and 60 seconds were used. Subjects performed the same difference-detection and memory tasks as in Experiment 1.

The hypotheses that guided the present study were identical to those in Experiment 1. It was hypothesized that the properties of complex forms would be extracted and/or compared in a global-to-local order. In the difference-detection task, it was expected that it should take less time to detect the difference between two stimuli when they differ in terms of a global rather than a local property. In the memory task, recognition was expected to be better when test stimuli differed in terms of a global as opposed to a local property. Further, recognition was expected to be better for 60 as opposed to 5 second exposure times. At 60 second exposures, the disadvantage associated with test stimuli differing at the local level should be diminished. Thus, as in the normal condition in Experiment 1, an interaction between property level and exposure duration was predicted.

Method

Subjects

One hundred and twenty male and female Simon Fraser University students participated in the study. Subjects had normal or corrected-to-normal vision. All subjects were randomly assigned to experimental conditions. There were 12 subjects in each of 10 groups.

Stimuli

Since no difference between margin and vein manipulations were found in Experiment 1, only margin manipulations were used in Experiment 2. In all other respects, the stimuli were similar to those used in the normal condition in Experiment 1.

Design

The design included two main variables: property level (P0, P1, and P2) and exposure duration (5 vs. 60 seconds). P0 was instantiated by the difference between white and red oak leaves. P1 and P2 were instantiated by lobe differences within either white or red oak leaves, as described below. For each property manipulation, two exposure times were used, either 5 or 60 seconds, as in Experiment 1. All groups received normal attention instructions as in Experiment 1.

Property manipulations are shown in Figure 7.

Condition 1 instantiated property level P0. In this condition, the (two) test stimuli consisted of a white and a red oak. The primary difference between them was that one leaf had smooth lobes, whereas, the other had pointed lobes. As mentioned, this is a major botanical difference between oaks. It would seem to be, therefore, a truly global difference. In Condition 2, the test stimuli were two red oak leaves. They differed at the level of P1, i.e., two lobes were combined in one leaf but not the other. This manipulation was identical to M1 in Experiment 1.

Condition 3 was the same as Condition 2 except that the stimuli were white oak leaves. In Condition 4, the test stimuli were two red oak leaves. They differed in that a small lobe on a larger lobe was eliminated in one, but not the other leaf. This condition is similar to M2 in Experiment 1, but entailed less change, since only one small lobe was eliminated in Experiment 2, instead of two as in Experiment 1. This was an attempt to increase the difference between P1 and P2.

Condition 5 differed from Condition 4 only in that white oak leaves were used. It was assumed that P0 represented a relatively more global change than P1 and

that P1 represented a relatively more global change than P2. Note that all leaves had identical vein patterns, so that pairs of leaves differed only in the way described above.

Insert Figure 7 about here

Procedure. The procedure was identical to that used for the normal attention condition in Experiment 1. In each condition, one half of the subjects received one of the members of the pairs of stimuli shown in Figure 7 as the training stimulus. The other half was shown the other member as the training stimulus. All subjects in each condition were presented both members as test stimuli. Each member of a test stimulus pair appeared on the left side of the page for one half of the subjects, on the right for the other half. In all other respects, the procedure was identical with that of Experiment 1. The response measures were also the same: latency, in the difference-detection task, and an old/new forced-choice recognition measure, in the memory task.

Results

Mean latency in the difference-detection task and percent correct recognition in the memory task are presented in Tables 3 and 4, respectively.

Difference-detection

Initial Levene's tests showed significant heterogeneity of variance in latency among the various conditions. Log transformation, however, resulted in the elimination of this heterogeneity. Therefore, all tests were conducted using log-transformed latencies. The main analysis was a 3 (property level: P0, P1, or P2) x 2 (exposure time: 5 or 60 s) ANOVA. For this analysis, Conditions 2 and 3 were combined to represent P1 and Conditions 4 and 5 were combined to represent P2. The main effect of property was significant, $F(2, 114) = 120.36, p < .0001$, with mean latencies of 5.5, 36.8, and 66.8 s, for P0, P1, and P2, respectively.

Insert Table 3 about here

Further (planned) comparisons showed that P0 was significantly different from P1, $F(1, 114) = 138.25, p < .0001$, and that P1 was significantly different from P2, $F(1, 114) = 19.79, p < .0001$. There was no effect

of exposure, with mean latencies of 41.6 s and 43.4 s at 5 and 60 s exposures, respectively, $F(1, 114) = .04$, $p > .05$. The property x exposure interaction was also not significant, $F(2, 114) = .02$, $p > .05$.

Recognition Memory

The major hypothesis was tested by using a 3 (property level: P0, P1, or P2) x 2 (exposure time: 5 or 60 s) weighted least squares analysis of proportions. Once again, Conditions 2 and 3 were combined to represent P1 and Conditions 4 and 5 were combined to represent P2. The main effect of property was significant, $X^2(2, N = 120) = 48.36$, $p < .0001$, with mean scores of 100.0, 70.8, and 54.2 percent, for P0, P1, and P2, respectively. There was no main effect of exposure, with mean accuracy scores of 60.0 and 80.0 percent at 5 and 60 s exposures, respectively, $X^2(1, N = 120) = 1.11$, $p > .05$. The property x exposure interaction was significant, $X^2(2, N = 120) = 7.72$, $p < .025$. The interaction is displayed in Figure 8. As can be seen from the figure, P0 is at ceiling ($M = 100.0\%$) at 5 seconds and remains at ceiling at 60 seconds. P2 is at floor ($M = 45.8\%$) at 5 seconds and remains near floor ($M = 62.5\%$) at 60 seconds. The interaction is entirely due to P1, which was at floor

(M = 54.2%) at 5 seconds and close to ceiling (M = 87.5%) at 60 seconds. This was confirmed by follow-up comparisons. When exposure was 5 seconds, performance was significantly more accurate at P0 (M = 100%) than at P1 (M = 54.2%), $\chi^2 (1, N = 36) = 18.35, p < .001$. The difference between P1 and P2 (M = 45.8%) was not significant, $\chi^2 (1, N = 48) = .34, p > .05$. In the 60 second exposure condition, performance at P0 (M = 100%) did not differ from that at P1 (M = 87.5%), $\chi^2 (1, N = 36) = 2.48, p > .05$. However, the difference between P1 and P2 (M = 62.5%) was significant, $\chi^2 (1, N = 48) = 4.36, p < .05$.

Insert Table 4 about here

Insert Figure 8 about here

Discussion

In general, the data supported the global/local hypothesis. Regarding latency, there was a main effect due to the global/local manipulation. When subjects were shown stimuli that differed in P0, less time was required to complete the difference-detection task than

when they were shown stimuli differing in P1. Similarly, less time was required to complete the task when subjects were shown stimuli that differed in P1 as opposed to P2. Thus, the present data support the claim that the different levels of geometrical structure, P0 - P2, correspond to different levels of perceptual structure. Performance on the memory task provided converging evidence for this claim. There was a main effect due to the property manipulation. Moreover, there was a significant interaction between property level and exposure time. The critical effect responsible for the interaction was that increased exposure lead to improved recognition in conditions that instantiated P1. It should be noted, however, that due to the presence of a ceiling effect in P0 and a floor effect in P2, the interaction may not be as readily interpretable as one might like.

It is also notable that, as in Experiment 1, in the recognition task an exposure of 5 seconds resulted in chance performance (.5 probability of success) for properties P1 and P2, indicating that this exposure was not sufficient to extract either of these properties.

In conclusion, the overall pattern of results is consistent with the hypothesis that P0, P1, and P2 are

ordered levels of geometrical structure that correspond to different levels of perceptual structure.

CHAPTER 4

General Discussion

The theoretical framework that guided the present work was that the properties of complex and unfamiliar forms are hierarchically structured as a series of global-to-local levels. The main hypothesis was that properties would therefore be extracted and/or compared in a global-to-local order. Therefore, for relatively short exposure times, only global properties are likely to be extracted. For relatively longer exposure times, local properties may also be extracted. Two independent variables - property level and exposure time - were manipulated. The dependent variables were latency, in the difference-detection task, and recognition, in the memory task.

In Experiment 1, the property manipulation included two levels, P1 and P2, that were assumed, a priori, to represent different levels of geometrical structure. The data, however, did not show that there was a corresponding perceptual difference. In Experiment 2 the global/local hypothesis was tested (1) by incorporating into the design of the experiment a more global level of stimulus structure, referred to as P0, and (2) by increasing the magnitude of the

difference between P1 and P2. The results of Experiment 2 were consistent with the global-to-local hypothesis. In the difference-detection task, the difference between stimuli that instantiated P0 was discovered faster than that between stimuli that instantiated P1. Similarly, the difference between stimuli that instantiated P1 was discovered faster than that between stimuli that instantiated P2. In the memory task, a significant property x exposure interaction indicated that at 5 second exposures, P0 was recognized better than P1, but P1 was not recognized better than P2. At 60 second exposures, due to improved performance on P1, P0 was not recognized better than P1, but P1 was recognized better than P2.

It should be noted that in the difference-detection task in Experiment 1 (normal condition), although the difference between P1 and P2 did not reach statistical significance, it was in the expected direction, with the mean latency for P2 (54.9 s) being about 25% greater than that for P1 (42.5 s). In general, therefore, the difference-detection task results of both experiments were consistent with the global-to-local hypothesis. It should also be noted that in the memory task, there was a difference between

P1 and P2 at 60 second exposures in Experiment 2, but not in Experiment 1. However, recall that P2 only involved a change in a single minor lobe in Experiment 2 as opposed to two minor lobes in Experiment 1. This difference in stimulus structure was apparently enough to produce a psychological difference.

Global Properties Reconsidered

At this point, it seems appropriate to reconsider the question, "What constitutes a global property"? The critical issue here has been best captured by Loftus et al. (1983) who wrote "...as is so often the case in psychological inquiry, we are faced with a conceptual catch-22. To investigate the properties of the hypothesized [global/local] information, we must operationalize it in some way; however, without knowing much about the properties, it is not terribly clear how the operationalization should be done. Hence a bootstrapping strategy is required in which operationalization is arrived at partly by logic and partly by intuition" (p. 197). As an example, Table 5 summarizes how different authors might characterize an oak leaf. As illustrated in Table 5 there are many properties that could be posited to regulate the

Insert Table 5 about here

detectability, discriminability, or recognizability of a complex and unfamiliar stimulus such as an oak leaf (Uttal, 1988; Zusne, 1970). The properties listed in Table 5 are only a partial list of all the possible properties that could be listed. In addition, a change in any property (e.g., merging two lobes [P1] of an oak leaf) implies covaried changes in other properties such as size, perimeter, symmetry, etc. Such confounding of stimulus properties is a well-known problem that occurs when the forms of continuous figures are manipulated (Garner, 1981; Pomerantz & Pristach, 1989; Uttal, 1988; Zusne, 1970). Thus, it is difficult to determine which aspect or aspects of a stimulus and their variations are responsible for observed effects. As previously noted, psychologists have had little success in precisely defining or quantifying form, either verbally or mathematically (Uttal, 1988). However, a promising approach is one of comparing structural descriptions based on the geometry of the stimulus with their psychological effects. This approach has been successfully utilized in the description and analysis

of scenes (Quinlan, 1991). This approach was also used in the present work: P0, P1, and P2 represented different levels of geometrical structure, and at least in Experiment 2, these levels were paralleled by corresponding perceptual effects. Within this framework, levels of globality are initially identified with different levels of geometrical stimulus structure. Having identified different levels of geometrical structure, the role of experiments is to determine whether these do in fact correspond to different levels of perceptual structure. The present experiments, therefore, are an example of the bootstrapping strategy advocated by Loftus et al. (1983).

Conclusion

In spite of the difficulty of constructing an adequate definition of global properties, the results of Experiment 2 and of other studies reviewed in this thesis, show that the distinction between global and local properties is important. In the Introduction, I mentioned that the British empiricist tradition has dominated the study of perception for most of the 20th century. In spite of the recent resurgence of interest in the wholistic view, most psychological theories

conceptualize visual form recognition as a process whereby elementary features are detected first and then combined into larger units (Uttal, 1988).¹ The theoretical approach subscribed to in the present work emphasizes the reverse order of processing: One first individuates the most inclusive (wholistic) aspects of a visual stimulus and then elaborates them as time permits, under the demands of the task at hand. The results obtained in this thesis are generally consistent with the latter view.

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Footnote

¹As an example of a current approach of this type, consider the feature-integration theory of attention proposed by Anne Treisman and her colleagues (Treisman, 1986; Treisman & Gelade, 1980; Treisman, Sykes, & Gelade, 1977). This theory claims that there are two levels of processing during the early stages of vision, the preattentive level and the attentive level. At the preattentive level, objects are decomposed into elementary features which are processed in parallel across the visual field. Subsequently, focal attention is necessary in order to recombine features into perceptual objects. Thus, objects are identified only at a later stage of visual processing. Treisman and Gelade (1980) wrote "the visual scene is initially coded along a number of separable dimensions, such as color, orientation, spatial frequency, brightness, direction of movement. In order to recombine these separate representations and to ensure the correct synthesis of features for each object in a complex display, stimulus locations are processed serially with focal attention. Any features which are present in the same central 'fixation' of attention are combined to form a single object" (p. 98).

Table 1

Mean Response Latency (seconds) in the Difference-Detection Task as a Function of Condition, Property, Exposure Duration, and Locus of Change in Experiment 1

Condition	5 Seconds		60 Seconds		Mean
	Margin	Vein	Margin	Vein	
Normal Attention					
P1 ^a	33.5	48.7	34.9	52.7	42.5
P2 ^b	49.8	61.7	66.9	41.2	54.9
Mean	41.7	55.2	50.9	47.0	48.7
Directed Attention					
P1 ^a	4.8	5.6	6.1	6.8	5.8
P2 ^b	8.7	8.2	5.6	7.6	7.5
Mean	6.7	6.9	5.8	7.2	6.7

Note. N = 12 subjects per cell.

^aP1 = property level 1. ^bP2 = property level 2.

Table 2

Percent Correct Recognition in the Memory Task as a Function of Condition, Property, Exposure Duration, and Locus of Change in Experiment 1

Condition	5 Seconds		60 Seconds		Mean
	Margin	Vein	Margin	Vein	
Normal Attention					
P1 ^a	41.7	66.7	66.7	66.7	60.4
P2 ^b	50.0	41.7	66.7	83.3	60.4
Mean	45.8	54.2	66.7	75.0	60.4
Directed Attention					
P1 ^a	100.0	100.0	100.0	91.7	97.9
P2 ^b	83.3	91.7	100.0	100.0	93.7
Mean	91.7	95.8	100.0	95.8	95.8

Note. N = 12 subjects per cell.

^aP1 = property level 1. ^bP2 = property level 2.

Table 3

Mean Response Latency (seconds) in the Difference-Detection Task as a Function of Property, Exposure Duration, and Species in Experiment 2

Property	5 Seconds		60 Seconds		Mean
P0 ^a	5.5		5.4		5.5
	Red Oak ^b	White Oak ^c	Red Oak ^b	White Oak ^c	
P1	41.7	27.6	48.6	29.4	36.8
P2	90.8	42.4	81.0	52.8	66.8
Mean ^d	66.2	35.0	64.8	41.1	

Note. N = 12 subjects per cell.

^aPerformance entails a comparison between a red oak and a white oak leaf. ^bPerformance entails a comparison between two red oak leaves. ^cPerformance entails a comparison between two white oak leaves. ^dMarginal means for P1 and P2.

Table 4

Percent Correct Recognition in the Memory Task as a Function of Property, Exposure Duration, and Species in Experiment 2

Property	5 Seconds		60 Seconds		Mean
P0 ^a	100.0		100.0		100.0
	Red Oak ^b	White Oak ^c	Red Oak ^b	White Oak ^c	
P1	41.7	66.7	75.0	100.0	70.8
P2	41.7	50.0	41.7	83.3	54.2
Mean ^d	41.7	58.3	58.3	91.7	

Note. N = 12 subjects per cell.

^aPerformance entails choosing between a red oak and a white oak leaf (or alternatively, Test stimuli consist of a red oak and a white oak leaf). ^bPerformance entails choosing between two red oak leaves. ^cPerformance entails choosing between two white oak leaves. ^dMarginal means for P1 and P2.

Table 5

Examples of Properties That Could be Used to Describe an Oak Leaf

Configural	Dimensions	Stimulus-specific
symmetry	size	lobed margination
shape	height/width ratio	sinus shape
repetition	perimeter	venation
closure	area	stem length
parallelism	orientation	margination
texture	numerosity	
compactness		
skewness		
unknown ^a		

^aSome authors (e.g., Pomerantz & Pristach, 1989) have posited the existence of unknown or undiscovered emergent global properties (e.g., unknown dimensional or configural interactions).

Figure Captions

Figure 1. Examples of the types of stimuli used in Navon's (1977) study. The stimuli on the left are consistent stimuli, i.e., the global and local letters are identical. The stimuli on the right are inconsistent stimuli, i.e., the global and local letters have different names. (Adapted from Navon, 1977.)

Figure 2. Examples of stimuli used in Kimchi and Merhav's (1991) study. The stimuli were constructed by orthogonally combining two types of global configurations (square and rectangle) with two types of local elements (squares and rectangles). Consistent and inconsistent stimuli are shown in the figure. Consistent stimuli are those in which the global and local levels have the same identity (i.e., both global and local forms were squares [top left] or both were rectangles [bottom right]). Inconsistent stimuli are those in which the global and local levels have different identities (i.e., a global square made up of local rectangles [bottom left] or a global rectangle made up of local squares [top right]). (Adapted from Kimchi & Merhav, 1991.)

Figure 3. Examples of Navon and Norman's (1983) compound stimuli. (Adapted from Navon & Norman, 1983.)

Figure 4. Examples of Martin's (1979) many-element (left) and few-element (right) compound stimuli. (Adapted from Martin, 1979.)

Figure 5. Marginal configuration changes. Original stimulus (A) and stimuli that instantiate M1 & M2 (B & C, respectively). See text for detailed description.

Figure 6. Venation changes. Original stimulus (A) and stimuli that instantiate V1 & V2 (B & C, respectively). See text for detailed description.

Figure 7. Stimuli that instantiate conditions P0 - P2. See text for detailed description.

Figure 8. Recognition memory performance (percent correct) as a function of exposure time in Experiment 2. (The curve parameter is property level. See text for detailed description.)

Figure 1

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H       H
H       H
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H       H
H       H
H       H

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S       S
S       S
S       S
S S S S S
S       S
S       S
S       S

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S S S S
S       S
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S
S       S
S S S S

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H H H H
H       H
H
H H H H
H
H       H
H H H H

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Figure 2

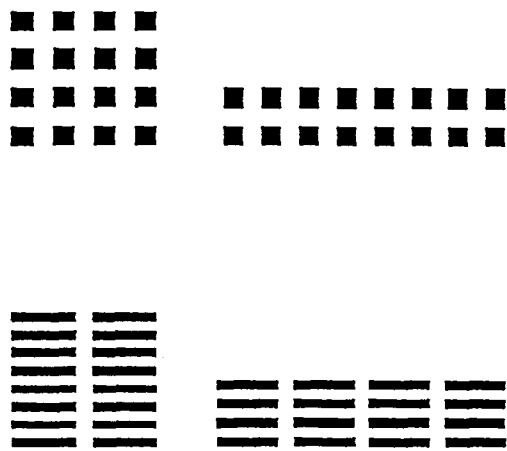


Figure 3

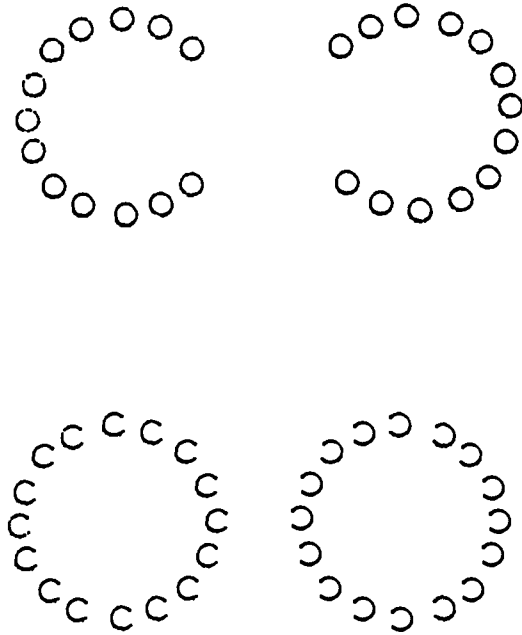


Figure 4

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Figure 5

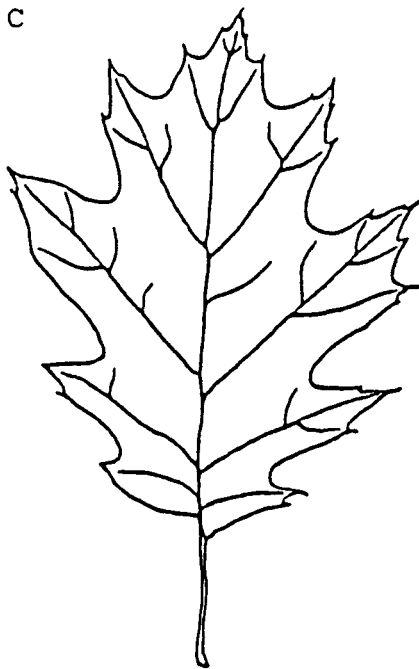
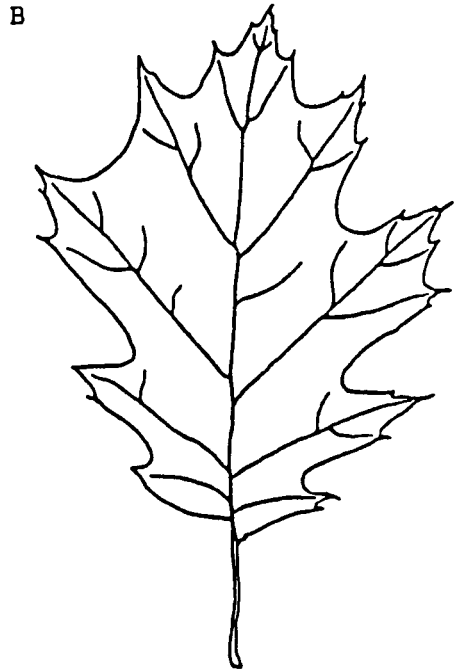
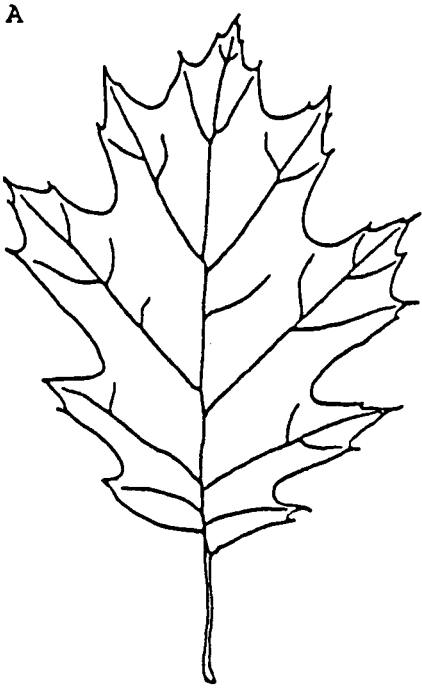
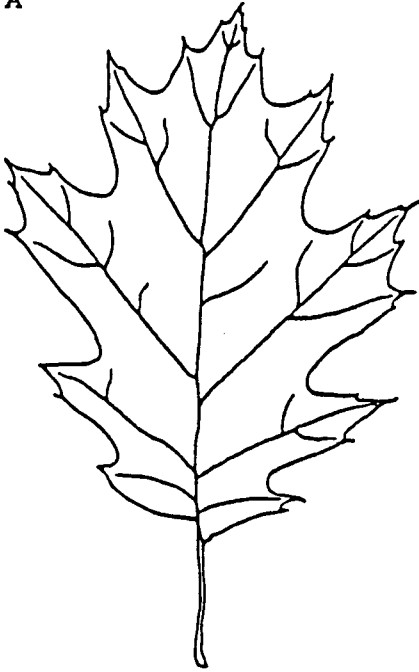
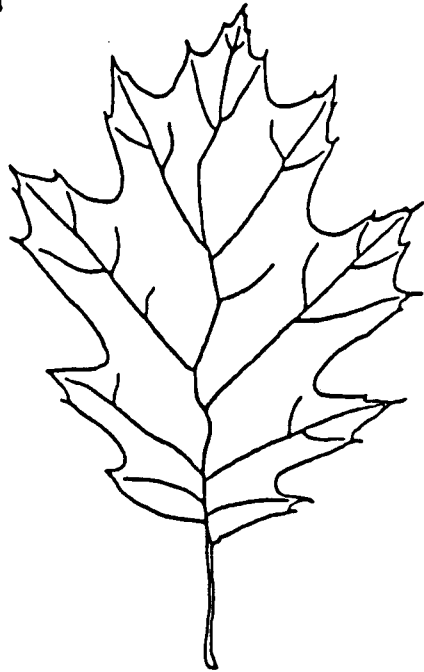


Figure 6

A



B



C

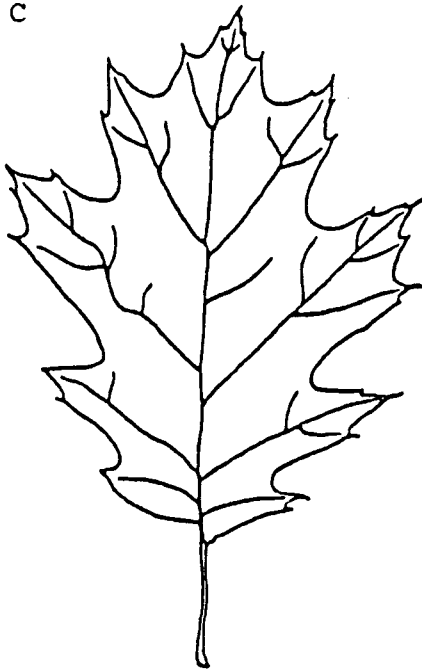


Figure 7

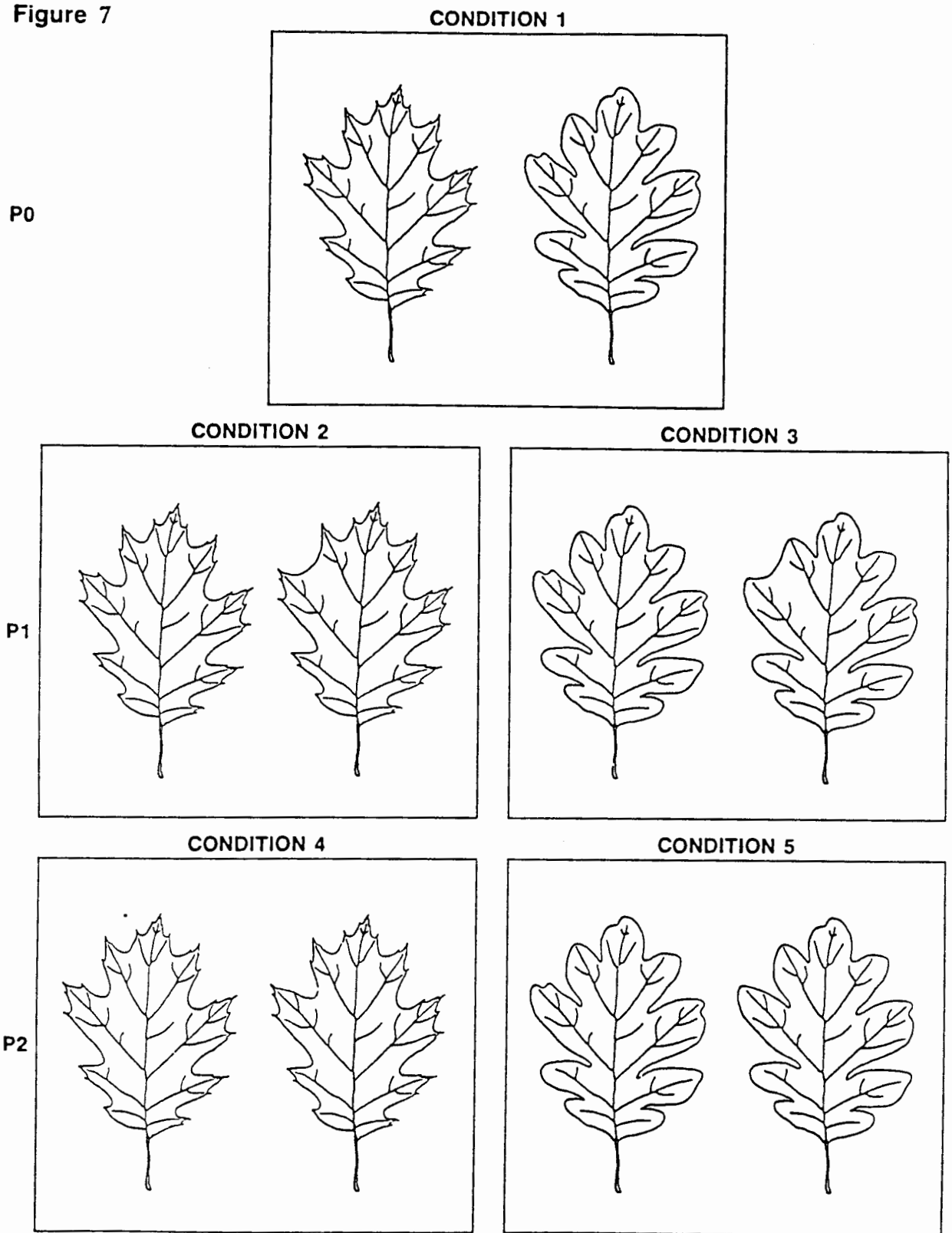


Figure 8

