OBJECT SUPERIORITY AS A FUNCTION OF TASK DIFFICULTY AND OBJECT COHERENCE

by

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ABSTRACT

This dissertation was concerned with the object superiority effect, namely, the well-known finding that briefly presented target lines that differ in location or orientation are identified more accurately when embedded in some contexts than in others. Previous models of object superiority have emphasized the role of (1) enhanced discriminability, (2) interstimulus dissimilarity and redundancy, or (3) the informativeness, or task-relevance, of a particular context. The present research extends the notion that informativeness of context affects performance. Experiment 1 tested the hypothesis that search for a part embedded in the context of a whole stimulus will be facilitated to the extent that properties of the stimulus provide informative cues to the location of the target. Performance was compared on a coherent context, which is presumed to contain informative location cues, and on an incoherent context, presumed not to contain such cues. Both types of contexts were presented at two levels of task difficulty. At one level, the target always appeared at the same fixed location relative to the context as a whole. At a more difficult level, the target appeared at variable locations relative to the whole. The target was also presented in isolation. A coherent object superiority effect was obtained when the target was located at variable relative positions but not when it was at a fixed relative position. It thus appears that in the variable condition, a coherent object can provide informative cues that may be used to locate the target. The lack of object superiority in the fixed condition suggests that the frame of the stimulus was probably the cue used to locate the target, since such a cue is independent of coherence. Results also showed that performance was better in the isolated part condition than in most other conditions. Experiment 2 replicated and extended the results of

Experiment 1. Experiment 3 eliminated lateral masking as a factor within the present paradigm. The findings are consistent with the view that object superiority depends on an interaction between the processing requirements of a task and the information provided by context vis-a-vis those requirements.

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CHAPTER 1

Object Superiority

An enduring issue in the psychology of perception concerns how one is able to identify parts of objects. The Gestalt psychologists proposed that the appearance of a part is strongly influenced by the object in which it is embedded. They demonstrated that a part, when embedded in one object context, may appear very different than when embedded in another context (Hochberg, 1974). As a result, the part may be more or less recognizable depending on context. While evidence in support of Gestalt context effects came mainly in the form of demonstrations rather than genuine experiments, recent studies have shown that briefly presented target lines are identified better when embedded in object-like contexts than in control contexts. This finding has been referred to as the object superiority effect. A closely related finding, the object-line effect, refers to the finding that target lines are identified better in an object-like context than when presented in isolation. The findings are examples of the top-down influence that higher order stimulus properties can have on the perception of component parts.

The present research was concerned with the role of two variables, coherence and task difficulty, in the identification of stimulus parts. The conceptual framework guiding this work will be described in chapter 2. The present chapter is concerned with basic definitions, followed by a review of relevant literature. Chapters 3 to 5 describe experiments that were conducted to test the theory. Finally, chapter 6 provides an integrative summary of the findings.

Definitions

This section provides definitions of several key terms that are common in the object superiority literature. I start by considering Garner's (1978) classification scheme. The terms global and local are then defined and related to Garner's scheme. Finally, I will define the terms object, object superiority effect, and context effect.

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, consider size. Although a particular 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, shape, 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 the stimulus that can be removed without affecting the rest of the stimulus. In contrast, if the dimension of size is removed, the stimulus would no longer exist. It should be mentioned that other authors define features differently. 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).

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. On the other hand, configural properties differ from features and dimensions in two important ways. First, they are emergent properties that depend on the interrelations between the component parts. Second, configural properties cannot be changed without changing some of the stimulus components. Examples of emergent configural properties are depth (three-dimensionality), connectedness, 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). Emergent properties may be as or more salient than the more elementary physical features on which they are defined (Pomerantz, Pristach, & Carson, 1989).

Global vs. local properties. The terms global and local are commonly used in the object superiority literature. These terms refer to properties of a stimulus. Properties that pertain to the whole stimulus are considered global (or structural) whereas properties of parts and the parts themselves are considered local. The terms global and local can be related to Garner's classification scheme as follows. An 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., depth, connectedness, coherence). 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). To illustrate, consider a face. It may be round, have a tanned complexion, long hair, and may be smiling. According to the present scheme, shape and hue would be global dimensions, hair presence would be a global feature and a smiling expression would constitute a global configuration. At a relatively more local level, the eyes might be green, almond-shaped and symmetrical.

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 shape (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 different authors conceptualize global properties. For example, some (e.g., Rock, 1986) refer to shape as depending on the geometrical spatial relationships among points or contour demarcations, a configural property in Garner's scheme. Others, refer to shape as a global dimension (Treisman, 1986). Similarly, as previously mentioned, there is disagreement in the way in which different authors conceptualize features.

Object. The concept of object is a psychologically difficult one. Due to the multidimensional nature of objects, particularly real-life ones, psychologists have had little success in precisely defining or quantifying them, either verbally or mathematically (Uttal, 1988). It may be for this reason that researchers working within the object superiority paradigm seldom make any attempt to define this construct. Instead, they typically use the term in a way that consensually communicates the necessary meaning in the context of their research paradigm. One exception is provided by Lanze, Weisstein, and Harris (1982) who defined an object as a stimulus that appears "three-dimensional, well structured, unified, and somewhat redundant" (p. 382). In the present work, the term object is defined as a stimulus in which all parts are <u>connected</u> to form a <u>coherent</u> structure. The stimulus may be strictly two-dimensional or may suggest a three-dimensional structure. As can be seen, this definition is quite similar to that provided by Lanze et al. especially in its implicit emphasis on the emergent configural aspects of a stimulus rather than the constituent elements. In the present definition, the term connected means to join rather than to associate closely. Thus, a stimulus is connected if the parts are physically joined together. If a connected stimulus is deconstructed so that the parts are (1) separated but the spatial relations are not otherwise changed (i.e., the parts remain in close proximity and are not rearranged) or (2) separated and rearranged, or jumbled, the stimulus is considered to be disconnected. The latter connotation is typically what most object superiority researchers seem to mean when they say that a stimulus is disconnected. Certainly, this is the way the term has usually been operationalized (e.g., Weisstein & Harris, 1974). The term, coherence, is taken to mean that the stimulus presents a unitary configuration. Coherence and connectedness appear often to be confused. Some authors use the two words in such a way as to imply that they refer to different properties yet the intended meanings are not made explicit. Others explicitly take the words to be synonyms (e.g., Weisstein, Williams, & Harris, 1982). Still others define a context to be coherent if it presents a unitary configuration whereas a context is connected if it has a continuous contour (e.g., Earhard, 1990). This latter usage is consistent with the way these terms are used in the present work.

Object superiority vs. context effects. The term object superiority will be used to refer to the part identification advantage conferred by stimuli that are object-like in appearance over stimuli that are not (e.g., Lanze et al., 1982). Whereas in previous research, the to-be-identified part was typically a line segment, the present work uses much more complex parts embedded in very complex stimuli. The term object-line effect will be used to refer to the identification advantage conferred by an object-like context over isolated line segments. The more general term, object-part effect, will be used to refer to the advantage conferred by an object-like context over any local component - be it a line or a more complex part - of the stimulus.

This concludes the section on definitional issues. The discussion now turns to a review of theory and data pertaining to object superiority.

Object Superiority: A Review

Object superiority effects were first demonstrated by Weisstein and Harris in 1974. Their experiment used four line segments differing in orientation and location relative to a central fixation point, as shown in Figure 1A, frames a - d. These lines were combined with different configurations of horizontal and vertical lines, as shown in Figure 1B, to produce six contexts (a - f in Figure 1B) that varied in dimensionality and coherence, e.g., context a in Figure 1B is three dimensional and coherent; context f is two dimensional and incoherent. All of the patterns were matched in basic features, i.e., they were equated in terms of number, length, and orientation of non-target line segments. The experiment utilized a visual detection task in which stimuli were sequentially presented on a cathode-ray tube screen. On each trial, a pattern was briefly presented and then masked. The participant's task was to indicate, by making an appropriate key-press, which one of the four diagonal line segments was present in the display. The main finding was that when a target line was part of a unitary, three-dimensional context (a in Figure 1B) it was identified more accurately than when in any other context (see difference column in Figure 1B). Since unified, three-dimensional contexts are object-like in appearance, Weisstein and Harris labeled this basic finding the object superiority effect. In Weisstein and Harris' study, the target line was always accompanied by context lines. Williams and Weisstein (1978) extended this research by including a condition in which the four lines shown in Figure 1A (frames a - d) were presented in isolation. Four experiments demonstrated that the lines were identified more accurately in the object context than when presented alone. This finding was labeled the object-line effect. A robust object superiority effect was also found between the overlapping squares context (a in Figure 1B) and the disconnected lines context (f in Figure 1B) in each of these experiments.

Insert Figure 1 about here

Following this seminal research, numerous studies have investigated the object superiority and object-line effects. In the following, I will review this work in terms of three main theories. The first theory emphasizes enhanced discriminability. The second focuses on the role of interstimulus dissimilarity and redundancy. The third stresses the interaction between the processing task and the nature of the context.

Enhanced Discriminability

Weisstein and her associates propose that certain structural properties such as three-dimensionality, coherence, and connectedness increase the discriminability of contexts and allow them to be processed more rapidly and accurately than contexts lacking these properties, or target lines presented alone (Lanze, Maguire, & Weisstein, 1985; Lanze et al., 1982; Weisstein et al., 1982; Williams & Weisstein, 1978). The notion is that target lines become available to conscious perception more rapidly in the advantaged contexts (e.g., Weisstein et al., 1982).

Most of the studies subsequent to the initial demonstrations of the object superiority and object-line effects fall within this conceptual framework. They have attempted to determine which properties facilitate the object superiority and object-line effects. Properties that have been investigated include: three-dimensionality and coherence (Lanze et al., 1985;

Lanze et al., 1982; Weisstein et al., 1982) structural relevance (McClelland & Miller, 1979), and connectedness of contour (Chen, 1982). The majority of studies have employed a paradigm that is very similar to the one used by Weisstein and Harris (1974) and Williams and Weisstein (1978). In particular, a search (or speeded identification) task is used in which participants determine which one of a number of line segments is present in a briefly (usually between 20 and 100 ms) displayed context pattern. Typically, the pattern is presented with spatial certainty, that is, at a fixed position on the screen, but the target line appears with locational uncertainty. In particular, the pattern is usually centered on a fixation point and the target line is presented at variable positions relative to the whole stimulus, i.e., the relative position of the target varies from one exposure to the next (see f - i in Figure 1A). In some studies a pre- or postmask is used (e.g., Enns & Prinzmetal, 1984) while in others no masking is used (e.g., Earhard, 1990). The dependent variable is typically accuracy (e.g., Weisstein & Harris, 1974); but response time (e.g., Klein, 1978) and detection thresholds (e.g., Purcell & Stewart, 1991) have also been used.

Three-dimensionality (and coherence) vs. structural relevance. Weisstein and Harris (1974) and Williams and Weisstein (1978) suggested that the perceived depth of the stimulus enhances identification of a component line. Other early evidence also seemed to support this interpretation (Weisstein & Harris, 1980; Womersley, 1977). However, since the object contexts differed from the control contexts in a number of ways, it was not clear which of the attributes of the former was responsible for the effects. McClelland and Miller (1979) challenged the proposal that depth was the critical factor. They argued that what matters is how important, or structurally relevant, the target line is to the context figure. According to these authors, the target line plays a critical role in determining what the object represents, and is not merely an incidental addition to that object. McClelland and Miller tested the structural relevance proposal in two object-line experiments. One used the stimuli shown in Figure 2A. As can be seen, two different contexts (corner squares and objects) and two different types of target lines (relevant vs. irrelevant) were used. The stimuli were rated by independent observers for three-dimensionality and structural relevance of the target segment to the figure as a whole. Results indicated an advantage for both types of contexts over single lines, i.e., object-line effects, when the target was structurally relevant. When the target was structurally irrelevant, no object-line effects were obtained. These results appeared to support the hypothesis that structural relevance is an important determiner of the object-line effect. However, the findings are difficult to interpret because the contexts that contained the structurally relevant targets were also rated as more three-dimensional in appearance than the contexts that contained the irrelevant targets. Thus, since these factors covaried, the results could have been due to structural relevance, depth, or both.

In a second experiment, McClelland and Miller manipulated structural relevance by utilizing the two contexts (hurdles and objects) shown in Figure 2B. The target lines were structurally relevant in the hurdles context and irrelevant in the objects context. Results showed that the hurdles context facilitated perception of the target lines compared to the single-line control, but the object context did not. While this result is consistent with the structural relevance proposal, once again, there are significant interpretive problems with the study. First, the total length of non-target lines was greater for the objects context than for the hurdles context. This is problematic since it has been shown that increases in total line length are correlated with decreases in accuracy in object superiority and object-line effect studies (e.g., Weisstein & Harris, 1974). Second, the target was an internal line in the objects context and an external line in the hurdles context. Thus, the target lines may have been masked by non-target lines to a greater extent in the objects context than in the hurdles context.

Insert Figure 2 about here

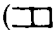
Weisstein et al. (1982) attempted to clarify the roles played by three-dimensionality and structural relevance in object superiority and object-line effects. In their experiments, participants rated each of 32 variations of 8 different context patterns for three-dimensionality and structural relevance. The ratings indicated that each of these factors was represented by a range of values. Other participants performed the line-identification task, which in this case involved four target alternatives. Weisstein et al. found that accuracy was highly correlated with judged pattern depth (95% of the variance) and also with judged structural relevance (88% of the variance). That is, accuracy was much greater on highly three-dimensional patterns than on flat patterns or lines alone. Greater accuracy was also evidenced for patterns containing structurally relevant target lines than for those containing irrelevant lines or lines alone. Unfortunately, depth and structural relevance were confounded in this study, so it is not clear which of these two attributes is more important.

Lanze et al. (1982) addressed this problem in three well-controlled experiments by utilizing sets of patterns in which judged depth and structural relevance of the target line were uncorrelated. In Experiments 1 and 2, perceived depth was varied while the structural relevance of the target lines was held constant (each target line appeared as an isolated fragment within each context). Results indicated that line identification accuracy was higher on three-dimensional patterns than on flat ones. In Experiment 3, judged depth and structural relevance were orthogonally varied. The results of this experiment indicated that accuracy depended on depth but not structural relevance. The authors concluded that object superiority depends on depth rather than on the specific role played by the target line within the pattern (see also Lanze et al., 1985). They proposed that the source of this effect was the visual system's ability to respond more quickly to three-dimensional stimuli than to two-dimensional stimuli. This proposal was supported by prior metacontrast experiments (Weisstein & Harris, 1980; Weisstein & Maguire, 1978; Williams & Weisstein, 1981).

It is important to point out that although robust object superiority effects were obtained by Lanze et al. (1982), none of the patterns produced an object-line effect. The authors ascribed this to the use of patterns that consist of a large number of lines compared to patterns used in previous studies. The extra lines may have caused lateral masking, a reduction in the signal-to-noise ratio, or response competition. Therefore, any positive effect of context may have been counteracted by one or more of these negative influences. Since the object-line effect seems to depend on the number, length, or both, of non-target lines in the display, it is difficult to predict whether this effect will occur in any given experimental situation. On the other hand, the object superiority effect appears to be a more reliable phenomenon, assuming, of course, that all extraneous information is held constant across contexts (cf. Lanze et al., 1982; Weisstein et al., 1982). Nevertheless, it is important to mention that object superiority does not depend solely on the structural properties of the context. Studies have indicated that it may be influenced (1) by the location of the fixation point relative to the target and other lines in the display (Earhard, 1980; Earhard & Armitage, 1980), (2) by the location of the target line relative to other lines in the display (McClelland & Miller, 1979) and (3) by the nature of the masking stimulus (e.g., McClelland, 1978). These factors are typically held constant in studies of object superiority, but exceptions were noted above.

Purcell and Stewart (1991) used an object-detection paradigm to test the hypothesis that a three-dimensional object is more perceptible than a two-dimensional one. This paradigm directly assesses the visibility of a stimulus by determining its detection threshold. The detection threshold is the stimulus exposure duration that produces a pre-established level of accuracy and is the dependent variable in this paradigm. The participant's task was to detect any part of a briefly presented two- or three-dimensional figure and indicate whether it appeared to the left or the right of a fixation point. Three experiments showed that the three-dimensional figure was detected faster (as indicated by a shorter detection threshold) than the two-dimensional figure under conditions of visual backward masking. These results support Weisstein and Harris's proposal regarding the perceptibility of three-dimensional stimuli. It is worth noting, perhaps, that since the perceptibility of the object is directly assayed in this paradigm, these results provide stronger support for the hypothesis than do those provided by line-identification tasks. In the latter, it is assumed that the greater the accuracy of target identification, the more visible the target, and by inference, the more visible the stimulus as a whole. Thus, greater accuracy of target identification only provides indirect support for the hypothesis.

Purcell, Stewart, and Giacoletti (1993) have recently extended Purcell and Stewart's (1991) research by directly determining line identification thresholds (the dependent variable) for target lines in three- and two-dimensional contexts. The target line could appear in one of four positions within each context. And the participants task on each trial was to indicate the location at which the target line was presented. Consistent with previous research on the object superiority effect, the identification threshold was lower for target lines embedded in three-dimensional contexts (24.4 ms) than for those embedded in two-dimensional contexts (32.3 ms).

Connectedness of contour. Chen (1982) proposed that the visual system is tuned to extract "global topological invariants" such as connectedness and thus predicted that stimuli with these properties would have a processing advantage. This prediction was tested in a single object-line effect experiment. The context, an H-shape on its side (), was combined with a vertical line segment to form two connected figures, one of which had the line on the left (), the other on the right (). On each trial, participants saw one of the connected figures, centered on fixation, or a line in isolation. The task was to report which side of fixation the line was on. The experiment yielded higher accuracy when the target was part of a connected whole (86% correct) than when it was presented in isolation (55%). Chen concluded that connectedness can facilitate the detection of a component target line. Two problems with the study suggest that this conclusion was premature. First, global shape was correlated with the target alternatives: When the target line to the left of fixation was combined with the context, the figure looked like a block letter A on its side with the top of the A on the left. When the target appeared on the right, the top of the A faced right. This information could have facilitated performance, that is, redundancy, rather than connectedness may have determined response accuracy (cf. Enns & Prinzmetal, 1984). Second, the study did not vary connectedness: performance on a connected context was not compared with that on a disconnected one.

Weisstein et al. (1982) have also investigated the role of connectedness in object superiority and object-line effects. In their experiments, which have been described above, independent groups of participants performed a rating task (connectedness, dimensionality) and a line-identification task. In Experiment 1, accuracy was highly correlated with judged connectedness. However, when variations in judged depth were partialled out, accuracy was uncorrelated with connectedness. The latter finding is difficult to interpret, however, since the patterns varied widely in depth and considerably less so in connectedness. In Experiment 2, Weisstein et al. attempted to address this issue by using patterns that varied in connectedness but not in depth. The authors found that connectedness was uncorrelated with accuracy and concluded that this factor was of minor importance in the experiments. Nevertheless, inspection of scatterplots presented for the pooled data from the two experiments (their Figure 3) revealed the presence of a range restriction for the connectedness data. This may have reduced the magnitude of the correlation making it appear that the two variables were uncorrelated.

Weisstein and her colleagues have also used a metacontrast paradigm to study the role of connectedness in object superiority and object-line effects (Weisstein & Harris, 1980;

Weisstein & Maguire, 1978). In this paradigm the target line is presented and then followed, after various delays, by the context pattern. The participant's task is to report on each trial which diagonal line segment has been presented. Using this method, Weisstein, Williams, and Williams (1979) have shown that, at certain delays the more fragmented patterns yielded lower accuracies than the connected ones (when depth is held constant). The implication of this finding is that connectedness may affect accuracy under sequential but not simultaneous presentation of the target and context (Weisstein & Harris, 1980; Weisstein et al., 1982).

Research reviewed so far has shown that contexts that are three dimensional (i.e., have a depth inducing perspective), coherent (i.e., present a unitary configuration), and connected (i.e., have a continuous contour) are effective in facilitating identification of constituent lines (e.g., Lanze et al., 1985; Lanze et al., 1982; Weisstein et al., 1982; Williams & Weisstein, 1978). These results have been obtained in target-identification (e.g., Weisstein et al., 1982) and object-detection (e.g., Purcell & Stewart, 1991) paradigms. However, two other lines of research have provided evidence that is inconsistent with this view. One has focused on the role of interstimulus dissimilarity and redundancy, the other on the role of the task itself.

Interstimulus Dissimilarity and Redundancy

Enns and his associates (Enns & Prinzmetal,1984; Enns & Gilani, 1988) propose that object superiority and object-line effects are a function of two factors: (1) the differential dissimilarity of contexts as the result of emergent features' being formed when target and context lines interact, and (2) the presence of a correlation between the emergent properties and the target lines themselves. The central idea is that context does not make the target line more perceptible, but is able, by virtue of its own structure, to convey information about which target line is present. And participants can use that information to identify the target line. Thus, object superiority is not a perceptual phenomenon, but one of inference and higher level cognitive processing. The proposal can be illustrated with reference to the displays used by Williams and Weisstein (1978; Experiments 2 & 3), shown in Panel A of Figure 3. In previous studies of superiority effects, the connected, three-dimensional contexts (1a and 1b) are compared with the disconnected flat contexts (3a and 3b) and with isolated lines (5a and 5b). Target identification is typically more accurate for the three-dimensional context than for the two-dimensional context, or lines alone, as previously reported. According to Enns and his colleagues, these effects are due to interstimulus dissimilarity and redundancy. Specifically, contexts 1a and 1b differ from one another more than do contexts 3a and 3b or lines 5a and 5b. The authors point out that, at the global level, context 1a might be perceived as a "step" viewed from below whereas context 1b might be perceived as a "wall" seen from above. Moreover, these salient configurational attributes are redundant with the target lines. Thus, participants may use this configurational information to infer which target line is present when contexts 1a and 1b are presented. Such information is not available when contexts 3a and 3b or lines 5a and 5b are displayed.

Insert Figure 3 about here

Enns and Prinzmetal (1984) have obtained support for this theory in three experiments. Their first used 10 different three-dimensional object contexts. There were two sessions in the study. In the first, participants were shown isolated-line displays and displays containing only one of the 10 contexts. As an example, an observer might see contexts 1a and 1b and lines 5a and 5b, as shown in Panel A of Figure 3. In the second, the same participants were shown all 10 contexts as well as isolated-line displays. In Session 1, accuracy was greater for lines in context than for lines alone. However, in Session 2 this finding was reversed, indicating an object-inferiority effect. The findings suggest that context contributes to performance by providing information that may be correlated with one or another of the target alternatives. When a given context is consistently mapped onto a particular target alternative, as in Session 1 (where, for example, the step interpretation of context 1 could have been mapped onto target A, the wall interpretation onto B), the result is an object-line effect. When there is no consistent mapping, as in Session 2, the object-line effect is reversed. Thus, the same three-dimensional contexts that facilitated performance in Session 1 interfered with performance in Session 2.

The second experiment manipulated the degree of redundancy between emergent features and target lines in two-dimensional contexts (arrows vs. triangles). Results indicated that when the emergent features of the contexts fully specified the target lines (i.e., complete redundancy; correlation = 1), accuracy was higher for lines-in-context than for lines alone. When emergent features did not specify the target lines at all (i.e., zero redundancy; correlation = 0), there was no difference in accuracy between lines-in-context and lines alone.

Their third study tested the hypothesis that line identification accuracy depends on interstimulus dissimilarity. One group of participants rated five different two-dimensional contexts (and lines alone) for dissimilarity while another group participated in the line identification task. Results showed that the dissimilarity ratings reliably predicted the size of the object-line effect. Furthermore, the ratings predicted target accuracy only when there was a correlation between emergent features and targets. Finally, the experiment showed that interstimulus dissimilarity can generate an object-line effect in the absence of any general configural property such as three-dimensionality, connectedness, or coherence. Thus, these results supported Enns and Prinzmetal's proposals that the object-line effect varies with (1) interstimulus dissimilarity and (2) the degree of correlation between emergent features and the target lines (see also Earhard, 1987 and Lanze et al., 1985). However, as noted by Enns and Prinzmetal, "no attempt was made to tightly control total line length, the local environment of the target line, or the judged connectedness, three-dimensionality, or structural relevance of the stimuli" (p. 30). As previously mentioned, however, each of these factors can influence target identification accuracy. Thus, these variables, either singly or in combination, might have had some influence in Enns and Prinzmetal's study.

Enns and Prinzmetal's proposal was subsequently tested by Enns and Gilani (1988). In one study (Experiment 1), perceived dimensionality (three, two) and context dissimilarity (high, low) were orthogonally varied to examine the relative contributions of these factors to the object-line and object superiority effects. One group of participants rated 16 different contexts, under free viewing exposure conditions, for both factors; another group participated in the line-identification task. Results indicated that accuracy was higher on three-dimensional contexts than on two-dimensional ones (object superiority) and it was higher on all three-dimensional contexts than on lines alone (object-line effect). There was no difference in accuracy between similar and dissimilar contexts. These results are therefore consistent with Weisstein's proposal that three-dimensional contexts are processed more efficiently than flatter contexts or isolated lines and not with Enns and Prinzmetal's hypothesis that interstimulus dissimilarity predicts superiority effects. In another study (Experiment 3), Enns and Gilani examined the relative contributions of dimensionality and perceptual discriminability to the object superiority effect. Perceptual discriminability was assessed using a tachistoscopic (40 - 60 ms) same-different task. A multiple regression analysis showed that dimensionality and discriminability made equal and independent contributions to line-identification accuracy. The discriminability effect appears to support Enns and Prinzmetal's proposal that discriminability affects the ability of observers to identify a target line in a briefly presented stimulus. However, the results of this study are difficult to interpret because discriminability judgments were made under brief presentation conditions. As a result, it is difficult to determine whether accuracy differences on the same-different task reflect true discriminability differences or processing difficulties associated with contexts of different structure (Earhard, 1990). According to Earhard (1990), "...good three-dimensional contexts may be judged more dissimilar than 'poor' unconnected two-dimensional contexts because they stand out as being more different or because subjects can discern differences in well-structured, three-dimensional context pairs more readily than in poorly structured, two-dimensional pairs during the brief time available. There is no simple way of deciding whether differences obtained reflect difficulties associated with the processing of different structural forms at short durations, as Weisstein et al. (1982) contend, or true dissimilarity differences, as Enns and Prinzmetal propose" (p. 397).

Earhard (1990) attempted to distinguish between the enhanced discriminability (e.g., Weisstein et al., 1982) and interstimulus dissimilarity (e.g., Enns & Prinzmetal, 1984) theories of the object-line and object superiority effects by conducting a series of experiments in which intercontext differences were controlled. In one experiment (Experiment 2), Earhard used the stimuli shown in Panel A of Figure 3 as follows. One group of participants discriminated between solid and dotted line segments presented alone and within the <u>same</u> three-dimensional context. One half of the participants in this group discriminated between contexts 1a and 2a, the other half, 1b and 2b. Another group of participants discriminated between solid and dotted lines presented alone and within the same two-dimensional context. One half of the participants in this group were shown contexts 3a and 4a, the other half, 3b and 4b. Thus, Earhard eliminated interstimulus context differences by using a single connected three-dimensional context and a single disconnected two-dimensional context, rather than a set of contexts exemplifying each structural type, as in previous experiments. If Enns and Prinzmetal's proposal was correct, then context effects should not be evidenced under such conditions. Nevertheless, the connected three-dimensional context produced a robust object-line effect (i.e., higher accuracy on contexts 1 and 2 than on lines 5 and 6) and an object superiority effect (higher accuracy on contexts 1 and 2 than on contexts 3 and 4). In order to address the possibility that the obtained effects were due to <u>intrastimulus</u> dissimilarity differences, Earhard obtained dissimilarity ratings for the stimuli. An analysis of these ratings indicated that the dissimilarity of target lines alone was higher than the dissimilarity of targets in the two- and three-dimensional contexts, but that the two context conditions did not differ from one another. Thus, intrastimulus dissimilarity could not account for the observed context effects. On the other hand, the proposal that structural properties such as dimensionality and connectedness are important determinants of the object-line and object superiority effects seems to provide a satisfactory account of the data.

Task-Based Processing

Earhard (1990) conducted a third experiment which led him to propose a new alternative explanation based on the effect of task demands. Three different tasks were used in the study: (1) a position-location task, (2) a detection task, and (3) a detail discrimination task. All three tasks used a single two-dimensional diamond-shaped context as shown in Panel B of Figure 3. In the position-location task, participants were required to indicate the location of a broken target line presented alone or as one of the four sides of the context. In the detection task, participants were required to detect whether the target line, presented alone or in context, was broken or solid. In the detail discrimination task, participants had to determine whether the target line, again presented alone or in context, had two or three breaks. Results showed that the magnitude of the object-line effect depended on task. The position-location task produced a large object-line effect, indicating that context was highly effective in facilitating performance in this task. The detection task produced a smaller object-line effect, and the detail discrimination task, which demanded the finest resolution of visual detail, produced no object-line effect. These results are not consistent with the view that contexts with certain properties (coherence, connectedness) are invariably processed more rapidly or efficiently than single lines. Nor are they compatible with the hypothesis that lines in good contexts are more perceptible than single lines. These views would predict that a given context should consistently facilitate target-line discrimination. Furthermore, since intercontext differences were controlled in the study, the results were not consistent with Enns and Prinzmetal's hypothesis that object-line effects are due to interstimulus dissimilarity and redundancy. Finally, the results could not be accounted for on the basis of intrastimulus dissimilarity differences. Dissimilarity ratings obtained for the stimuli indicated that the dissimilarity of target lines alone was higher than the dissimilarity of targets in context. The results led Earhard to propose a new theory of the object-line effect. The proposal consists of two propositions. First, a given context will facilitate target-line discrimination only to the extent that that context can provide information of relevance to the task required. Second, "if task requirements are such that contexts can provide information relevant to a particular task, structural factors will permit information to be extracted more readily from some contexts than from others" (p. 398). This theory accounted for the results as follows. Superior performance on the position-location task was due to two sources of information that were present when lines were presented in context: (1) a spatial framework, provided by the object, that could be used as a guide in specifying the location of the target line with respect to the fixation point, and (2) the contrast difference between the dotted target line and the solid adjacent context lines. All this information was absent when lines were presented alone. In the detection task, the effect of context was diminished because the spatial framework was no longer relevant. Information about contrast differences, however, was still relevant and useful, allowing participants to perform the task with a comparatively high degree of accuracy. In the detail discrimination task context provided no task-relevant information and performance suffered accordingly.

Summary

This section has reviewed theory and data pertaining to the object superiority and object-line effects. Three different theories were considered. The first was the view that structural properties such as three-dimensionality, connectedness, and coherence increase the discriminability of contexts and allow them to be processed more rapidly than contexts lacking these properties, or target lines alone. Of these properties, three-dimensionality has received the most attention. In general, research has supported this factor's role in producing object superiority and object-line effects. Moreover, recent research suggests that the mechanism may be one of enhanced perceptibility (e.g., Purcell & Stewart, 1991; Purcell et al., 1993). The second theory was proposed by Enns and Prinzmetal (1984; Enns & Gilani, 1988) who advanced a view that emphasizes (1) interstimulus dissimilarity, the degree to which contexts differ from one another, and (2) redundancy, the degree to which context information correlates with target alternatives. This view was strengthened by Enns and Prinzmetal's (1984; Experiment 3) finding that interstimulus dissimilarity, in the absence of structural properties such as three-dimensionality, connectedness, or coherence, can produce reliable object-line effects. However, a subsequent study (Enns & Gilani, 1988; Experiment 1) showed that when dimensionality and context dissimilarity were orthogonally varied, three-dimensionality accurately predicted context effectiveness (i.e., produced both object superiority and object-line effects), but dissimilarity did not. Moreover, Earhard (1990) demonstrated that when interstimulus differences are controlled, structural properties still play an important role in producing object-line effects. The third view, advanced by Earhard (1990), focuses on (1) the informativeness of stimulus structure with respect to the task at hand, and (2) the components of structure that either impede or facilitate information extraction in a given task. Earhard's Experiment 3 provided preliminary evidence supporting this proposal. The research reported in chapters 3 - 5 extends the notion that informativeness of context affects performance. The theoretical framework that guided this research is developed in the next chapter.

CHAPTER 2

Theoretical Framework

In this chapter, I will first present a general framework that specifies the component operations that are available for performing a target-identification (or search) task. The discussion then focuses on one component, viz., part localization, and examines the role of object coherence in this process.

Suppose one has to identify a particular part of a complex object. To perform this search task, it is reasonable to assume that one will begin by using properties of the object in order to locate the part in question. Once located, the target can be identified. This two-part sequence - locate, identify - represents the general processing that must happen in a search task where a part of a complex object has to be identified. Thus, it is assumed that observers will first perform an initial global analysis of a display and then use that analysis to guide subsequent analyses (cf. Neisser, 1967; Rabbitt, 1984). The latter will be facilitated to the extent that informative location cues are present in the display. To put it differently, if initial global analysis reveals cues to the target's location, then search will be guided. Otherwise, an exhaustive, unguided serial search of the display will be required (e.g., Treisman & Gelade, 1980). Once located, the target can be identified. Identification is itself a complex process (e.g., Marr, 1982; Selfridge & Neisser, 1960; Uttal, 1988), but one that is not of central concern here. This dissertation is concerned with factors that may help locate parts of complex stimuli as a function of coherence. The approach is based on an extension of ideas proposed by Earhard (1990). Before turning to these, however, it is useful to first describe the stimuli and task used in the present experiments. The stimuli are shown in Figures 4 - 6.

The stimuli of Figure 4A were derived from a photomicrograph of a snow crystal (Nakaya, 1954, p. 413, Figure 557). As can be seen, these stimuli are intact, coherent, and object-like. The stimuli of Figure 4B are fragmented, incoherent, and were derived from those of Figure 4A, as described later.

In the task used, a single stimulus is briefly presented and the observer must identify a target part as being either "T1" or "T2" (see Figure 4C). The stimuli are complex and the task cannot be accomplished via a simple detection process such as the pop-out effect described by Treisman and Gelade (1980). This type of search task can therefore be characterized as one that involves attentive processes throughout. The first component of these processes is to locate the whole object, the second to locate the part, and the third to identify the part. It is part localization that is of interest here. More specifically, the location of the whole is automatically given by the abrupt onset of the stimulus (e.g., Jonides & Yantis, 1988; LaBerge, 1995; Yantis, 1993; Yantis & Jonides, 1984). The target part, which is embedded in the whole, must then be located. It is assumed that the whole provides the context for part localization, and that aspects of the context may be informative (provide useful cues) with respect to this component process (Earhard, 1990). The question at issue, therefore, is whether and to what degree global aspects of a particular context are informative with respect to the task of locating the target.

As mentioned above, two main types of contexts are considered here, an intact context (Figure 4A) and a fragmented one (Figure 4B). An intact context is an <u>object-like context that presents a single coherent (unified) structure</u>. Such a structure would be expected to provide many sources of potentially useful global information of relevance to the task of locating the part. In particular, global properties such as size, orientation, shape, symmetry, and compactness might be useful. I will illustrate by referring to Figure 4A. The stimulus is relatively large and has strong horizontal and vertical axes of symmetry. In contrast, the target part, which is located in the top left quadrant of the object, is small and negatively sloped. As a result, the dimensions of size and orientation, may emerge as useful cues in distinguishing between the target and the rest of the stimulus, thereby aiding target localization. Global symmetry could also be useful. For example, in the case of the object shown in Figure 4A, the strategy might be to look in the direction of the greater relative proportion across an axis of symmetry. Emergent configural properties other than symmetry, such as compactness and shape, may also provide useful cues to target location. For example, compactness could be important, if, by placing the target at one location, the surrounding region is more densely packed than other regions of the stimulus. In Figure 4A, the parts are more densely packed in the top left quadrant of the object than in any other quadrant. Finally, the global shape of the stimulus might be used to locate the target part (the configuration may be more detectable than the part, due to its larger size). Cues such as these are available in a coherent structure and may be used to locate the target. The point here is not that any one of the foregoing cues is used, but rather that potentially useful global information is available for use in a coherent context. In contrast, such information is largely absent in a fragmented context. A fragmented context is one that does not present a single coherent (unified) form (cf. Biederman, 1972). Because such a form does not cohere, many higher order properties and relations are absent. As an example of a fragmented context, see Figure 4B. In this stimulus, the parts are more homogenous in size and spacing, compared to

Figure 4A, and there are no strong symmetry axes. Furthermore, the elements do not configure to form salient shapes and patterns. In this type of context, the constituents are more likely to be apprehended as elements of a texture (e.g., Kimchi, 1992; Kimchi & Palmer, 1982), thereby reducing the efficacy of configural properties or dimensions as indicators of part location. Thus, potentially useful information that the observer might otherwise have been able to draw upon to locate the part has been greatly diminished, e.g., cues such as size, compactness, and symmetry are no longer available. In short, the observer would not be able to systematically detect and use meaningful patterns of relationships to decide where to look first and in what sequence to seek further information (cf. Rabbit, 1984). As a result, the observer would likely be forced to conduct an exhaustive serial search of the stimulus to locate the part. Thus, the general prediction is that a coherent object should produce faster and more accurate target-identification performance than an incoherent one, i.e., an object superiority effect. If the results confirmed this prediction they would extend the theory proposed by Earhard (1990) to an identification task involving complex objects consisting of complex parts (as opposed to line segments).

Insert Figure 4 about here

Insert Figure 5 about here

Insert Figure 6 about here

In addition to the intact and fragmented stimulus conditions, a condition in which a part is presented in isolation was also used in the experiments (see Figure 4C). This condition was included in order to determine whether the equivalent of the object-line effect, which will be called the object-part effect, would be obtained with the type of stimuli used here. The prediction is that, in the present situation, an object-part effect would probably not obtain. On the contrary, performance in the isolated part condition should be better than that in the other conditions. The reason is that the location of the isolated part is automatically given by the abrupt onset of the stimulus (e.g., Yantis, 1993). There is therefore no need to locate the part relative to a whole by using contextual cues. It should be noted that faster performance in the isolated part condition than in the other two conditions would be important in confirming the assumption that the processes underlying performance in the other conditions are intrinsically attentive. This result would be consistent with the view that a controlled, effortful search, rather than an automatic one (Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977), is required in both the intact and fragmented conditions.

CHAPTER 3

Experiment 1

The main purpose of Experiment 1 was to test the hypothesis that search will be facilitated to the extent that global properties of a context provide informative cues to the location of the target. Further, as discussed in chapter 2, more informative global cues are assumed to be available when the stimulus is an intact, coherent object than when it is a fragmented, incoherent one. The amount of facilitation will depend on the level of difficulty of the task. Consider first two conditions, both using a coherent object. In one, the target (T1 or T2) always appears at the same fixed location relative to the whole stimulus (see Figure 4A). In this case, the observer is assumed to quickly adopt a strategy whereby the informative cues provided by the context may be used consistently from trial to trial to locate the target. In the other, a higher level of difficulty is achieved by having the target attached to variable relative locations of the coherent stimulus, as shown in Figure 5. In this case the task is more difficult because target location is uncertain, thus, a more effortful search of the stimulus is required. For each coherent object condition there was a parallel incoherent context condition, i.e., one in which the target was at a fixed relative position (see Figure 4B) and one in which it was at a variable (see Figure 6) relative position. Regardless of whether the stimulus is coherent or incoherent, the variable condition will obviously be more difficult than the fixed one. It is also to be expected that performance will be better with the coherent as compared to the incoherent context, since the former is more likely to contain informative cues, for the reasons discussed in chapter 2. More importantly, however, the variable condition should hinder performance more in the incoherent than in the coherent stimulus conditions. The reason is that, in the variable/coherent case, the observer can use structural cues to guide search. As described in chapter 2, global properties such as size, shape, and symmetry may be used as cues to the location of the target. However, in the variable/incoherent case, the observer can only rely on a serial exhaustive search to locate the target. The interesting prediction is therefore that there should be an interaction between structure (coherent vs. incoherent) and relative position (fixed vs. variable). In addition to the variable condition just described, a second one, for both coherent and incoherent stimuli, was included in the experiment. This was used to control for the possibility that a difference between the fixed and variable conditions might be due to the absolute positional variability of the stimulus (i.e., on the screen) rather than to the relative positional variability of the target (i.e., relative to the stimulus itself). The rationale for this control is described in more detail below. A final condition involved the parts in isolation. This condition allowed for a determination of whether an object-part effect, similar to the object-line effect, would be evidenced within the present paradigm. As noted in chapter 2, such an effect is not predicted here.

Method

Design. The design consisted of seven conditions. One was the isolated part condition. The other six corresponded to a 3 (condition: fixed relative position, variable relative position 1, variable relative position 2) x 2 (structure: coherent, incoherent) factorial design. All conditions were between-subjects. The dependent measures were mean target-identification RT for correct responses and percentage error.

Apparatus. The stimuli were displayed on an ADI 3G non-interlaced VGA color monitor controlled by an IBM 486 DX2-66MHz computer with the following components: 8 Megabytes of RAM, ATI Ultra Pro VLB 2 Megabyte graphics card, IDE VLB disk controller, 350 Megabyte hard disk drive, monochrome (control) monitor, 8-button button box, and an SFU timer/button box interface card. All stimulus timing, and data recording functions were controlled by the microcomputer. The experiment was programmed and run using the Visual Stimulation Program (VSP version 3), designed by the technical staff of the Department of Psychology at Simon Fraser University. VSP displays PCX image files on the VGA monitor and simultaneously displays responses on the monochrome monitor. The apparatus also included a chin rest which maintained a viewing distance of 154 cm.

Stimuli. Stimuli for the experiment were derived from a photomicrograph of a snow crystal, as previously mentioned. The original photomicrograph was first doubled in size by photocopy and then traced using fine tracing paper and a Staedtler graphic pigment liner with a .2 mm nib. The tracing was scanned at a resolution of 300 dpi using an HP ScanJet flatbed scanner and saved in a PCX file format. The scanned image was then modified, using MS Paint for Windows 95, to create the stimuli. Each image was saved with a 256 color palette (8 bit color) in a 640 x 480 resolution. All images were black on a white background, as shown in Figures 4 - 6.

Two different complex context patterns, one coherent, the other incoherent, were used (see Figures 4 - 6). The coherent object was a two dimensional picture of the snow crystal. All of the parts were connected and the outer contour was continuous. This object was deconstructed to produce an incoherent, or fragmented context pattern in which the parts were disconnected and jumbled. At a viewing distance of 154 cm, the coherent context subtended a maximum of 3.9 deg in width and 3.2 deg in height. The incoherent context was a maximum of 4.6 deg wide and 3.2 deg high.

Two target parts, as shown in Figure 4C, were used. The one on the left (henceforth target T1) was a maximum of .3 deg wide and .7 deg long. The other (henceforth target T2) was a maximum of .4 deg wide and .7 deg long. In the fixed conditions, the targets were always located in the top left quadrant of the stimulus (see Figure 4). In the variable conditions, the targets appeared at one of four different relative locations (top left, top right, bottom left, bottom right; see A - D in Figures 5 and 6).

Past research has highlighted the need to control (1) interstimulus differences (e.g., Earhard, 1990; Enns & Prinzmetal, 1984), (2) total line length, (3) the local neighborhood of the target (e.g., Weisstein et al., 1982), and (4) dimensionality. The stimuli were constructed with these considerations in mind. In particular, the global form of the coherent object is the same regardless of whether target T1 or T2 is attached to it. Similarly, the form of the incoherent pattern is identical regardless of which part it contains. Therefore, differential configural properties, which could be used by the participant to identify the target (e.g., Enns & Prinzmetal, 1984), are not produced by attaching the targets to the stimuli in the manner described. Total line length was held constant across the coherent and incoherent contexts. In particular, no lines were added or deleted when the intact context was deconstructed to produce the fragmented context. Regarding the third point, an attempt was made to ensure that the local "neighborhood," or micro-environment, surrounding the target would be similar across contexts (e.g., compare A and B in Figure 4). The intention was to reduce the likelihood that irrelevant variation due to these local factors would determine experimental findings. Finally, all stimuli were two-dimensional so as to avoid depth effects.

A fixation point and a pattern mask were also used. The fixation point (a "+" sign) was white on a black background and centered at 320 x 240 pixels in the visual field (the screen resolution was 640 x 480). At a viewing distance of 154 cm, the fixation point subtended a visual angle of .6 deg x .6 deg. The pattern mask was black on a white background and masked the entire screen. It was constructed by "dicing" the coherent pattern into fragments smaller than the target parts (see Figure 7).

Insert Figure 7 about here

<u>Conditions</u>. In the <u>isolated part</u> condition, the target, T1 or T2, could appear randomly at one of four critical target locations as shown in Figure 8. The screen distance between the fixation point and each of the four critical locations was 3.5 cm, measured center-to-center. Thus, at a viewing distance of 154 cm, the target appeared at about 1.3 deg into the periphery.

In the <u>fixed</u> conditions, the target was embedded in a stimulus that was either coherent or incoherent. And the target was always located at the same position relative to the stimulus, namely, in the top left quadrant (see Figure 4A and 4B). The stimuli were presented at four different screen locations, as shown in Figure 9, so that the target always landed on one of the same four critical target locations, as in the isolated part condition. In the fixed conditions, therefore, the screen location of the target varies, as in the isolated part condition, but the relative position of the target is constant.

In all variable conditions, the target was again embedded in a stimulus that was either coherent or incoherent. In these conditions, the relative position of the target varied randomly across four different locations (top left, top right, bottom left, bottom right) as shown in A - D of Figures 5 and 6. In the variable relative position 1 (hence variable 1) conditions, the stimuli were presented at four different screen positions around each critical target location so that the target, in each of the four stimuli shown in Figures 5 and 6, always landed on one of the critical locations. To illustrate, the small plusses (and corresponding circles) in Figure 10 indicate one set of screen locations clustered around the top left critical target location. When the stimuli (A - D in Figures 5 or 6) were centered on the small plusses, as shown, the target always landed on the top left location. There was an analogous set of stimulus locations around each of the other three critical target locations. In the variable 1 condition, therefore, the stimuli were centered at 16 different screen positions and the targets always landed on the four critical locations. In the variable relative position 2 (hence variable 2) conditions, the stimuli (A - D in Figures 5 and 6) were presented at the same four screen locations as in the fixed condition (see Figure 9). Therefore, since the target could appear at four different relative locations, it could appear at 16 different screen locations. The target would land on one of the four critical locations only when stimuli with the target in the top left relative position were presented.

The rationale for including both variable 1 and variable 2 conditions is as follows. In the fixed conditions, the target appeared at only one relative position and the stimuli appeared at four different screen locations. In the variable 1 condition, the target appeared at four relative positions and the stimuli appeared at 16 different screen locations. Thus, the fixed and variable 1 conditions differed not only in the number of relative positions of the target, which is intended to be the main variable, but also in the number of screen positions at which the whole stimulus appeared (the target appeared at the same four screen locations in both the fixed and variable 1 conditions). To control for this confound, a condition is needed in which the relative position of the target varies and the screen positions of the whole stimuli are identical to those in the fixed condition. In the variable 2 conditions, therefore, the target appeared at four relative positions, as in the variable 1 conditions, and the stimuli appeared at four different screen locations, as in the fixed conditions. If there is no performance difference between the variable 1 and variable 2 conditions, but performance is poorer in both of these than in the fixed conditions, this would strengthen the hypothesis that the effect is due to the position of the target relative to the stimulus, rather than to the position of the stimulus on the screen. Moreover, since the variable 1 and variable 2 conditions entailed 4 versus 16 screen positions of the target, respectively, a lack of difference between these conditions would also suggest that the position of the target on the screen was not relevant.

Insert Figure 8 about here

Insert Figure 9 about here

Insert Figure 10 about here

Procedure. The participant's visual acuity was tested using a Snellen-scale eye chart (Snellen, 1862). Only those who passed the acuity test were allowed to participate in the study. The participant then read and signed a voluntary agreement form and the experiment began. The participant was randomly assigned to one of the seven conditions and was provided an instruction sheet appropriate to that condition; the participant was also provided index cards depicting examples of the stimuli that would appear in the condition. The instructions for the fixed and variable conditions were the same. They read as follows: "Visual stimuli will be sequentially presented on a computer screen and your task will be to identify a part of each stimulus as quickly and as accurately as you can. A sample stimulus is shown on one of the index cards in front of you. The two parts that you will identify are also shown on the cards. The procedure for the experiment will be as follows. I will tell you which response button should be pressed for each part and I will place the relevant cards next to the appropriate response buttons. When ready, you will press a key on the button-box to start the experiment. You will then receive one or more sets of 18 practice trials until you reach a criterion performance level of about 70 - 75 percent correct. This will be followed by two sets of 64 experimental trials. On each trial the stimulus will be preceded by a fixation point (a white plus sign). Please look directly at the fixation point and try not to move your eyes. When the stimulus appears, please respond as quickly and as accurately as possible. Since the stimuli are presented very briefly you may find that on some trials you do not have enough time to clearly see the critical part and thus you may be uncertain about what you just saw. When this happens, please respond by taking your best guess. Instructions on the monitor screen will guide you through the experiment. However, if you have any questions during the practice trials please feel free to ask them."

The instructions for the isolated part condition were the same as those for the other conditions except for the first paragraph which read as follows: "Visual stimuli will be sequentially presented on a computer screen and your task will be to identify each stimulus as quickly and as accurately as you can. The stimuli that will be used are shown on the index cards in front of you."

The instructions were then reviewed with the participant and any questions that he or she might have were answered. The sample stimuli were also reviewed with each participant and the main differences between targets T1 and T2 were pointed out. Participants in the fixed and variable conditions were not told where the targets might appear relative to the contexts that they would be viewing. If they asked, they were told that one aim of the study was to examine how people do when they are not provided such information.

The participant sat in front of a monitor screen and a chin rest maintained a viewing distance of 154 cm. Index cards depicting the target parts were placed next to the appropriate response buttons. Stimulus-response mapping was counterbalanced across participants. The participant then pressed a button to begin the condition. The participant received the first set of 18 practice trials, 6 of which were long exposure trials and 12 of which were short exposure trials. On long exposure trials the stimulus was presented for 1 s, the main purpose being to orient participants to the task and to further familiarize them with the stimuli. On short exposure trials, the stimuli were presented for 300 ms. As mentioned above, participants had to reach a criterion performance level of 70 - 75 percent correct (calculated over the 18 trials) before they could begin the experimental trials. Thus, accuracy of performance on the first set of practice trials was recorded and participants were given feedback on their performance after the trials were completed. Participants were given a second set of practice trials if they responded at less than 70% correct. Once participants had completed the practice trials, they received two blocks of 64 experimental trials. On each trial, participants saw a fixation point, a stimulus (either a whole stimulus or an isolated part, depending on condition) and a full-screen random pattern mask. The mask was used to limit stimulus exposure duration to 300 ms and thereby reduce the likelihood that subjects would make eye movements. The fixation point was presented for 2 s. Stimuli were selected without replacement from pre-defined image lists in a random fashion, with the constraint that all 32 possible stimuli (8 stimuli by 4 locations) in the variable conditions were displayed before being displayed again in the remaining 32 trials in a block. Similarly, in the fixed and isolated part conditions, the eight possible stimuli (2 stimuli by 4 locations) were sampled without replacement eight times to make up a block of 64 trials. Overall, the stimuli appeared equally often in each possible location. And targets T1 and T2 were equally represented in the experimental trials. The mask remained on the screen until a button-press response was made. An interval of 1 s separated the participant's response and the appearance of the fixation point for the next trial. After the last trial of the first block, participants received a message on the monitor stating: "End of first block of experimental trials. Please take a short break. When you are ready, press a key to begin the second block of trials". After the last trial of the second block of trials, participants were presented a final message that read "End of condition," and the screen went blank. Participants were then debriefed and any questions that they had were answered. The experiment took about 20-25 minutes for each participant.

Participants. The 70 participants (34 men and 36 women) were psychology undergraduates at Simon Fraser University. Ten students were randomly assigned to each of the seven conditions described above. All participants had normal or corrected-to-normal vision and received course credit for their participation.

Results

Treatment of results. The practice trials were not included in any of the analyses. And only the data from the four critical target locations that were common to all conditions were entered into data analysis. Thus, 128 trials were available for each participant in the fixed, variable 1, and isolated part conditions and 32 trials were available in the variable 2 condition. All of the available trials contributed to the accuracy analyses. However, for RT analysis, the data were trimmed as follows. Since all RT analyses were based on log-transformed latencies (Kirk, 1982; Winer, 1971), the mean log-transformed reaction time for correct responses (i.e., error trials were excluded) was calculated for each participant. Any observations greater than plus or minus three standard deviations from the mean were excluded. Thus, the tails of each RT distribution were trimmed to remove those trials with extremely short or extremely long RTs. As might be expected, the majority of trimmed observations were from the positive tail of each distribution. Less than one percent of the recorded data were trimmed; separate analyses showed that the pattern of results is the same when these trials are included. The results are also the same when untrimmed, untransformed latencies are used. However, the use of log-transformed, trimmed latencies eliminated heterogeneity of variance. The variances of the accuracy measure were stabilized by using an inverse sine transformation (Kirk, 1982; Winer, 1971). All analyses were carried out with BMDP (Dixon, Brown, Engelman, & Jennrich, 1990).

Latency. The means of participants' mean untransformed reaction times for correct responses for the seven conditions are shown in Table 1 and Figure 11. The main analysis was a 3 (condition: fixed, variable 1, variable 2) x 2 (structure: coherent, incoherent) analysis of variance (ANOVA). The main effect of condition was significant, $F=(2,54) = 20.05$, $p < .0001$, and the main effect of structure approached significance, $F(1,54) = 3.98$, $p = .0512$. More importantly, there was a significant condition x structure interaction, $F(2,54) = 4.18$, $MSe = .008$, $p < .05$. A series of planned comparisons were conducted to probe this interaction. One test showed that in the fixed condition, response time did not differ on coherent and incoherent stimuli, $p > .05$; the mean latencies were 634.79 and 559.76 ms for coherent and incoherent structures, respectively. A second test showed that in the variable 1 condition, the target was identified faster in the coherent structure than in the incoherent one, $F(1,54) = 5.85$, $p < .05$; the means were 780.97 and 1014.84 ms for coherent and incoherent patterns, respectively. Similarly, a third comparison showed that in the variable 2 condition, the target was identified faster in the coherent structure than in the incoherent one, $F(1,54) = 5.03$, $p < .05$; the mean latencies were 785.70 and 1003.73 ms for coherent and incoherent contexts, respectively.

An ANOVA was conducted primarily to determine whether the variable 1 condition differed from the variable 2 condition. The analysis was a 2 (condition: variable 1, variable 2) x 2 (structure: coherent, incoherent) ANOVA. The main effect of condition was not significant, and condition did not interact with structure ($p > .05$). As expected, given the foregoing comparisons, the main effect of structure [$F(1,36) = 9.59$, $p < .01$] was significant.

Since the data for the isolated part condition were not included in the above analyses, a planned comparison was conducted to determine whether this condition differed from the fixed condition (the test collapsed over structure conditions). The comparison showed that the target was identified significantly faster in the isolated part condition than in the fixed condition, $t(28) = 4.81$, $p < .0001$; the mean latencies were 439.76 and 597.27 ms for the isolated part and fixed conditions, respectively.

An ANOVA was conducted to probe for learning effects. The analysis was a 3 (condition: fixed, variable 1, variable 2) x 2 (structure: coherent, incoherent) x 2 (blocks: block 1, block 2) analysis of variance. This analysis duplicated the results of the main 3 x 2 ANOVA reported above. That is, the main effect of condition was significant, the main effect of structure approached significance, and there was a significant condition x structure interaction. The main effect of blocks was also significant, $F(1,54) = 94.24$, $p < .0001$. More importantly, there was a significant condition x blocks interaction, $F(2,54) = 12.62$, $MSe = .001$, $p < .0001$. A series of planned comparisons was conducted to probe this interaction. One test showed that in the fixed condition, response time did not differ across blocks, $p > .05$; the mean latencies were 607.96 ms and 586.58 ms for block 1 and block 2, respectively. A second test showed that in the variable 1 condition, the target was identified faster in block

2 than in block 1, F(1,57) = 59.03, p < .0001; the means were 995.20 and 800.61 ms for block 1 and block 2, respectively. Similarly, a third comparison showed that in the variable 2 condition, the target was identified faster in block 2 than in block 1, F(1,57) = 43.05, p < .0001; the means were 977.35 and 812.08 ms for block 1 and block 2, respectively. Neither the blocks x structure interaction nor the three-way interaction were significant. Since the data for the isolated part condition were not included in the present analysis, a planned comparison was conducted to determine whether performance improved over blocks in this condition. The comparison showed that response time did not differ across blocks, p > .05; the mean latencies were 436.26 ms and 443.27 ms for block 1 and block 2, respectively.

Insert Table 1 about here

Insert Table 2 about here

Insert Figure 11 about here

Percent error. Mean percent error scores are shown in Table 2 and Figure 11. The main analysis was a 3 (condition: fixed, variable 1, variable 2) x 2 (structure: coherent, incoherent) ANOVA conducted on arcsine transformed scores. The main effects of condition [F=(2,54) = 42.55, p < .0001] and structure [F=(1,54) = 12.47, p < .001] were significant.

More importantly, there was a significant condition x structure interaction, F(2,54) = 3.98, MSe = .05, p < .05. A series of planned comparisons were conducted to probe this interaction. One test showed that in the fixed condition, accuracy did not differ on coherent and incoherent stimuli, p > .05; the mean error rates were 4.61 and 4.53 percent for coherent and incoherent structures, respectively. A second test showed that in the variable 1 condition, the target was identified more accurately in the coherent structure than in the incoherent one, F(1,54) = 12.25, p < .001; the mean error rates were 16.09 and 29.22 percent for coherent and incoherent patterns, respectively. Similarly, a third comparison showed that in the variable 2 condition, the target was identified more accurately in the coherent structure than in the incoherent one, F(1,54) = 8.12, p < .01; the error rates were 18.6 and 30.0 percent for coherent and incoherent contexts, respectively.

An ANOVA was conducted primarily to determine whether the variable 1 condition differed from the variable 2 condition. The analysis was a 2 (condition: variable 1, variable 2) x 2 (structure: coherent, incoherent) ANOVA. The main effect of condition was not significant, and condition did not interact with structure (p > .05). As expected, given the foregoing comparisons, the main effect of structure [F(1,36) = 16.04, p < .001] was significant.

Since the data for the isolated part condition were not included in the above analyses, planned comparisons were conducted to determine whether this condition differed from the fixed and variable conditions (the tests collapsed over structure conditions). The comparisons showed that the isolated part condition did not differ from the fixed condition (p > .05); the error rates were 3.6 and 4.57 percent for the isolated part and fixed conditions, respectively. However, the target was identified more accurately in the isolated part condition than in both the variable 1 [t(25.3) = 7.30, p < .0001] and variable 2 [t(26.9) = 9.22, p < .0001] conditions; the error rates were 22.66 and 24.3 percent for the variable 1 and variable 2 conditions, respectively.

An ANOVA was conducted to probe for learning effects. The analysis was a 3 (condition: fixed, variable 1, variable 2) x 2 (structure: coherent, incoherent) x 2 (blocks: block 1, block 2) analysis of variance. This analysis duplicated the results of the main 3 x 2 ANOVA reported above. That is, the main effects of condition and structure were significant and the condition x structure interaction was significant. The main effect of blocks was also significant, F(1,54) = 11.06, p < .01; the error rates were 19.21 percent and 15.14 percent for block 1 and block 2, respectively. None of the remaining interaction effects were significant. Since the data for the isolated part condition were not included in the present analysis, a planned comparison was conducted to determine whether performance improved over blocks in this condition. The comparison showed that performance did not differ across blocks, p > .05; the mean error rates were 2.89 percent and 4.32 percent for block 1 and block 2, respectively.

<u>Speed-accuracy analysis</u>. The RT effects in Table 1 are closely paralleled by the accuracy effects in Table 2. The Pearson product-moment correlation between mean RT and percent error was r(69) = +.65, p < .0001. As reaction time increases, the error rate increases. Thus, the effects cannot be accounted for by speed-accuracy tradeoffs.

Discussion

The results were consistent with the hypothesis that global properties of intact coherent objects provide informative cues that can be used to locate the target. A robust (coherent) object superiority effect was present in both latency and percentage error data when the target appeared at variable positions relative to the stimulus, although not when the target was at a fixed relative position. The variable 1 and variable 2 conditions yielded identical patterns of results. Recall that in the variable 1 conditions there were four positions of the target relative to the stimulus, four screen locations of the target, and 16 different screen locations of the whole stimulus. In the variable 2 conditions, there were four positions of the target relative to the stimulus, 16 screen locations of the target (four of which were critical ones), and the whole stimulus appeared at four screen locations. Since performance did not differ in these conditions, it appears that the screen location of either the target or the whole stimulus may be irrelevant. This suggests that the difference between these conditions and the fixed one was due to the difference in relative positional uncertainty of the target rather than to its absolute screen location or to the screen location of the whole stimulus. It thus appears that under variable conditions, a coherent object can provide informative cues that can be used to locate the target. The lack of difference between coherent and incoherent stimuli in the fixed condition was somewhat surprising. It was thought that the coherent stimulus would still provide an advantage, although not as great as in the variable case. The lack of difference suggests that the frame of the stimulus may have been the cue used to locate the target, since such a cue is independent of coherence. The notion is that the context as a whole acts as a <u>spatial framework</u> that can be used to specify the relative position of the target (cf. Earhard, 1990; Baylis & Driver, 1993). In this sense, context qua spatial framework, provides the informative location cue. It appears, therefore, that when relative location is fixed, coherence is not important - any stimulus can act as a spatial cue to the location of the target.

The overall pattern of results is consistent with previous studies of object superiority that have used lines as targets. For example, in Weisstein and Harris's (1974) study, the target appeared at variable positions relative to the whole. And accuracy was higher on two-dimensional coherent stimuli (see Figure 1B, row c) than on two-dimensional incoherent stimuli (row f in Figure 1B). In Lanze, Weisstein, and Harris's (1982) and Womersley's (1977) studies the target appeared at a fixed position relative to the parent context. And accuracy did not differ on two-dimensional coherent and incoherent stimuli. In these studies, the whole stimulus always appeared at a single fixed central screen position rather than at one of four peripheral positions, as in the present experiment. The similarity in results is consistent with the above interpretation that the location of the whole stimulus may be irrelevant in these types of tasks.

The present findings are difficult to explain by appealing to (1) enhanced discriminability, (2) interstimulus dissimilarity and redundancy, or (3) intrastimulus differences. According to the enhanced discriminability view, structural properties such as coherence, connectedness, and three-dimensionality increase the discriminability of contexts and allow them to be processed more rapidly than contexts lacking these properties or target lines presented alone (e.g., Lanze et al., 1985; Lanze et al., 1982; Weisstein et al., 1982; Williams & Weisstein, 1978). The target should always be more discriminable when it appears in a coherent as opposed to an incoherent context, resulting in better performance on the coherent context. However, the lack of difference between the two types of contexts in the fixed condition undermines the enhanced discriminability hypothesis. The results could not be accounted for by interstimulus dissimilarity differences either (e.g., Enns & Prinzmetal, 1984; Enns & Gilani, 1988) since robust object superiority effects were produced in the variable conditions even though interstimulus differences were controlled (i.e., emergent features of the coherent context were not correlated with the target alternatives). Intrastimulus differences cannot account for the results either. Such an explanation would hold that the observed object superiority effects are due to the coherent contexts being more dissimilar than the incoherent contexts. To elaborate, there are four pairs of coherent contexts and the same number of incoherent contexts in the variable conditions. In each pair, one context contains target T1, the other target T2. An intrastimulus argument would hold that each pair of coherent contexts is more dissimilar than the corresponding pair of incoherent contexts. While such an explanation might account for the object superiority effects in the variable conditions it could not account for the overall pattern of findings. In particular, it could not account for the absence of an object superiority effect in the fixed condition. Earhard's (1990) task-based account comes closer to explaining the present results. Earhard proposed that context will facilitate target discrimination to the extent that it provides information of relevance to the task required. In particular, if one context provides task-relevant information and such information is not provided by another context, then object superiority is expected. The results for the variable condition are consistent with this notion. That is, informative task-relevant cues - global, local, or both - are present in the coherent context and absent in the incoherent one. If, by contrast, both contexts provide task-relevant information of a similar nature, object superiority is not expected. The fixed condition results are consistent with this prediction, assuming of course that the same informative cue, the stimulus qua reference frame, is used to locate the target when it is located at a fixed relative position in both coherent and incoherent contexts. Although the information that is useful in the fixed case appears to be different from that in the variable case, and from that delineated in chapter 2, this does not undermine the notion that informativeness is important. The present results suggest that different types of information become useful over subtle changes in task requirements. Since it is difficult to know, a priori, what type of information is useful for a particular task or level of task difficulty, such a finding poses a major challenge for future researchers. Moreover, it challenges the earlier notion that the object superiority effect is a reliable and predictable phenomenon (e.g., Lanze at al., 1982; Weisstein et al., 1982).

There was no evidence for an object-part effect, similar to the object-line effect, in the present study. Instead the experiment produced context-inferiority effects (i.e., superior target-identification performance in the isolated part condition than in the conditions involving context). Reaction time was faster in the isolated part condition than in the fixed and variable conditions. And accuracy was higher in the isolated part condition than in the variable conditions (cf. Weisstein & Harris, 1974) but it did not differ across the isolated part and fixed conditions. Context-inferiority effects are typically accounted for in terms of lateral masking by adjacent contours or the camouflaging effects of higher order stimulus structure on stimulus elements (e.g., Banks & Prinzmetal, 1976; Enns & Prinzmetal, 1984). The lateral masking issue is explored further in Experiment 3.

The present experiment also produced learning effects in both latency and percentage error data. However, the effects were different for the two response measures. For the RT measure, the learning effect depended on condition but not structure. That is, the target was identified faster in block 2 than in block 1 but only in the variable 1 and variable 2 conditions. There was no learning effect in the fixed condition. For the error measure, the learning effect did not depend on condition or structure. That is, the target was identified more accurately in block 2 than in block 1 irrespective of condition or structure. The reason for the dissociation between the two response measures is unknown. In any event, this finding does not permit a conclusive statement to be made regarding the underlying cause of the learning effects.

It is important to mention that in the isolated part condition there was no evidence of learning in either latency or percentage error. In particular, performance did not differ across blocks according to either measure. This finding is consistent with the present proposal that performance is automatic in the isolated part condition. Note, however, that it should not necessarily be assumed that performance is reflexive (completely independent of practice) in this condition. Since only a small number of trials (64 per block) were used, it is possible that evidence for learning might be obtained if a larger number of trials were used. This issue and the above-mentioned dissociation effect should be explored in a future study that is expressly designed to investigate learning effects.

The issue of whether the object superiority effects obtained in the variable conditions in Experiment 1 are due to global or local factors is addressed in Experiment 2.

CHAPTER 4

Experiment 2

The results of Experiment 1 appear to be consistent with the proposal that properties of a coherent object provide informative cues that may be used to locate the target under variable conditions. However, it is still not entirely clear whether global properties or relatively more local ones were responsible for the object superiority effects. Since a coherent object consists of both global and local properties, it is possible that relatively local properties determined the effects. For example, an identifiable configuration embedded within the stimulus, rather than properties of the whole stimulus, might have been used to locate the part. That is, there might be an easily detectable configuration that contains the target but is smaller than the whole stimulus. If the local configuration is more detectable than the part, it could be the main cue used to locate the target. Thus, while an attempt was made to control the local environment of the target in Experiment 1, one cannot rule out the possibility that, in the coherent stimulus, informative local cues in the immediate environment of the target may have been used. In Experiment 2, therefore, a new context was introduced, in which the local environment of the target was held constant (see Figure 12). Performance on this context, which henceforth will be called the hybrid context, was compared to that on coherent and incoherent contexts to determine whether properties of the local environment could account for the object superiority effects obtained in Experiment 1. In the hybrid context, all parts of the coherent object were fragmented except for the local region surrounding the target (cf. Figures 5 & 12). As can be seen in Figure 12, the hybrid does not configure to produce a coherent object. It lacks continuity (of contour), closure, and coherence, and therefore does not qualify as an object according to the definition used in this dissertation. The hybrid context also lacks strong axes of symmetry and does not have a well-defined global shape. In sum, the hybrid lacks global configural properties that are present in the coherent object. Nevertheless, the local environment of the target is identical in both contexts as can be seen by comparing corresponding illustrations (A - D) in Figures 5 and 12 (e.g., compare Figure 5A with Figure 12A). Further comparison of Figures 6 and 12 also reveals that the hybrid context is intermediate in structure between the coherent and incoherent contexts.

Insert Figure 12 about here

The purpose of Experiment 2, then, was to compare performance on coherent, hybrid, and incoherent contexts. The theoretical framework outlined in chapter 2 makes the following prediction for the variable condition: As structural coherence increases, search time should decrease and accuracy increase. To elaborate, in the coherent case, the search process would be to locate the whole and then locate and identify the part. In the hybrid case, an extra step is posited in that the observer will first have to locate the whole, then locate the relevant local environment, and finally, locate and identify the target. Search may be somewhat guided in this case, however, since properties of the local environment may aid in locating the target. In particular, each local environment of the target in the hybrid context is coherent in form (see A - D in Figure 12) and some of the cues outlined in chapter 2 that pertain to such forms, such as relative size, orientation, and overall shape (i.e., of the local environment), may still be useful indicators of target location. It is also possible that an emergent property such as the type of angle (e.g., acute vs. obtuse) that is formed by the interaction between the target and the part to which it is attached may be useful (cf. Lanze et al., 1985; Pomerantz, Sager, & Stoever, 1977). All of these potential cues are absent in the incoherent context. In this case, therefore, a completely serial, unguided search may be required to locate the target. As a result, a comparatively large number of stimulus elements may have to be inspected prior to locating the target. In sum, performance should be ordered such that it is best on the coherent context, at an intermediate level on the hybrid, and poorest on the incoherent context. It is important to emphasize that this prediction only applies to the variable condition. In the fixed condition, performance should not differ on the three types of contexts (coherent, hybrid, and incoherent) if, as suggested by the results of Experiment 1, the frame of the stimulus, rather than specific global or local stimulus attributes, are used. This pattern of results would (1) replicate the results obtained in Experiment 1, (2) suggest that relatively global factors played a significant role in the object superiority effects obtained in that experiment, and (3) provide further support for the guided search proposal.

Experiment 2 utilized the same conditions and stimuli as Experiment 1, with two exceptions: (1) the variable 2 condition was not carried over to Experiment 2, and (2) the hybrid context was added.

Method

Design. The design consisted of seven conditions. One was the isolated part condition. The other six corresponded to a 2 (condition: fixed relative position, variable relative position) x 3 (structure: coherent, hybrid, incoherent) factorial design. All conditions were between-subjects. The dependent measures were mean target-identification RT for correct responses and percentage error, as in Experiment 1.

Stimuli. The coherent and incoherent stimuli of Experiment 1 were used in the study. A set of hybrid stimuli, each of which preserved the local environment of the target, were also used (see Figure 12). The hybrid contexts were constructed by retaining the entire area surrounding each of the four possible target areas in the intact stimulus and fragmenting the rest of the stimulus (cf. Figures 5 & 12). In this way, approximately 1/4 of the intact stimulus was retained in each hybrid context. Each hybrid was black on a white background. At a viewing distance of 154 cm, each was a maximum of 4.6 deg wide and 3.2 deg high. As in Experiment 1, the targets (T1 or T2) were located in different positions relative to the whole stimulus, depending on condition. In the fixed condition, the targets were always located in the top left quadrant of the stimulus. In the variable condition, the targets appeared at one of four different relative locations (top left, top right, bottom left, and bottom right; see Figure 12). A fixation point and a pattern mask, identical to those used in Experiment 1, were also used in Experiment 2.

Conditions. The isolated part, fixed relative position, and variable relative position conditions were identical to those used in Experiment 1. The variable relative position condition corresponded to the variable relative position 1 condition of Experiment 1.

Procedure. The procedure was identical to that used in Experiment 1.

Participants. The 70 participants (24 men and 46 women) were psychology undergraduates at S.F.U. Ten students were randomly assigned to each of the seven conditions described above. All participants had normal or corrected-to-normal vision and received course credit for their participation.

Results

Treatment of results. The results were treated as in Experiment 1. However, since the variable 2 condition was not used, 128 trials were available from each participant for each condition. All these contributed to the accuracy analyses. Data trimmed for RT analyses resulted in the exclusion of 1.2 percent of the recorded data; separate analyses showed that the pattern of results is the same when these trials are included. The results are also the same when untrimmed, untransformed latencies are used. However, the use of log-transformed, trimmed latencies eliminated heterogeneity of variance. The variances of the accuracy measure were stabilized by using an inverse sine transformation.

Latency. The means of participants' mean untransformed reaction times for correct responses for the seven conditions are shown in Table 3 and Figure 13. The main analysis was a 2 (condition: fixed, variable) x 3 (structure: coherent, hybrid, incoherent) analysis of variance. The main effects of condition [F=(1,54) = 85.18, p < .0001] and structure [F(2,54) = 5.12, p < .01] were significant. There was also a significant condition x structure interaction, F(2,54) = 8.02, MSe = .005, p < .001. The simple main effect of structure for the fixed condition was not significant (p > .05); the mean latencies were 623.19, 587.61, and 601.81 ms for coherent, hybrid, and incoherent structures, respectively. The simple main effect of structure for the variable condition was significant, F(2,54) = 12.75, p < .0001; the means were 742.72, 942.81, and 1121.20 ms for coherent, hybrid, and incoherent patterns, respectively. Planned comparison tests were conducted to probe this effect. One test showed that the target was identified faster in the coherent structure than in the hybrid, $F(1,54) = 8.29$, $p < .01$. A second comparison showed that the target was identified faster in the hybrid structure than in the incoherent structure, $F(1,54) = 4.64$, $p < .05$.

Since the data for the isolated part condition were not included in the above analyses, a planned comparison was conducted to determine whether this condition differed from the fixed condition (the test collapsed over structure conditions). The comparison showed that the target was identified significantly faster in the isolated part condition than in the fixed condition, $t(38) = 6.39$, $p < .0001$; the mean latencies were 460.82 and 604.21 ms for the isolated part and fixed conditions, respectively.

An ANOVA was conducted to probe for learning effects. The analysis was a 2 (condition: fixed, variable) x 3 (structure: coherent, hybrid, incoherent) x 2 (blocks: block 1, block 2) analysis of variance. This analysis duplicated the results of the main 3 x 2 ANOVA reported above. That is, the main effect of condition and structure were significant and the condition x structure interaction was significant. The main effect of blocks was also significant, $F(1,54) = 37.83$, $p < .0001$. More importantly, there was a significant condition x blocks interaction, $F(2,54) = 18.72$, $MSe = .001$, $p < .0001$. Planned comparisons were conducted to probe this interaction. One test showed that in the fixed condition, response time did not differ across blocks, $p > .05$; the mean latencies were 610.60 ms and 597.81 ms for block 1 and block 2, respectively. A second test showed that in the variable condition, the target was identified faster in block 2 than in block 1, $F(1,57) = 50.21$, $p < .0001$; the means were 1003.22 and 867.93 ms for block 1 and block 2, respectively. Neither the blocks x structure interaction nor the three-way interaction were significant. Since the data for the isolated part condition were not included in the present analysis, a planned comparison was conducted to determine whether performance improved over blocks in this condition. The comparison showed that response time did not differ across blocks, p > .05; the mean latencies were 457.28 ms and 464.37 ms for block 1 and block 2, respectively.

Insert Table 3 about here

Insert Table 4 about here

Insert Figure 13 about here

Percent error. Mean percent error scores are shown in Table 4 and Figure 13. The main analysis was a 2 (condition: fixed, variable) x 3 (structure: coherent, hybrid, incoherent) analysis of variance conducted on arcsine transformed scores. The main effects of condition [F=(1,54) = 145.93, p < .0001] and structure [F(2,54) = 10.29, p < .001] were significant. There was also a significant condition x structure interaction, F(2,54) = 13.25, MSe = .02, p < .0001. The simple main effect of structure for the fixed condition was not significant (p > .05); the mean error rates were 3.28, 6.32, and 2.23 percent for coherent, hybrid, and incoherent structures, respectively. The simple main effect of structure for the variable condition was significant, F(2,54) = 20.15, p < .0001; the error rates were 9.45, 20.34, and

25.78 percent for coherent, hybrid, and incoherent patterns, respectively. Planned comparison tests were conducted to probe this effect. One test showed that the target was identified more accurately in the coherent structure than in the hybrid, $F(1,54) = 17.05$, $p < .001$. A second comparison showed that the target was identified more accurately in the hybrid structure than in the incoherent structure, $F(1,54) = 4.45$, $p < .05$.

Since the data for the isolated part condition were not included in the above analyses, planned comparisons were conducted to determine whether this condition differed from the fixed and variable conditions (the tests collapsed over structure). The comparisons showed that the isolated part condition did not differ from the fixed condition ($p > .05$); the error rates were 2.5 and 3.94 percent for the isolated part and fixed conditions, respectively. However, the target was identified more accurately in the isolated part condition than in the variable condition, $t(30.4) = 9.43$, $p < .0001$; the error rate for the variable condition was 18.52 percent.

An ANOVA was conducted to probe for learning effects. The analysis was a 2 (condition: fixed, variable 1, variable 2) x 2 (structure: coherent, incoherent) x 3 (blocks: block 1, block 2) analysis of variance. This analysis duplicated the results of the main 3 x 2 ANOVA reported above. That is, the main effects of condition and structure were significant and the condition x structure interaction was significant. The main effect of blocks was also significant, $F(1,54) = 17.07$, $p < .01$; the error rates were 12.74 percent and 9.73 percent for block 1 and block 2, respectively. None of the remaining interaction effects were significant. Since the data for the isolated part condition were not included in the present analysis, a planned comparison was conducted to determine whether performance improved over blocks in this condition. The comparison showed that performance did not differ across blocks, p > .05; the mean error rates were 2.34 percent and 2.66 percent for block 1 and block 2, respectively.

Speed-accuracy analysis. The RT effects in Table 3 are closely paralleled by the accuracy effects in Table 4. The Pearson product-moment correlation between mean RT and percent error was r(69) = +.77, p < .0001. As reaction time increases, the error rate increases. Thus, the effects cannot be accounted for by speed-accuracy tradeoffs.

Discussion

This experiment replicated the results of Experiment 1. In particular, there were no performance differences in the fixed condition, however, in the variable condition, the target was identified faster and more accurately in the coherent than in the incoherent context. Moreover, the ordering of the RT and error data for the latter condition was consistent with the prediction that as structural coherence increases, search time should decrease and accuracy, increase. That is, the target was identified better in the coherent context than in the hybrid and better in the hybrid than in the incoherent context. Since the local environment of the target was identical in coherent and hybrid contexts, the superiority of the coherent context over the hybrid could not be due to local factors. Instead, it appears that global properties of the coherent context facilitated response. However, since the local environment of the target was the main structural difference between the hybrid and incoherent contexts, the superiority of the hybrid over the incoherent context appears to be due to properties of the local environment. The data are consistent, therefore, with the guided search proposal. The crux of this proposal is that when informative global properties are available, search will be facilitated. And when informative local cues are the only ones available, search will still be facilitated, but to a lesser degree. Thus, the properties of an intact, coherent context or of a coherent local unit embedded in a cluttered context (the hybrid) are both capable of facilitating response, although in a graded fashion since the former provides more immediately useful cues to location than the latter. That is, in the hybrid case, the relevant local environment must be located before the informative cues of that environment may be used. It should be noted that although the present results imply that the coherent/incoherent object superiority effects obtained both here and in Experiment 1 are strongly influenced by global cues, local cues cannot be ruled out. Nevertheless, it is not necessarily true that, since local cues were used in the hybrid case, they are also used in the coherent case. While the local environment of the target is identical in both the hybrid and coherent contexts, this environment stands in a very different relation to the remainder of the context in each case. It is an integrated aspect of the coherent context but only another nonintegrated component, albeit larger than the other components, in the hybrid. Suppose that relative size, orientation, or both are used in the coherent context and also when the relevant local environment is located in the hybrid. In addition to being more immediately available for use in the coherent context, such relational contrasts (size, orientation) would also be greatly amplified in that context, implying that the question of whether local properties are used in addition to global ones may be moot, assuming of course that the present example is correct.

As in Experiment 1, the present experiment produced context-inferiority effects. Reaction time was faster in the isolated part condition than in the fixed and variable conditions. And accuracy was higher in the isolated part condition than in the variable conditions but it did not differ across the isolated part and fixed conditions. These results, particularly those for the RT measure, appear to be consistent with the hypothesis that, when a context is present, the observer must conduct an effortful search, using any informative cues that may be present, to locate the target. However, the differences in RT between the isolated part condition and the other conditions could be due, at least in part, to lateral masking by adjacent contours (e.g., Lanze et al., 1982). Experiment 3 was designed to investigate the possibility that lateral masking may have played a role in Experiments 1 and 2. The experiment focused exclusively on the fixed and isolated part conditions.

Before turning to Experiment 3, however, it is important to mention that the present experiment replicated the learning effects obtained in Experiment 1. That is, evidence of learning was obtained in both latency and percentage error data. And once again the pattern of findings was different for the two response measures. For the RT measure, the learning effect depended on condition but not structure. In particular, the target was identified faster in block 2 than in block 1 in the variable condition but not in the fixed condition. For the error measure, however, the learning effect did not depend on condition or structure. That is, the target was identified more accurately in block 2 than in block 1 irrespective of condition or structure. As mentioned previously, the reason for the dissociation between the two response measures is unknown. And no conclusive statement can be made regarding the underlying cause of the learning effects.

As in Experiment 1, there was no evidence of learning in either latency or percentage error in the isolated part condition. In particular, performance did not differ across blocks according to either measure. As mentioned previously, this finding is consistent with the present proposal that performance is automatic in the isolated part condition.

CHAPTER 5

Experiment 3

In the fixed conditions of Experiments 1 and 2, performance was independent of coherence and RT was significantly slower than in the isolated part condition. It was suggested that the frame of the stimulus was used as a cue that guides target localization. The notion that the frame of the stimulus is used, implies that some additional processing is required when any context is present that is not required when context is absent. Such processing might account for the RT difference between the fixed and isolated part conditions. In other words, when the target is embedded in a context, as in the fixed condition, it must be effortfully located, presumably by using the stimulus as a spatial framework. When the target is presented in isolation, as in the isolated part condition, target [illegible]cation is automatically given by the abrupt onset of the stimulus, eliminating the need for effortful localization.

It is also possible, however, that lateral masking might account, at least in part, for the RT differences under consideration. For example, Lanze et al. (1982) used stimuli that were more complex than those used in previous object-line effect studies and obtained context-inferiority effects. Although they attributed the observed effects to lateral masking, this proposal was never actually tested. Lateral masking refers to the reduced detectability of a stimulus when its contours are in close spatial proximity to other contours (e.g., Bouma, 1970; Wolford & Chambers, 1983, 1984; Uttal, 1988). It is important, therefore, to establish whether lateral masking might have contributed to the RT differences between the fixed and isolated conditions in Experiments 1 and 2. In these experiments, the target was presented

1.3 deg into the periphery and its contours were located between .2 deg and .4 deg from adjacent contours. Eriksen and Hoffman (1972) presented targets 2 deg into the periphery and found considerable masking with a target-mask separation of .5 deg but little or none with a separation of 1.4 deg. Bouma (1970) orthogonally varied the retinal eccentricity of the target and the target-mask separation. He estimated that the range over which target and lateral mask interact was about one half of the target eccentricity. In Experiments 1 and 2, this would constitute a range of between 0 - .65 deg of visual angle. Thus, since the above mentioned target-contour separation falls well within this range, it appears that there is sufficient justification for an investigation of the possible effects of lateral masking.

The lateral masking hypothesis was tested by using a fixed condition, a masking control condition, and an isolated part condition. The fixed and isolated part conditions were the same as in the previous studies. That is, the target was presented in context in the fixed condition and alone in the isolated part condition. Only coherent stimuli were used since the previous studies showed that performance is independent of coherence in the fixed condition. The masking control was a new condition in which the target appeared along with adjacent contours that were extracted from the coherent context used in the fixed condition (the rest of the context was absent; cf. Figures 4A & 14). Thus, contours adjacent to the target were identical in the fixed and masking control conditions. It was predicted that if there is lateral masking, the target should be identified faster in the isolated part condition than in the masking control condition and the latter might not differ from the fixed condition. If there is no lateral masking, the target should be identified equally fast in the masking control and isolated part conditions, and faster than in the fixed condition. Given the results of Experiments 1 and 2, no accuracy differences were expected.

Insert Figure 14 about here

Method

Design. The experiment used a single-factor within-subjects design involving the three previously described conditions. The dependent measures were mean target-identification RT for correct responses and percentage error, as in Experiments 1 and 2.

Stimuli. The two coherent stimuli shown in Figure 4A were used in the fixed condition. The two stimuli for the masking control condition are shown in Figure 14. They were constructed by extracting the targets and their neighboring contours from the coherent stimuli. Thus, contours adjacent to the target are identical in the fixed and masking control conditions, but, in the latter, the remainder of the coherent stimulus was eliminated. At a viewing distance of 154 cm, the masking control stimuli were a maximum of 1.4 deg wide and 1.3 deg high. Targets T1 and T2 were presented alone in the isolated part condition. The targets always appeared at one of the four critical onset locations on each trial, as in the previous studies (see Figure 8). A fixation point and a pattern mask, identical to those used in Experiments 1 and 2, were also used in the present experiment.

Procedure. The procedure was similar to that used in Experiment 1, with two exceptions: (1) each volunteer participated in three conditions rather than only one; and (2) each condition consisted of 64 rather than 128 experimental trials.

The participant was randomly assigned to a block of three conditions. The order of conditions in each block was randomly determined. He or she was provided an instruction sheet and index cards depicting the stimuli that would appear in the first condition of the block. The instructions were as follows: "Visual stimuli will be sequentially presented on a computer screen and your task will be to identify each item as quickly and as accurately as you can. You will participate in three different conditions. The procedure for each condition will be as follows. You will be shown the stimuli that will appear in the upcoming condition and told which response button should be pressed for each. Index cards depicting the stimuli will then be placed next to the appropriate response buttons. When ready, you will press a key on the button-box to start the condition. You will then receive one or more sets of 18 practice trials until you reach a criterion performance level of about 70 - 75 percent correct. This will be followed by a set of 64 experimental trials. On each trial the stimulus will be preceded by a fixation point (a white plus sign). Please look directly at the fixation point and try not to move your eyes. When the stimulus appears, please respond as quickly and as accurately as possible. Since the stimuli are presented very briefly, you may find that on some trials you do not have enough time to clearly see the critical item and thus you may be uncertain about what you just saw. When this happens, please respond by taking your best guess. Instructions on the monitor screen will guide you through the sequence of practice and experimental trials in each condition. However, if you have any questions during any of the practice sessions please feel free to ask them."

The instructions were then reviewed with the participant and any questions that he or she might have were answered. The stimuli for the first condition, and the differences between them, were also reviewed. At the start of each subsequent condition, participants were provided with the two stimuli appropriate to the condition and the differences between them were again pointed out. Before the participant started a particular condition, the index cards depicting the stimuli for that condition were placed next to the appropriate response buttons. The assignment of stimuli to responses was counterbalanced for each condition across participants and was also counterbalanced within each participant to ensure that, over the entire experiment, the two targets were assigned equally often to each of the two response buttons (cf. Pomerantz, 1983).

In each condition, participants received both long and short exposure practice trials, as in Experiments 1 and 2. Participants had to again reach the criterion performance level of 70 - 75 percent correct before proceeding to the experimental trials. The timing and sequencing of events on each trial was the same as in Experiments 1 and 2. All other aspects of the procedure were identical to those in Experiments 1 and 2. The experiment took about 30-35 minutes for each participant.

Participants. The 16 participants (8 men and 8 women) were psychology undergraduates at S.F.U. All participants had normal or corrected-to-normal vision and received course credit for their participation.

Results

Treatment of results. The results were treated as in the previous experiments. One-hundred and ninety-two trials, 64 for each of the three conditions, were available from each participant. All these contributed to the accuracy analyses. Data were trimmed for RT analyses as in Experiment 1, resulting in the exclusion of 1.0 percent of the recorded data;

separate analyses showed that the pattern of results is the same when these trials are included. Since trimming eliminated heterogeneity of variance, the latency scores were not log-transformed. The variances of the accuracy measure were stabilized by using an inverse sine transformation.

Latency. The means of the mean untransformed reaction times for correct responses were 628.32 (SD = 79.22 ms), 531.77 (SD = 72.36 ms), and 517.11 ms (SD = 67.83 ms) for the fixed, masking control, and isolated part conditions, respectively (see Figure 15). A single-factor repeated measures ANOVA was conducted on the mean latencies. The main effect of condition was significant, F(2,30) = 41.75, MSe = 1399.38, p < .0001. Planned comparisons showed that the target was identified faster in the masking control condition than in the fixed condition, F(1,15) = 46.22, p < .0001 and that reaction time did not differ in the masking control and isolated part conditions (p > .05).

Insert Figure 15 about here

Percent error. The mean percent error scores were 4.88 (SD = 6.48 percent), 3.32 (SD = 2.90 percent), and 2.54 percent (SD = 2.05 percent) for the fixed, masking control, and isolated part conditions, respectively (see Figure 15). A single-factor repeated measures ANOVA was conducted on the arcsine transformed error scores. The main effect of condition was not significant (p > .05).

Speed-accuracy analysis. Reaction time and errors were compared and there was no indication of a speed-accuracy tradeoff, r(47) = +.12, p > .05.

Discussion

The results showed that the target was identified faster in the isolated part condition than in the fixed condition, replicating the results of Experiments 1 and 2. More importantly, RT was essentially the same in the isolated part and masking control conditions. Finally, there were no accuracy differences among the three conditions. These results eliminate lateral masking by adjacent contours as a possible cause of the difference between the fixed and isolated part conditions in this and the previous studies. Since lateral masking is eliminated, one must consider what may be causing the difference between these conditions. One possible explanation is that when the target is presented in isolation, it can be automatically located by its abrupt onset. However, when embedded at a fixed location in any context, the target must be located by specifying its position relative to the whole context and then shifting attention to the appropriate location.

It may be interesting to note that, in the masking condition, there was also a context relative to the isolated part condition, albeit a minimal one. In the masking condition, RT was slightly slower (531.77 ms) than in the isolated part condition (517.11 ms), although this difference did not approach significance. It would be interesting, therefore, in a future experiment to compare the masking and isolated part conditions using a more powerful design with a larger number of participants. In any case, masking by contours does not appear to have played a significant role in Experiments 1 and 2.

CHAPTER 6

General Discussion

This dissertation was concerned with the object superiority effect, namely, the well-known finding that briefly presented target lines that differ in location or orientation are identified more accurately when embedded in some contexts that in others. The stimuli used in the present research were more complex, however, than those used previously. The main thrust of the present work was an extension of Earhard's (1990) notion that informativeness of context affects performance. Experiment 1 tested the hypothesis that search will be facilitated to the extent that global properties of a context provide informative cues to the location of the target. Performance was compared on a coherent context, which is presumed to contain informative location cues, and on an incoherent context, which is presumed not to contain such cues. Both types of contexts were presented at two levels of task difficulty. At one level, the target always appeared at the same fixed location relative to the context as a whole. At a higher level, the target was attached to variable relative locations of the context. The target was also presented in isolation. A robust object superiority effect, that is, better performance on the coherent than on the incoherent context, was obtained in both latency and percentage error when the target appeared at variable positions relative to the whole stimulus, although not when it was at a fixed relative position. It thus appeared that under variable conditions, the global properties of a coherent object provide informative cues that can be used to locate the target. However, it was still not entirely clear whether global properties or relatively more local ones were responsible for the object superiority effects. Experiment 2 investigated the possibility that the object superiority effects may have been due to more local factors than originally imagined by comparing performance on a hybrid context with that on the coherent and incoherent contexts. The hybrid lacked global properties that were present in the coherent context but preserved the local environment of the target. In addition to replicating the results of Experiment 1, Experiment 2 showed, again only in the variable condition, that the target was identified better in the coherent context than in the hybrid and better in the hybrid than in the incoherent context. The difference between the coherent and hybrid contexts suggests that global factors play a significant role in the object superiority effects obtained in both experiments. However, the difference between the hybrid and incoherent contexts also suggests that more local factors cannot be ruled out.

Object superiority was not observed in the fixed conditions, in either Experiment 1 or 2. The lack of difference between the coherent and incoherent stimuli in the fixed condition in Experiment 1 was unexpected. It was predicted that a coherent structure would still be beneficial compared to an incoherent one, although perhaps to a lesser degree than in the variable conditions. The implication of the fixed condition results is that a property of the stimulus that is independent of its internal structure may have been used. A plausible assumption is that the frame of the stimulus acts as the informative cue, regardless of coherence. To elaborate, in the fixed condition, the target is located at a fixed position relative to the whole stimulus. Because there is a consistent whole-to-part mapping, the whole may be used as a spatial cue to locate the target, and <u>any</u> context may be used in this fashion. Search will therefore be guided by the spatial framework provided by context regardless of coherence of context. The position taken here is similar to that taken by Baylis and Driver (1993), who propose that the relative positions of parts of an object are explicitly coded in the routine derivation of an object-based description. Baylis and Driver tested this proposal by requiring participants to judge which of two contours, presented on a computer monitor, was lower on the screen. The contours could be parts of a single object or parts of two different objects. The results of five experiments showed that judging the relative location of the contours was more difficult when they belonged to two objects rather than one. These results were consistent with object-based views of attention and with a hierarchical scheme for position coding, whereby object parts are located relative to the whole stimulus (cf. Watt, 1988). This scheme implies that the object-based description inherently contains the information regarding the relative position of the target. The present approach is also similar to the notion that a perceptual reference frame, analogous to a coordinate system in analytic geometry, is assigned to the object and the target's position is coded relative to the axes of the frame (e.g., Palmer, 1989; Rock, 1973; Wiser, 1981). Regardless of the actual mechanism, however, the main idea is that, under fixed conditions, the spatial context, as opposed to configurational or other cues, provides precise information as to the location of the target, and this information is provided equally by coherent and incoherent contexts. In this sense, one might say that the whole is analogous to a sign that points to a particular location or a word that points to its meaning. The precise graphemic or surface structure details are irrelevant (e.g., a word can be written in upper- or lower-case and can be in one of numerous different fonts and the meaning is unaffected). Nevertheless, some global aspect of the context is necessary (just as a word is necessary) for pointing out the location of the search target. This aspect has been called the frame, but it could also be referred to as the outline, envelope, luminance discontinuity, or primal sketch. Further research is necessary in order to determine which designation is most appropriate. Moreover, while the emphasis has primarily been on the role of context in specifying the location of the target, the foregoing makes it clear that processing in the fixed condition involves both the use of the context in specifying location <u>and</u> subsequent search, which entails attentional operations throughout. Such operations may involve enhancement of information flow in the target area (e.g., zooming), inhibition of the surrounding context (e.g., filtering), or both (LaBerge, 1995). Subsequent research is needed to determine whether one or more of these mechanisms may be appropriate. Also, further study is needed to provide a reliable estimate of the number of attentional "snapshots" that might be involved in the fixed condition.

Neither Experiment 1 nor Experiment 2 showed any evidence for an object-part effect, similar to the object-line effect. Instead, the experiments produced context-inferiority effects in both latency and percentage error. That is, performance was generally better when the target was presented in isolation than when in context. A possible reason for these results was lateral masking. Therefore, Experiment 3 investigated the possibility that lateral masking may have caused the context-inferiority effects observed in Experiments 1 and 2. The experiment tested the masking hypothesis by using a fixed condition, a masking control in which contours adjacent to the target were identical to those in the fixed condition, and an isolated part condition. Results showed that the target was identified equally fast in the masking control and isolated part conditions and faster than in the fixed condition. These results suggested that lateral masking, by adjacency of local contours, is not the likely cause of the RT difference between the fixed and isolated part conditions. The results are consistent, however, with the proposal that effortful attention is needed to locate the target in the former but not the latter condition. As previously discussed, effortful target localization may be achieved in the fixed condition by using the stimulus as a spatial reference frame. By contrast, the target is automatically located by its abrupt onset in the isolated part condition. These considerations may also account for the inferiority effects found in some previous studies (e.g., Lanze et al., 1982;1985).

Conclusion. This research has been concerned with the role of context in the perception of constituent elements, an issue that originally concerned Gestalt psychologists. While the Gestaltists provided compelling demonstrations of context effects, particularly those involving objects, it has only been in the last two decades that experimental studies have been conducted on this issue. Weisstein and her colleagues were the first to provide experimental evidence for what they called the object superiority (Weisstein & Harris, 1974) and object-line (Williams & Weisstein, 1978) effects. Following this seminal research, significant advances were made by proponents of the enhanced discriminability (e.g., Weisstein et al., 1982) and interstimulus dissimilarity (e.g., Enns & Prinzmetal, 1984) views. A more recent development, provided by Earhard (1990), was that the magnitude of the object-line effect depended on task factors. This was consistent with an information-relevance view. The present research, which extended the notion that informativeness of context affects performance, has shown that the object superiority effect also depends on task factors, in particular, task difficulty. Thus, it now seems apparent that context effects are influenced both within and across tasks. Moreover, whereas previous views have emphasized detection or identification processes, it is apparent that target identification performance can be analyzed into (at least) two components, localization and identification.

And target localization appears to be critical, at least within the present paradigm. To account for object superiority effects, a model must therefore consider the interaction between the processing requirements of a task and the information provided by context vis-a-vis those requirements. Overall, the proposed whole-to-part guided search model, which claims that search will be facilitated to the extent that global properties of a context provide informative cues to the location of the target, appears to be a reasonable initial account of the object superiority effects obtained here. It is clear, however, that this is only the beginning. Further research is necessary to delineate the global properties that may govern response in the variable condition. In chapter 2, I provided a list of several global properties that seem to be good candidates. In particular, I suggested that global properties such as size, orientation, shape, symmetry, and compactness might act as informative location cues. According to Garner (1978), these properties belong to two main categories - dimensions (e.g., size and orientation) and configurations (e.g., shape, symmetry, and compactness). Future research could first determine whether performance is affected to a greater degree by properties in one of these categories rather than the other. Subsequent studies could then be designed to determine whether performance is influenced by a single property or some combination of properties.

REFERENCES

Banks, W.P., & Prinzmetal, W. (1976). Configurational effects in visual information processing. Perception & Psychophysics, 19, 361-367.

Baylis, G.C., & Driver, J. (1993). Visual attention and objects: Evidence for hierarchical coding of location. Journal of Experimental Psychology: Human Perception and Performance, 19, 451-470.

Biederman, I. (1972). Perceiving real-world scenes. Science,177, 77-79.

Bouma, H. (1970). Interaction effects in parafoveal letter recognition. Nature, 226, 177-178.

Chen, L. (1982). Topological structure in visual perception. Science, 218, 699-700.

Dixon, W.J., Brown, M.B., Engelman, L., & Jennrich, R.I. (Eds.). (1990). BMDP Statistical software manual (Vols. 1 & 2). Berkeley, CA: University of California Press.

Earhard, B. (1980). The line-in-object superiority effect in perception: It depends on where you fix your eyes and what is located at the point of fixation. Perception & Psychophysics, 28, 9-18.

Earhard, B. (1987). The object-line effect as an information-extraction strategy. Canadian Psychology, 28, 153. (Abstract)

Earhard, B. (1990). The object-line effect: Is it attributable to intercontext differences or the structural properties of contexts and task demands? Canadian Journal of Psychology, 44, 384-399.

Earhard, B., & Armitage, R. (1980). From an object-superiority effect to an object-inferiority effect with movement of the fixation point. Perception & Psychophysics, 28, 369-376.

Enns, J.T., & Gilani, A.B. (1988). Three-dimensionality and discriminability in the object-superiority effect. Perception & Psychophysics, 44, 243-256.

Enns, J.T., & Prinzmetal, W. (1984). The role of redundancy in the object-line effect. Perception & Psychophysics, 35, 22-32.

Eriksen, C.W., & Hoffman, J.E. (1972). Temporal and spatial characteristics of selective encoding from visual displays. Perception & Psychophysics, 12, 201-204.

Garner, W.R. (1978). Aspects of a stimulus: Features, dimensions, and configurations. In E. Rosch & B.B. Lloyd (Eds.), Cognition and categorization (pp. 99-133). Hillsdale, NJ: Erlbaum.

Hochberg, J. (1974). Organization and the Gestalt tradition. In. E.C. Carterette & M.P. Friedman (Eds.), Handbook of perception (Vol. 1). New York: Academic Press.

Jonides, J., & Yantis, S. (1988). Uniqueness of abrupt visual onset in capturing attention. Perception & Psychophysics, 43, 346-354.

Kimchi, R. (1992). Primacy of wholistic processing and global/local paradigm: A critical review. Psychological Bulletin, 112, 24-38.

Kimchi, R., & Palmer, S.E. (1982). Form and texture in hierarchically constructed patterns. Journal of Experimental Psychology: Human Perception and Performance, 8, 521-535.

Kirk, R.R. (1982). Experimental design: Procedures for the behavioral sciences (2^{nd} ed.). Monterey, CA: Brooks/Cole.

Klein, R. (1978). Visual detection of line segments: Two exceptions to the object superiority effect. Perception & Psychophysics, 24, 237-242.

LaBerge, D. (1995). Attentional processing: The brain's art of mindfulness. Cambridge, MA: Harvard Press.

Lanze, M., Maguire, W., & Weisstein, N. (1985). Emergent features: A new factor in the object-superiority effect? Perception & Psychophysics, 38, 438-442.

Lanze, M., Weisstein, N., & Harris, J. (1982). Perceived depth vs. structural relevance in the object-superiority effect. Perception & Psychophysics, 31, 376-382.

Marr, D. (1982). Vision. San Francisco, CA: Freeman.

McClelland, J.T. (1978). Perception and masking of wholes and parts. Journal of Experimental Psychology: Human Perception and Performance, 4, 210-223.

McClelland, J.T., & Miller, J. (1979). Structural factors in figure perception. Perception & Psychophysics, 26, 221-229.

Nakaya, U. (1954). Snow crystals: Natural and artificial. Cambridge, MA: Harvard Press.

Neisser, U. (1967). Cognitive psychology. New York: Appleton-Century-Crofts.

Palmer, S.E. (1975). Visual perception and world knowledge. In D.A. Norman, D.E. Rumelhart, & LNR Research Group (Eds.), Explorations in cognition (pp. 279-307). San Francisco: W.H. Freeman.

Palmer, S.E. (1989). Reference frames in perception of shape and orientation. In B.E. Shepp & S. Ballesteros (Eds.), *Object perception* (pp. 121-163). Hillsdale, NJ: Erlbaum.

Pomerantz, J.R. (1983). Global and local precedence: Selective attention in form and motion perception. *Journal of Experimental Psychology: General, 112*, 516-540.

Pomerantz, J.R., Pristach, E.A., & Carson, C.E. (1989). Attention and object perception. In B.E. Shepp & S. Ballesteros (Eds.), *Object perception* (pp. 53-89). Hillsdale, NJ: Erlbaum.

Pomerantz, J.R., Sager, L.C., & Stoever, R.G. (1977). Perception of wholes and their component parts: Some configural superiority effects. *Journal of Experimental Psychology: Human Perception and Performance*, 3, 422-435.

Purcell, D.G., & Stewart, A.L. (1991). The object-detection effect: Configuration enhances perception. *Perception & Psychophysics, 50,* 215-224.

Purcell, D.G., Stewart, A.L., & Giacoletti, A.M. (1993). The object-superiority effect by threshold assessment. *Bulletin of the Psychonomic Society, 31,* 295-298.

Rabbitt, P. (1984). The control of attention in visual search. In R. Parasuraman & D.R. Davies (Eds.), *Varieties of attention (pp.273-291)*. Orlando, FA: Academic Press.

Rock, I. (1973). *Orientation and form*. New York: Academic Press.

Rock, I. (1986). The description and analysis of object and event perception. In K.R. Boff, L. Kaufman, & J.P. Thomas (Eds.), *Handbook of perception and human performance* (Vol. 2, pp. 33: 1-71). New York: Wiley.

Schneider, W., & Shiffrin, R.M. (1977). Controlled and automatic human information processing: I. Detection, search, and attention. *Psychological Review*, *84*, 1-66.

Selfridge, O.G., & Neisser, U. (1960). Pattern recognition by machine. Scientific American, 203, 60-68.

Shiffrin, R.M., & Schneider, W. (1977). Controlled and automatic human information processing: II. Perceptual learning, automatic attending, and a general theory. Psychological Review, 84, 127-190.

Snellen, H. (1862). Probebuchstaben zur bestimmung der sehscharfe. Utecht: Weijer.

Treisman, A.M. (1986). Properties, parts, and objects. In K.R. Boff, L. Kaufman, & J.P. Thomas (Eds.), Handbook of perception and human performance (Vol. 2, pp. 35: 1-70). New York: Wiley.

Treisman, A.M., & Gelade, G. (1980). A feature integration theory of attention. Cognitive Psychology, 12, 97-136.

Tversky, A. (1977). Features of similarity. Psychological Review, 84, 327-352.

Uttal, W.R. (1988). On seeing forms. Hillsdale, NJ: Erlbaum.

Watt, R. (1988). Visual processing: Computational, psychophysical, and cognitive research. Hillsdale, NJ: Erlbaum.

Weisstein, N., & Harris, C. (1974). Visual detection of line segments: An object-superiority effect. Science, 186, 752-754.

Weisstein, N., & Harris, C. (1980). Masking and the unmasking of distributed representations in the visual system. In C.S. Harris (Ed.), Visual coding and adaptability (pp. 317-364). Hillsdale, NJ: Erlbaum.

Weisstein, N., & Maguire, W. (1978). Computing the next step: Psychophysical measures of representation and interpretation. In A. Hanson & E. Riseman (Eds.), Computer vision systems. New York: Academic Press.

Weisstein, N., Williams, M.C., & Harris, C.S. (1982). Depth, connectedness, and structural relevance in the object-superiority effect: Line segments are harder to see in flatter patterns. Perception, 11, 5-17.

Weisstein, N., Williams, M.C., & Williams, A. (1979). Connectedness and three-dimensionality affect different aspects of the metacontrast function. Investigative Ophthalmology and Visual Science, 18(Suppl.), 1 (Abstract).

Williams, A., & Weisstein, N. (1978). Line segments are perceived better in a coherent context than alone: An object-line effect in visual perception. Memory & Cognition, 6, 85-90.

Williams, M.C., & Weisstein, N. (1981). Spatial frequency response and perceived depth in the time-course of object superiority. Vision Research, 21, 631-646.

Winer, B.J. (1971). Statistical principles in experimental design. New York: McGraw-Hill.

Wiser, M. (1981, August). The role of intrinsic axes in shape recognition. Paper presented at the Third Annual conference of Cognitive Science, Berkeley, CA.

Wolford, G., & Chambers, L. (1983). Lateral masking as a function of spacing. Perception & Psychophysics, 33, 129-138.

Wolford, G., & Chambers, L. (1984). Contour interaction as a function of retinal eccentricity. Perception & Psychophysics, 36, 457-460.

Womersley, M. (1977). A contextual effect in feature detection with application of signal detection methodology. Perception & Psychophysics, 21, 88-92.

Yantis, S. (1993). Stimulus-driven attentional capture. Current Directions in Psychological Science, 2, 156-161.

Yantis, S., & Jonides, J. (1984). Abrupt visual onsets and selective attention: Evidence from visual search. Journal of Experimental Psychology: Human Perception and Performance, 10, 601-621.

AUTHOR NOTES

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Table 1

Mean Response Latency (and Standard Deviation) in the Target-Identification Task as a Function of Condition and Structure in Experiment 1

	Structure		
Condition	Coherent	Incoherent	Mean
Fixed	634.79 (142.92)	559.76 (84.26)	597.27
Variable 1	780.97 (202.43)	1014.84 (290.03)	897.90
Variable 2	785.70 (178.78)	1003.73 (206.54)	894.72
Mean	733.82	859.44	796.63
Isolated part	439.76 (44.41)		

Note. N = 10 participants per cell. The entry in each cell is the mean of the mean correct reaction time for all 10 participants. Standard deviations are shown in parentheses.

Table 2

Mean Percentage Error (and Standard Deviation) in the Target-Identification Task as a Function of Condition and Structure in Experiment 1

	Structure		
Condition	Coherent	Incoherent	Mean
Fixed	4.61 (2.59)	4.53 (4.23)	4.57
Variable 1	16.09 (12.85)	29.22 (8.03)	22.66
Variable 2	18.60 (10.42)	30.00 (7.96)	24.30
Mean	13.10	21.25	17.17
Isolated part	3.60 (2.11)		

Note. N = 10 participants per cell. Standard deviations are shown in parentheses.

Table 3

Mean Response Latency (and Standard Deviation) in the Target-Identification Task as a Function of Condition and Structure in Experiment 2

	Structure			
Condition	Coherent	Hybrid	Incoherent	Mean
Fixed	623.19 (73.48)	587.61 (74.23)	601.81 (80.68)	604.21
Variable	742.72 (97.43)	942.81 (261.37)	1121.20 (317.03)	935.57
Mean	682.96	765.21	861.51	769.89
Isolated part		460.82 (42.30)		

Note. N = 10 participants per cell. The entry in each cell is the mean of the mean correct reaction time for all 10 participants. Standard deviations are shown in parentheses.

Table 4

Mean Percentage Error (and Standard Deviation) in the Target-Identification Task as a Function of Condition and Structure in Experiment 2

	Structure			
Condition	Coherent	Hybrid	Incoherent	Mean
Fixed	3.28 (2.08)	6.32 (4.73)	2.23 (1.58)	3.94
Variable	9.45 (3.34)	20.34 (9.53)	25.78 (2.71)	18.52
Mean	6.37	13.33	14.00	11.23
Isolated part		2.50 (1.55)		

Note. N = 10 participants per cell. Standard deviations are shown in parentheses.

FIGURE CAPTIONS

Figure 1. Panel A shows the target lines (a - d) used by Weisstein and Harris (1974). Each target line was combined with the overlapping squares context in e to produce compound patterns f - i. The same procedure, involving different contexts, was used to construct the patterns in each row in panel B. As can be seen, patterns f - i in A correspond to the patterns shown in row a of Panel B. All of the patterns in B consisted of the same eight vertical and horizontal lines with only their arrangement varied. In the experiment, only these 24 patterns were used. Each target line was, therefore, always accompanied by context lines. On each trial, a single context pattern such as f in Panel A was randomly displayed and then followed immediately by a dotted masking stimulus (j). The subject's task was to indicate which of the four diagonal line segments was present in the display. All stimuli were white lines on a dark background. Note that the last column in Figure 1B gives the mean difference in percentage correct between context a and each of the other contexts.(Adapted from Weisstein and Harris, 1974.)

Figure 2. Target displays used in McClelland and Miller's (1979) Experiments 2 (A) and 3 (B). (Adapted from McClelland and Miller, 1979.)

Figure 3. Context patterns employed in Earhard's (1990) Experiments 2 (Panel A), and 3 (Panel B). (Adapted from Earhard, 1990.)

Figure 4. Panel A shows the coherent patterns used in the fixed condition in Experiments 1-3. Panel B shows the incoherent patterns used in the fixed condition in Experiments 1 and 2. Targets T1 (left) and T2 (right), used in Experiments 1 - 3, are shown in Panel C.

Figure 5. Coherent patterns used in the variable condition in Experiments 1 and 2.

Figure 6. Incoherent patterns used in the variable condition in Experiments 1 and 2.

Figure 7. The full-screen random pattern mask used in Experiments 1 - 3.

Figure 8. Fixation point (center) and four critical target onset locations used in Experiments 1 - 3. At a viewing distance of 154 cm, each onset location appeared at about 1.3 deg into the periphery. The monitor screen was 29.2 cm wide and 21.6 cm high.

Figure 9. Onset locations (small plusses) for stimuli in the fixed and variable relative position 2 conditions. When stimuli with the target at the top left relative position (see Figures 4A and 4B) were centered on the small plusses, the target appeared on one of the four critical target onset locations.

Figure 10. One illustrative set of stimulus onset locations (small plusses) for stimuli in the variable relative position 1 condition. When stimuli were centered on the small plusses, the target appeared at the top left critical location (large plus). A - D in the figure refer to A - D in Figures 5 and 6. To illustrate, when Figure 5A was centered on the small plus indicated by the uppercase A in Figure 10, the target appeared at the top left target location. There was an analogous set of four stimulus locations around each of the other three critical target locations. In this condition, therefore, the stimuli could appear at a total of 16 different screen locations, but the targets landed on only the four critical locations.

Figure 11. Mean reaction times (top panel) and error rates (bottom panel) for Experiment 1.

Figure 12. The hybrid patterns used in Experiment 2.

Figure 13. Mean reaction times (top panel) and error rates (bottom panel) for Experiment 2.

Figure 14. Stimuli used in the masking control condition of Experiment 3.

Figure 15. Mean reaction times for Experiment 3.

Figure 1

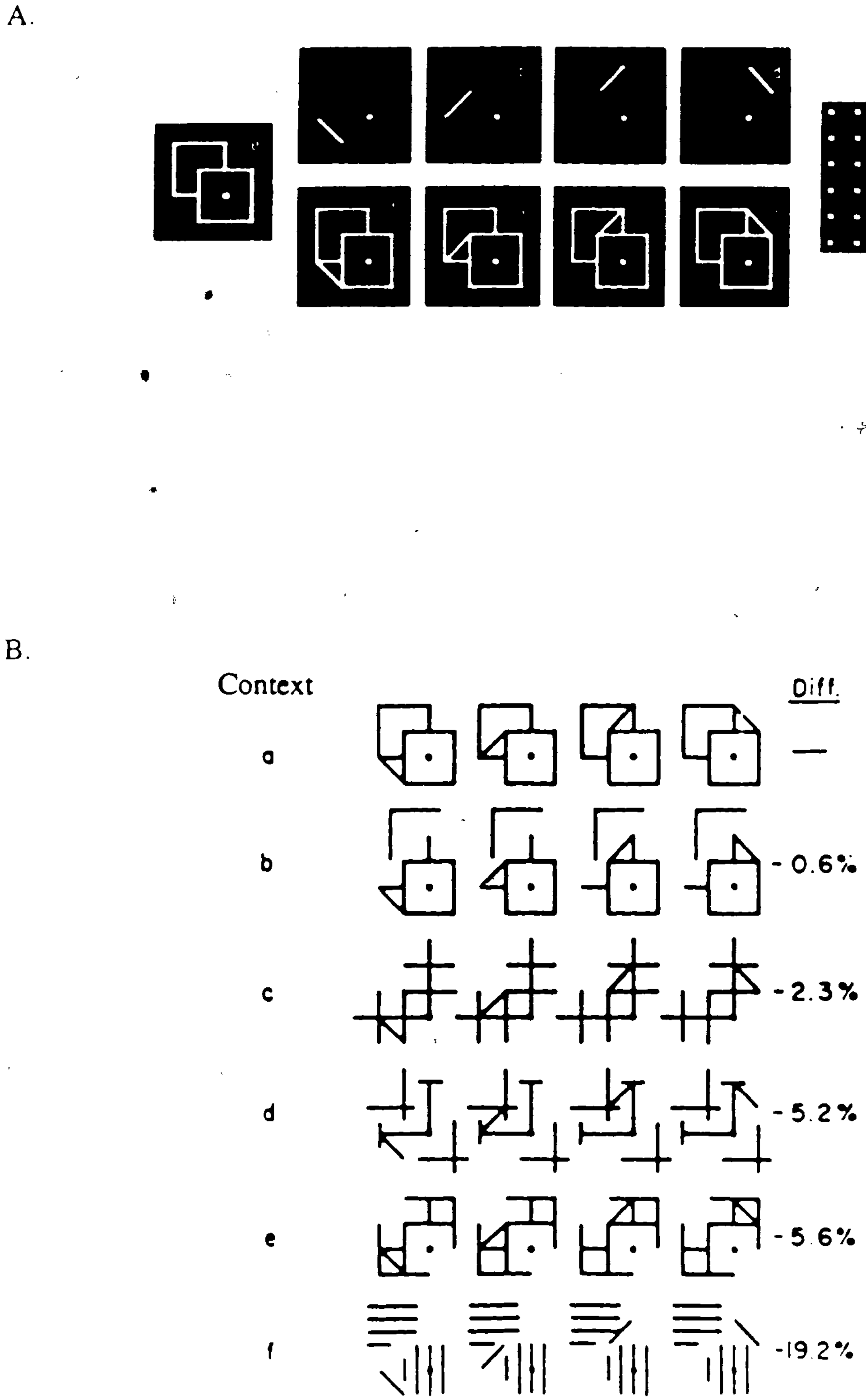


Figure 2

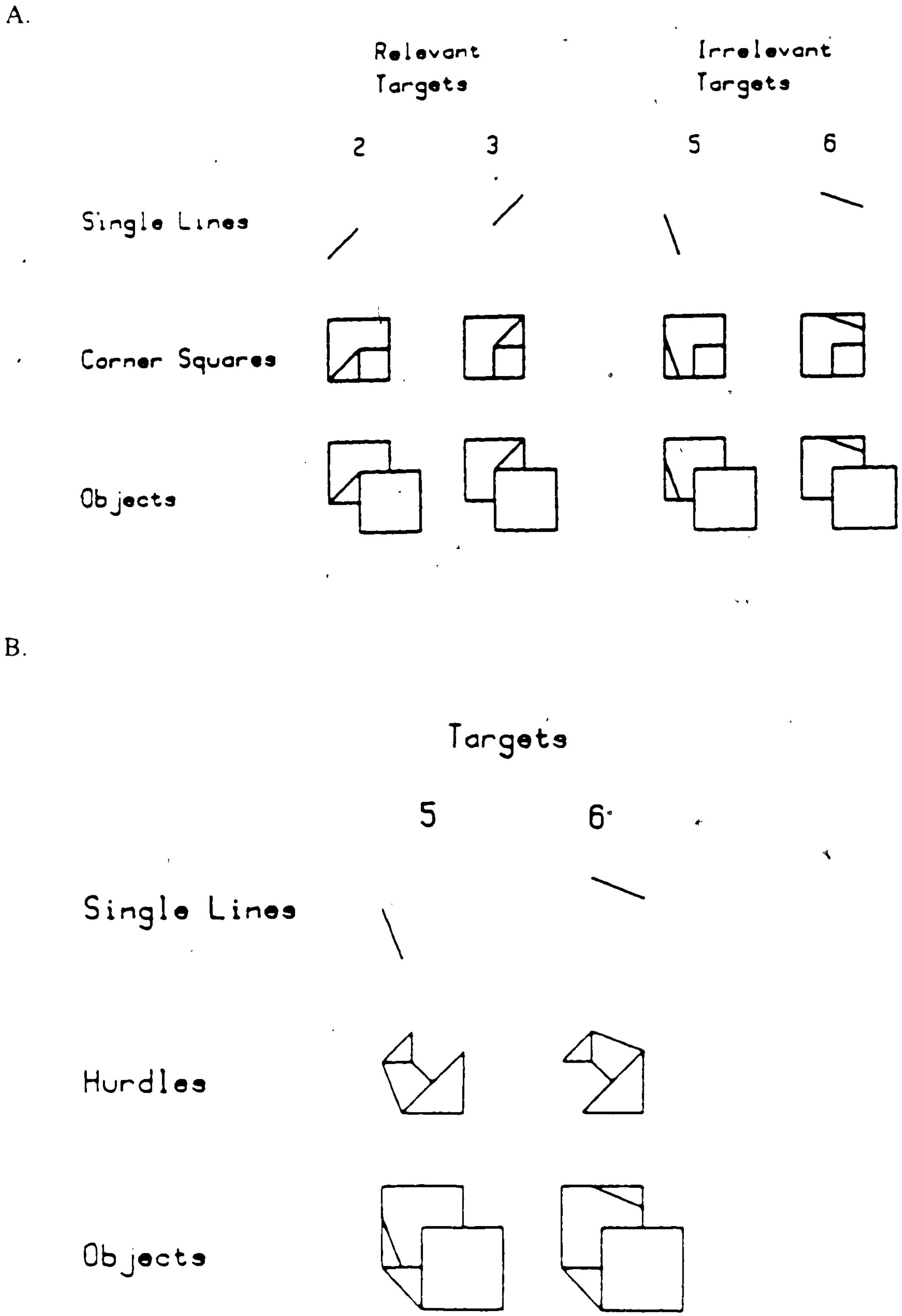

A.
Relevant Targets
Irrelevant Targets
2
3
5
6
Single Lines
Corner Squares
Objects
B.
Targets
5
6
Single Lines
Hurdles
Objects

Figure 3

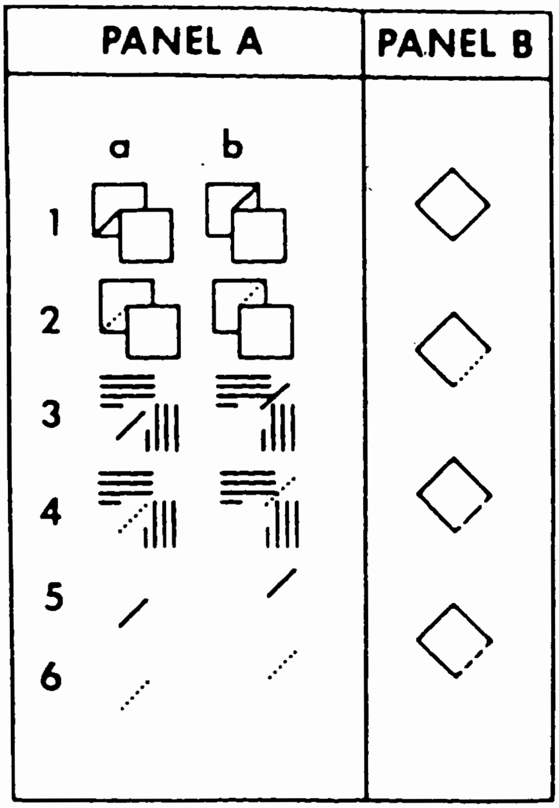
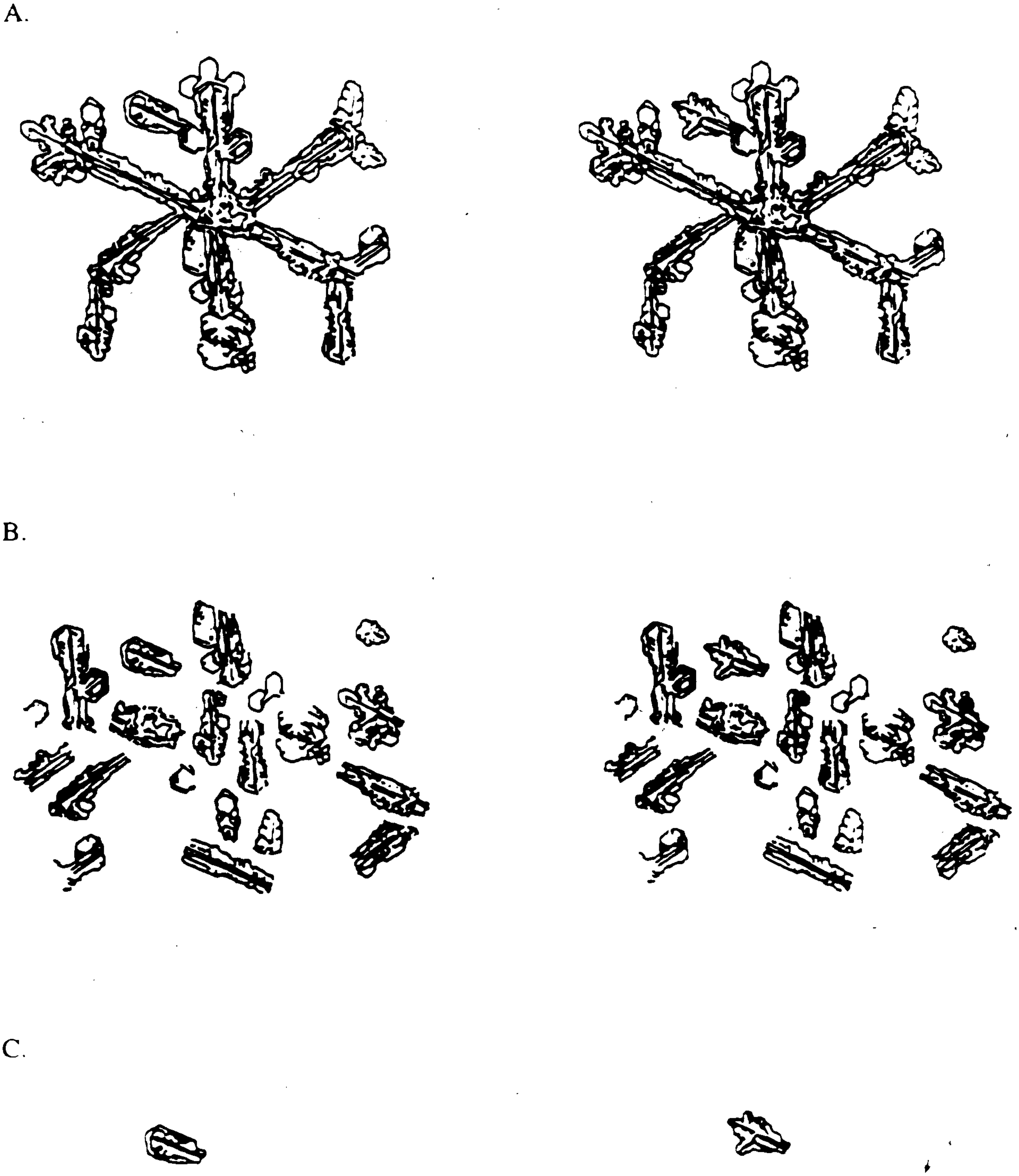


Figure 4



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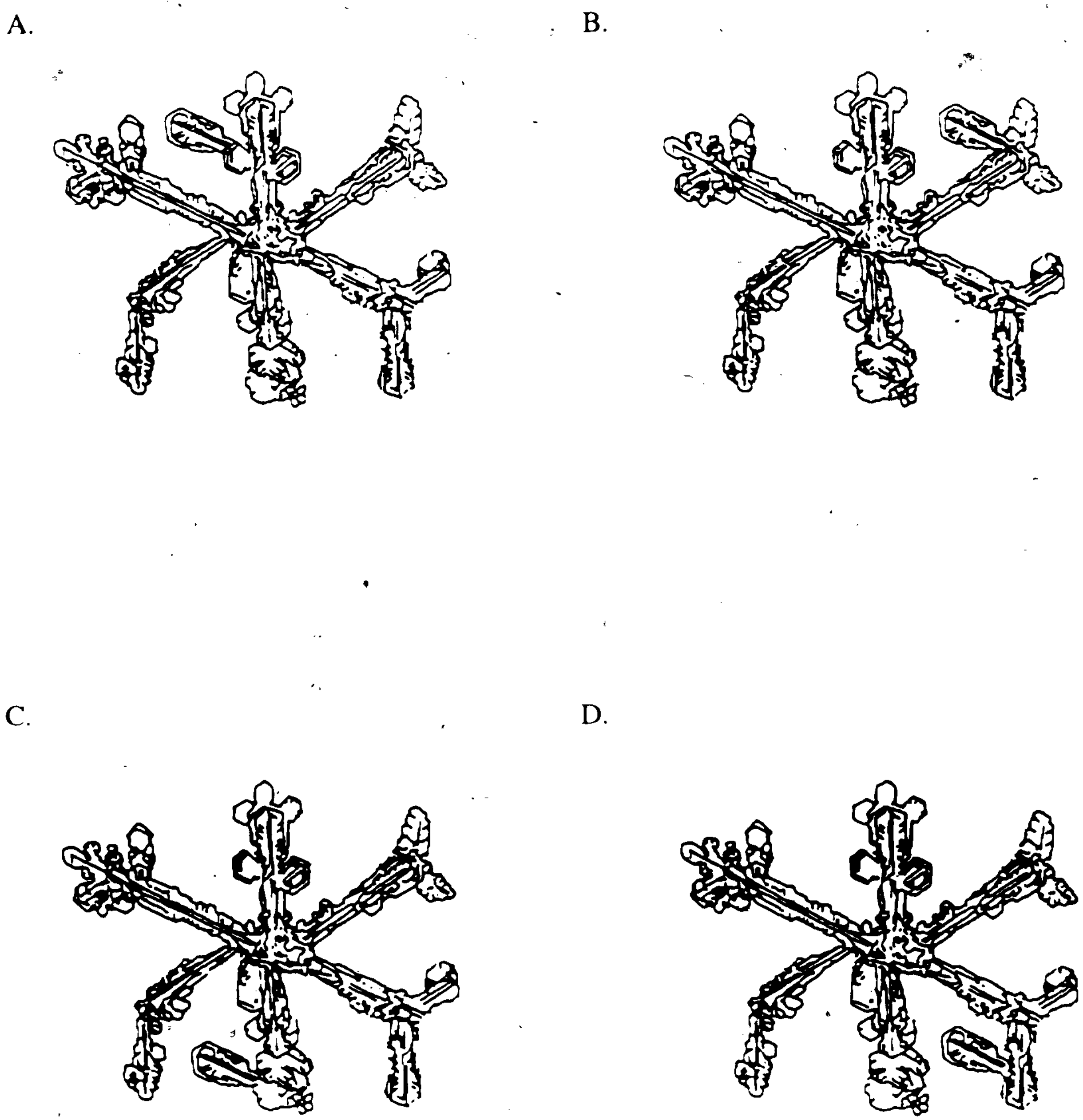

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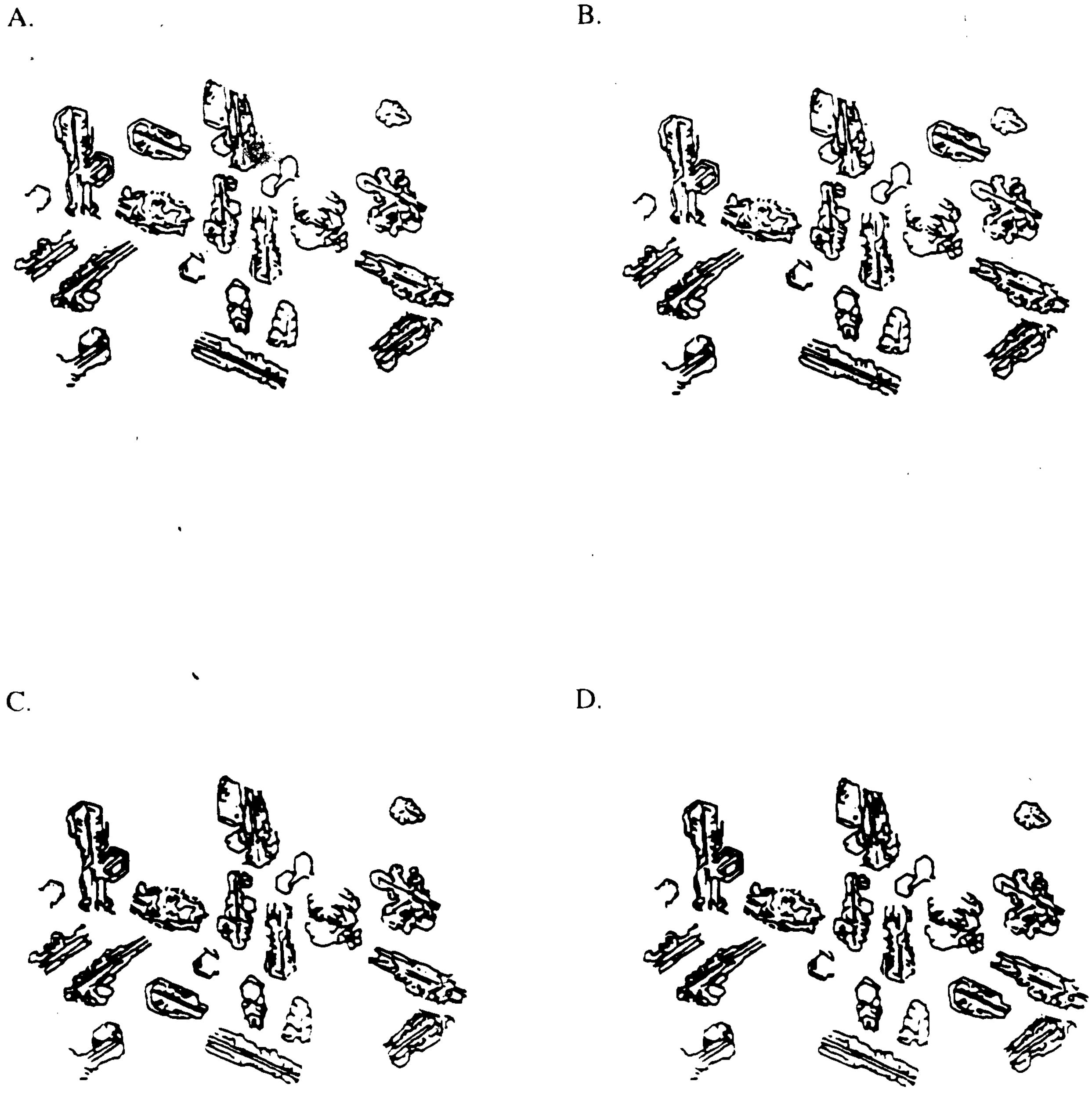

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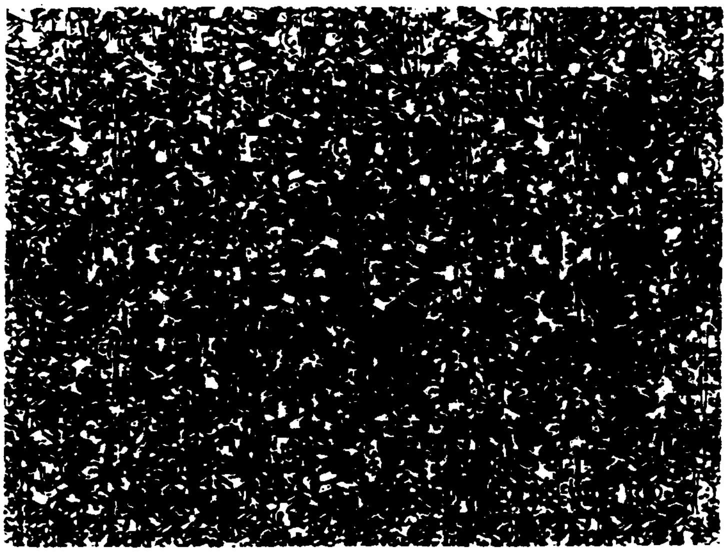

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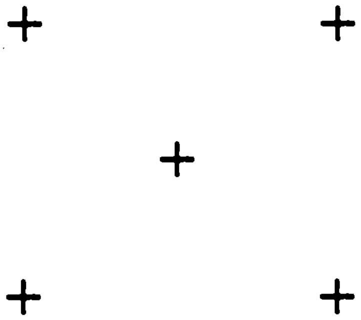

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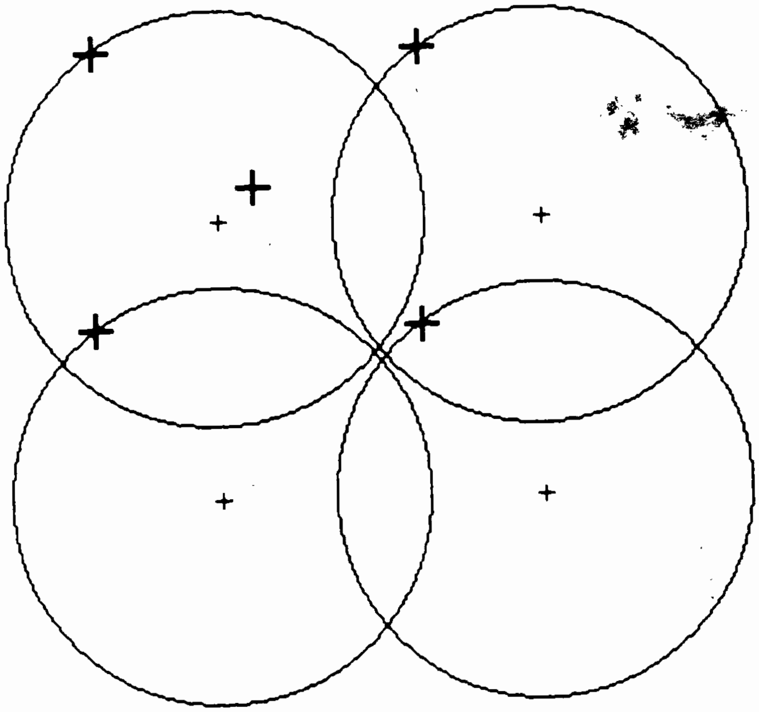


Figure 10

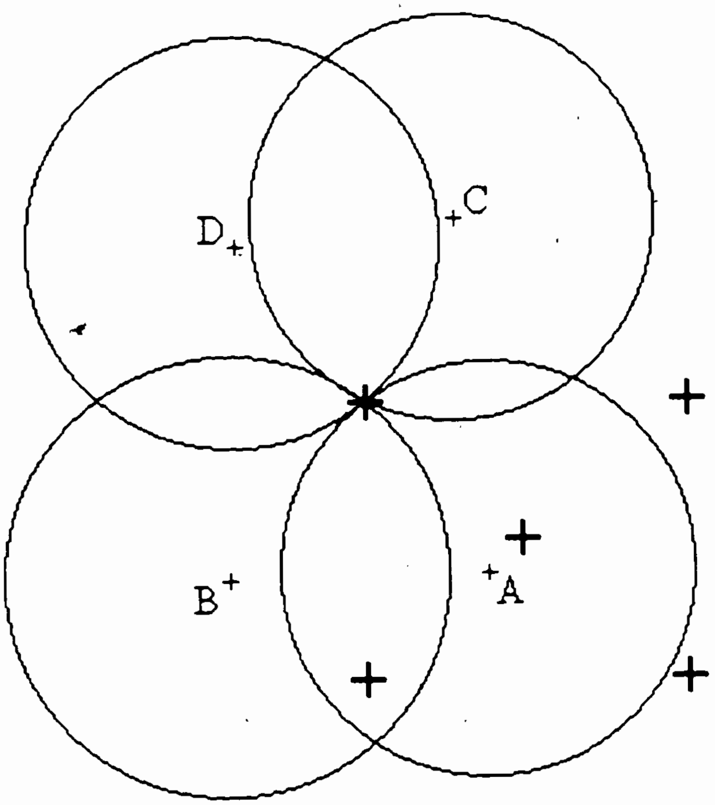


Figure 11

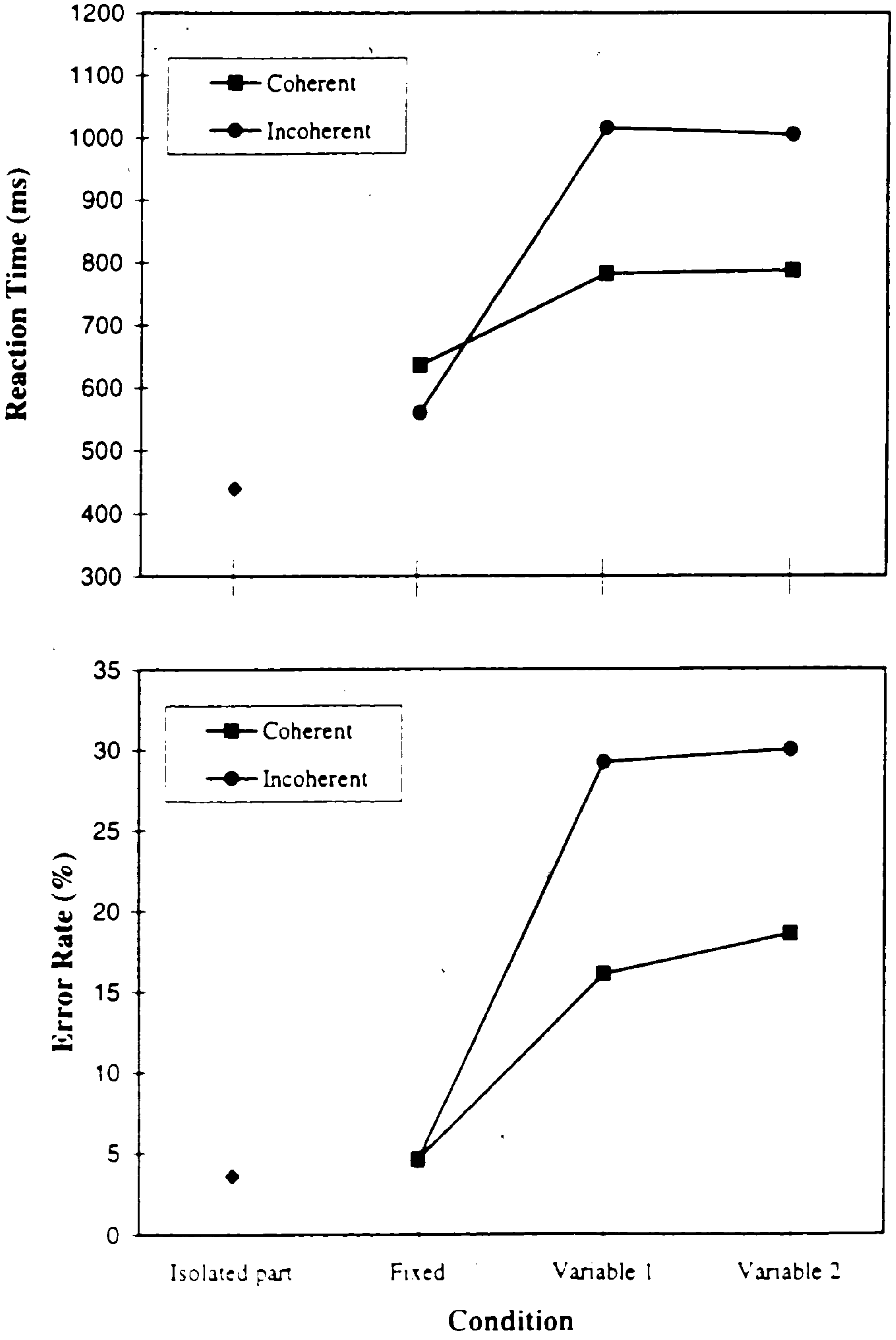
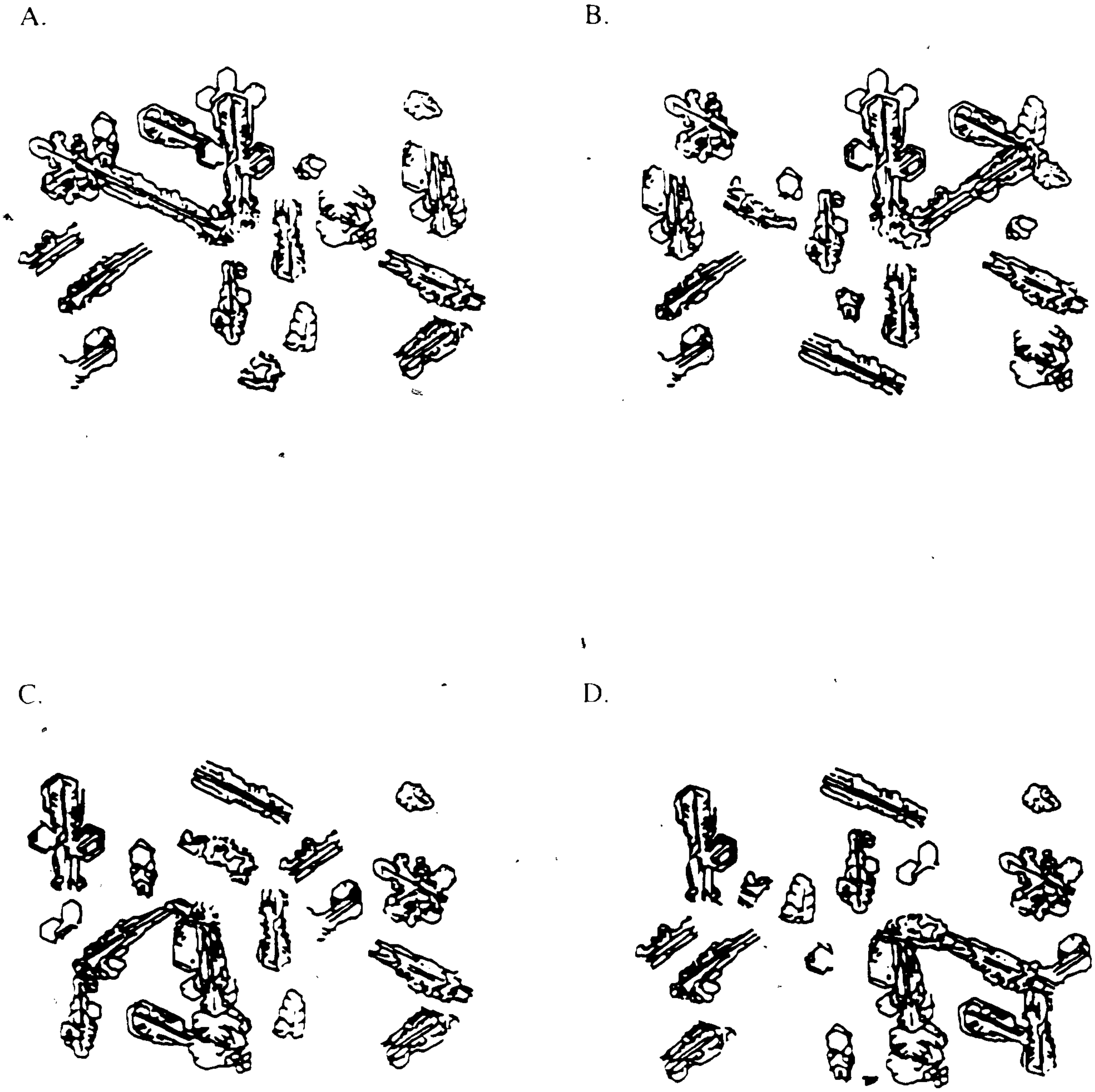

1200
1100
1000
900
800
700
600
500
400
300
Reaction Time (ms)
Coherent
Incoherent
35
30
25
20
15
10
5
0
Error Rate (%)
Coherent
Incoherent
Isolated part
Fixed
Variable 1
Variable 2
Condition

Figure 12



A.

B.

C.

D.

Figure 13

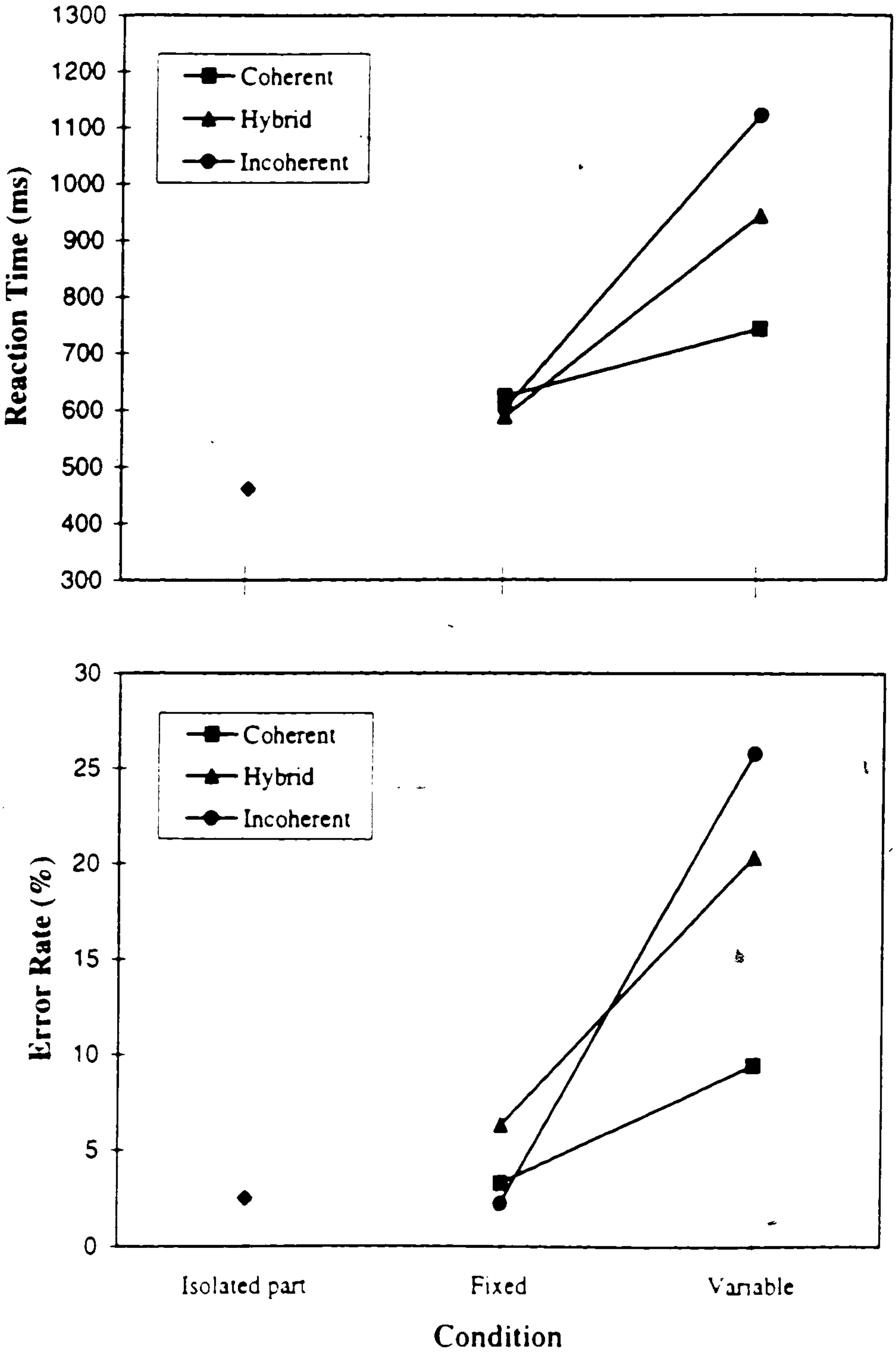
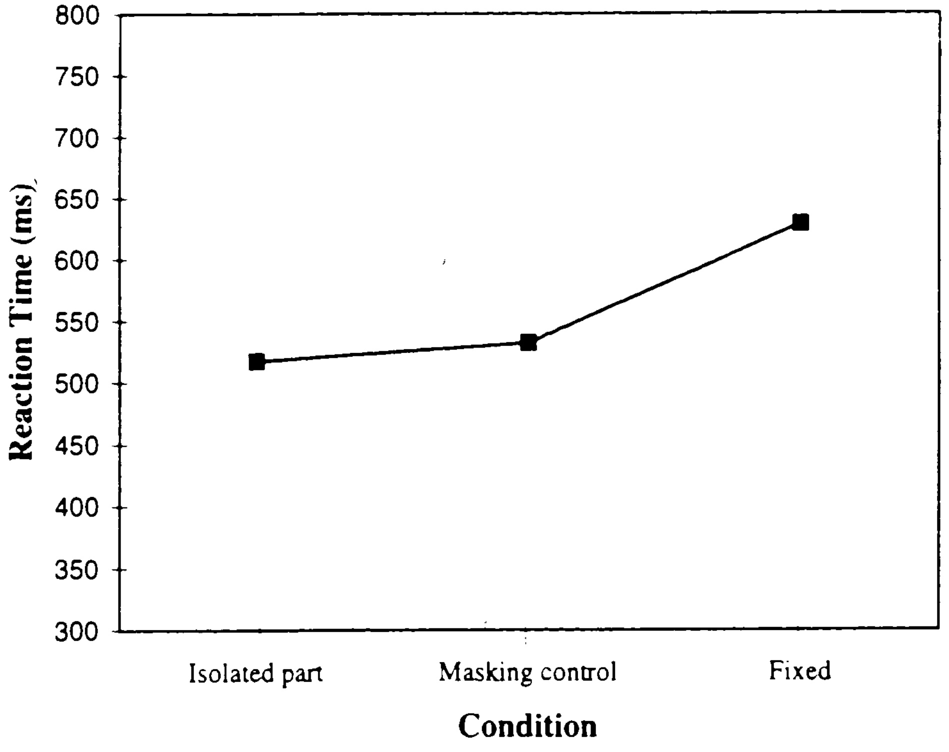

1300
1200
1100
1000
900
800
700
600
500
400
300
Reaction Time (ms)
Coherent
Hybrid
Incoherent
30
25
20
15
10
5
0
Error Rate (%)
Coherent
Hybrid
Incoherent
Isolated part
Fixed
Variable
Condition

Figure 14

Figure 15


800
750
700
650
600
550
500
450
400
350
300
Reaction Time (ms)
Isolated part
Masking control
Fixed
Condition