Proceedings of the Annual Meeting of the Cognitive Science Society

Title

Variations on Parts and Wholes: Information Precedence vs. Global Precedence

Permalink

https://escholarship.org/uc/item/03s26022

Journal

Proceedings of the Annual Meeting of the Cognitive Science Society, 7(0)

Authors

Sebrechts, Marc M.
Fragala, John J.

Publication Date

1985

Variations on Parts and Wholes:
Information Precedence vs. Global Precedence

MARC M. SEBRECHTS and JOHN J. FRAGALA

Department of Psychology
Wesleyan University
Middletown, CT 06457

Many current perceptual theories assume a two-stage model of perception in which there is a fast global analysis of a scene, followed by a slower description of constituent parts. This general view is referred to as "global precedence." This study reports experimental results that support an alternative model of "information precedence." Using pattern goodness as an operationalization of information, it is shown that speed of processing in a "same"-"different" task is affected by both global and local pattern information. This effect is partly strategic or attentional as demonstrated by a change in response pattern across three conditions: attention to global only, local only, or both global and local dimensions of a pattern. There are also perceptual effects as demonstrated by the effects of stimulus goodness within conditions. Good patterns were processed faster when they constituted the relevant dimension. When a dimension was irrelevant, good patterns slowed responding through stronger response competition. It is argued that any theory of perception must be able to account for the relative importance of these organizational factors. It is proposed that the probability of constraint satisfaction is one way to provide a processing description of these results.

Current models of visual perception frequently make assumptions about the order in which information is processed. These models are based on claims about the kinds of components that are necessary for object identification. In many cases, it is assumed that there are several stages of image formation, frequently specified by spatial frequency (see Marr, 1982). Thus, Lockhead (1972), for example, has argued that there are two stages in visual perception, an initial holistic or "blob processing", followed by a slower serial analysis.

Although there has been much controversy surrounding this issue, in many basic texts it has come to be assumed that there is an initial global analysis, followed by an identification of components. The most frequently cited evidence for this position, comes from the work of Navon (1977, 1981a, 1981b). In a series of studies he used a set of letters composed of smaller constitutent letters. He found that, in general, subjects had difficulty ignoring the global letter when asked to rapidly identify the local letter, whereas they were good at ignoring the component letters when making speeded identity responses about the global letter. Other studies have lent support to this view. Millspaugh (1978), for example, composed patterns out of a series of letters; the subjects' task was to indicate whether or not all of the constituent letters were the same. When the overall pattern in which these letters were embedded was highly organized, subjects had far more difficulty finding a disparate letter than when the overall pattern was less organized.

A number of studies have placed limits on the claims of global precedence. It has been shown that the effects of order of processing can be changed by manipulations of the visual angle (Kinchla and Wolfe, 1979) or the sparsity of the component stimuli (Martin, 1979). Others have argued that the precedence effects reflect attentional strategies (Miller, 1981; Boer & Keuss, 1982; Ward, 1982). These studies, however, argue for different ways of viewing the basic theory and generally accept the fact that global precedence is an accurate description of much of normal perception.

In contrast to these views, others have argued that there is no priority given to global aspects of a stimulus. Pomerantz and Sager (1975), for example, demonstrated local precedence in a card sorting task. Subjects were more influenced by local variation in patterns while trying to sort according to the global dimension than they were influenced by global variation when focusing on the local dimension. The explanation for this discrepancy is that Navon and others have failed to match baseline discriminability. If the experimenter is free to choose the perceptual salience of the dimensions, it is argued, then either global or local aspects can be said to have precedence. Grice, Canham, and Boroughs (1983) used position as a way to experimentally manipulate perceptual salience. They presented patterns either in varying positions, as did Navon, or in a fixed central location. They found that when the position varied they replicated Navon's results. However, when the pattern was in a fixed location, there was no evidence of global precedence. Presumably, variation in location made it more difficult to perceive the constituent elements.

These studies again show defects in the experimental strategies used previously, without providing a conceptual basis for the alternative findings. Hoffman's (1980) studies suggested that precedence is perhaps due to the relative quality of information that is available at local and global dimensions. He selectively distorted the local and global stimulus properties, and then required subjects to determine if the stimuli matched a specified memory set (Sternberg, 1969). Using this technique, he demonstrated that it was possible to find either global or local precedence by distorting the other dimension.

The present study attempts to extend Hoffman's results by utilizing another paradigm and another set of stimuli. Hoffman used the Sternberg scanning task with a changing memory set. The items in the memory set can serve either as global or local targets. The present experiment used a sequential "same"-"different" task in which target items where themselves composed of both global and local elements; as a consequence, local stimuli and global stimuli were always present simultaneously. This makes it possible to examine the effects of goodness in a physical match. Evaluating differences in response time for a physical identity match is a fairly strong test of the power of the independent variables.

The stimulus set was also changed for this experiment. One of the important characteristics of "global" processing is that it has served as a means to explain many of the Gestalt phenomena, especially pattern goodness. If the global precedence hypothesis is correct, then the organizational properties of a stimulus may be made available before any of its elements. If, however, pattern goodness is a structural characteristic of stimuli that can be present at any level of a pattern (Sebrechts, 1980; Sebrechts & Garner, 1981), then pattern goodness should not be identified with "global" characteristics alone. In addition, although most of the research to date has utilized letter stimuli, there has been only limited study of their informational properties. In contrast, there is an extensive literature on the relation of perceived pattern goodness and information (Garner, 1962; 1976).

The following experiments suggest that perception is guided by the availability of information rather than by a strict, sequential hierarchical approach to scene analysis. On this view, perception is neither top-down nor bottom-up, in principle. Rather, it is defined by the informational context. To test this hypothesis, we presented subjects with patterns that varied in informational salience (goodness) at both a global and local level. If, in fact, the order of perceptual processing is mediated by information quality, then response time should vary as a function of pattern structure at the global and local levels. In addition, the control of perceptual consequences may be mediated by attentional mechanisms. To examine that possibility, subjects were presented with three instructional conditions: attend only to the global properties of the stimulus (the Global condition), attend only to the local properties of the stimulus (the Local condition), and attend to both (the Dual condition).

Method

Subjects

Twenty-four Wesleyan University students served as subjects in the experiment. All subjects were right-handed and had normal or corrected-to-normal vision. Subjects who had an error rate greater than 7.5% were eliminated from the study.

Stimuli

The stimuli consisted of global patterns made up of patterns that served as elements. The elements consisted of an array of 9 dots distributed in a 5 X 5 matrix with at least one dot in each row and each column. The global pattern was then constructed as an array of 9 of these elements distributed in a larger 5 X 5 matrix. The elements in any given global pattern were always the same. There were 8 patterns that could serve as elements and as global patterns. These consisted of 4 "good patterns" which were symmetrical about their vertical, horizontal, and diagonal axes, and 4 "poor patterns" that were created by rearranging the dots in one of the rows or columns in the matrix of the corresponding good pattern.

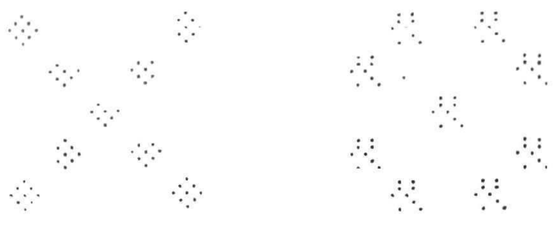
An example would therefore be a large "X" (global level) constructed of small diamonds (local level). In this case both the global and local levels are "good". Likewise a globally good, locally poor stimulus was formed from a large "circle" formed from small aberrations of "X"s. In this way, a total of 64 stimuli can be constructed by combining factorially the 4 good and 4 poor arrangements on the global and local levels. This number was reduced to 56 by eliminating those patterns which have the same local and global arrangements (e.g., there are no global diamonds made up of local diamonds used in the study.) Examples of the four types of stimuli (Gg: Globally good, locally good; Gp: Globablly Good, locally poor; Pg: Globally Poor, locally good; and Pp: Globally Poor,locally poor) appear in Figure 1. Each of the 56 stimuli could be used as either the initial "target" or as the following "probe" on any given trial.

Apparatus

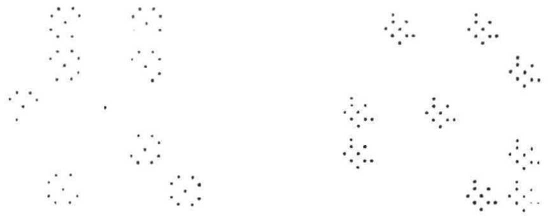
The stimuli were presented on the monitor of a Terak 8510 microcomputer. Subjects sat in a well-lit room, with their heads on a chin rest to ensure that they remained 14 inches from the screen throughout the experiment. At this distance, the overall pattern subtended a visual angle of 7 degrees, and each local element subtended a visual angle of approximately 1 degree. The subjects rested the index and middle fingers of the right hand on two keys of the Terak keyboard. Half of the subjects were told to use their index finger for "same", and their middle for "different", and the other half were given the opposite finger-response assignment. The microcomputer displayed the patterns and recorded the responses and reaction times. All stimuli appeared in the center of the screen.

Procedure

Each trial consisted of the following events. A fixation point appeared in the center of the screen for 500 milliseconds, accompanied by a warning tone. The screen was cleared and the first stimulus or "target" was displayed for a duration of 200 milliseconds. The screen was again cleared, and after a delay of 500 milliseconds (the inter-stimulus-interval or ISI), the second stimulus or "probe" was displayed. Upon striking a response key, the screen was cleared and the next trial followed after a delay of three seconds. If no response was made within four seconds, the trial was recorded as an error, the screen was cleared and the next trial began. Subject were instructed to respond as quickly as possible while avoiding errors.



Globally Good, Locally good (Gg) Globally Good, Locally poor (Gp)



Globally Poor Locally good (Pg) Globally Poor, Locally poor (Pp)

Figure 1 Examples of the four types of stimuli.

Conditions

Each subject participated in three experimental conditions which were defined by the dimension(s) which were relevant to making a response of "same" or "different": Global, Local, Dual. In the Global condition, subjects were instructed to attend only to the overall configuration. In the Local condition, subjects were told to base their decisions solely on comparison of the elements. Finally, in the Dual condition the two stimuli were to be judged "same" only when they were identical on both the global and local dimensions.

Experimental Design

A representative sample of approximately 448 pairings were selected from the pool of 3136 possible ordered pairings of the 56 stimuli. This sample was divided into two groups, with half of the subjects receiving 224 of the pairings and the other half receiving the remaining 224 pairings. There were an equal number of males and females receiving each of these sets of stimuli.

Each subject received a block of practice trials followed by seven blocks of randomized trials for each of the three conditions. Subjects were given a short rest at the end of each block of trials. The order of conditions and blocks was determined by a Latin Square design. Each subject received an equal number of "same" and "different" trials and an equal number of the four trial types (Gg, Gp, Pg, Pp) in each condition.

Results

Since the logic of this type of reaction time experiment assumes optimal performance, subjects with an error rate of greater than 7.5% were eliminated from the study. Mean error rate for the remaining subjects was 3.7%. There were too few errors for analysis of individual response categories. The following analyses are based only on median correct response time for each type of stimulus pairing for each subject.

"Same" Response: Identity Trials

Table 1 presents the response times for those trials in which the target is identical to the probe, both globally and locally. The global and local dimensions can be either good or poor, resulting in the four target-probe categories Gg-Gg, Gp-Gp, Pg-Pg and Pp-Pp for each of the three conditions. The same set of target and probe stimuli were used in all three conditions, and a "same" response was always required; the only difference between conditions for these trials was the level to which subjects were told to attend. For these identity trials, the goodness of the relevant dimension affected performance, whereas the goodness of the irrelevant dimension did not. In the Global condition, globally good pairs were faster than globally poor pairs (537 vs 563 msec; $F(1,23)=7.31$, $p=.01$) whereas there was no difference between locally good and locally poor pairs (550 vs 550 msec). In the Local condition, locally good pairs were faster than locally poor pairs (537 vs 593 msec; $F(1,23)=19.44$, $p<.01$) but no effect was obtained for goodness on the global dimension (565 vs 566 msec). In the Dual condition, both dimensions were relevant, and there were significant effects of both global ($F(1,23)=6.14$, $p=.02$) and local ($F(1,23)=16.89$, $p<.01$) pattern goodness. Response time was fastest when the global and local dimensions were good, slower when one of the dimensions was poor, and slowest for the Pp-Pp category.

Table 1
Mean Reaction Time (in msec)
for "Same," Identity Trials

		Condition		
Target	Probe	Dual	Global	Local
Gg	Gg	558	544	538
Gp	Gp	591	530	591
Pg	Pg	581	556	537
Pp	Pp	604	569	596

"Same" Response: Non-Identical Trials

The irrelevant dimension of target and probe in the identity trials always matched physically. In this section, responses are analyzed for stimuli that match physically on the relevant dimension, thus requiring a "same" response, but that do not match physically on the irrelevant dimension. (This was true only for the Global and Local conditions, since any variation in the stimuli for the Dual condition required a "different" response.) In general, across these trials subjects responded faster when the relevant dimension was good. Thus for the Global condition, globally good stimuli were faster than globally poor ones (611 vs 663 msec, $t(23)=3.96$, $p<.01$), and for the Local condition, locally good stimuli were faster than locally poor ones (621 vs 681 msec; $t(23)=4.01$, $p<.01$).

In order to analyze the effect of the goodness of the irrelevant dimension, it is necessary to extract those patterns for which target and probe are matched for goodness on the irrelevant dimension. Table 2 contains the response times for those target-probe pairs which have an identical pattern on the relevant dimension and thus require a "same" response, but have different patterns with the same goodness (good or poor) on the irrelevant dimension and were therefore not identical. This subset of patterns again showed faster reaction time if the relevant dimension was good rather than poor. Thus, in the Global condition, globally good pairs were faster than globally poor pairs (594 vs 662 msec; $F(1,23)=12.88$, $p<.01$), and in the Local condition locally good pairs were faster than locally poor ones (626 vs 672 msec; $F(1,23)=8.66$, $p<.01$) The opposite effect was found for the irrelevant dimension; a good pattern on the irrelevant dimension slowed response time. In the Local condition, globally good pairs were slower than globally poor ones (668 vs 630 msec; $F(1,23)=6.27$, $p<.02$), and in the Global condition, locally good pairs were slower than locally poor pairs (650 vs 606 msec; $F(1,23)=6.11$, $p=.02$).

Table 2
Mean Reaction Time (in msec)
for "Same," Non-Identity Trials

		Global	Local
T	P	Glob. Identity Loc.Same Good	Loc. Identity Glob.Same Good
Gg	Gg	610	641
Gp	Gp	578	695
Pg	Pg	689	611
Pp	Pp	634	648

Note. T = target; P = probe.

"Different" Trials

Whenever the relevant dimension of target and probe were not identical, the correct response was "different." Tables 3 and 4 present the data for "different" trials in which goodness was matched for both global and local patterns of target and probe. These cases are most comparable to the "same" responses already analyzed.

In general, the RT differences within each condition were small, although there was substantial consistency in the pattern of responding. The data in Table 3 are for pairings which had different stimuli of the same goodness on a relevant dimension, and thus required a "different" response, although there was a physical identity match for one dimension of the target and probe. In these cases, responses were generally faster if the relevant dimension was good. The only effect that was statistically reliable at the subjects responded more quickly if target and probe were both locally good than if they were both locally poor ($F(1,23)=21.28$, $p<.01$). Responses also were generally faster when the dimension that matched between target and probe was poor, but these effects were again not significant.

In sum, "different" RTs were fairly uniform within conditions with few reliable effects. However, the absolute values of the RTs suggest that it may be easier to differentiate patterns when the relevant patterns are good rather than poor. In contrast, a "different" response may be slowed more by a physical match of good stimuli than by a match of poor stimuli. This parallels the results for the "same" trials, although the differences are much smaller.

Table 3
Mean Reaction Time (in msec)
for "Different" Trials
with Physical Identity on One Dimension

		Condition			
		Dual		Global	Local
T	P	Global Identity	Local Identity		
Gg	Gg	604	641	661	637
Gp	Gp	713	615	630	666
Pg	Pg	601	641	660	608
Pp	Pp	660	651	652	648

Note. T = target; P = probe.

Table 4 contains the results for stimuli in which neither global nor local patterns of target and probe match physically, although they are matched for goodness. For these pairings, the data are less consistent, and there are no significant differences between RT to good and RT to poor patterns.

Discussion

To the extent that reaction time is used as a measure of order of processing, the pattern of results reported here is not consistent with any simple view of global precedence. Rather, pattern perception seems to reflect a parallel analysis of global and local characteristics. The speed of response to either dimension depends on the strategic constraints (manipulated by the attention conditions here) and informational constraints (manipulated by changes in pattern goodness).

A strong version of global precedence claims that, for any object or set of objects, the visual system analyses the overall global properties first. The validity of that claim was tested here by determining whether or not changes in global and local goodness could affect the relative speed of response to a given pattern. In the limit case, on a strict precedence view, RT should take longer for local than for global aspects of a pattern. That prediction was violated by our data, as indicated by the results for the identity trials (Table 1). The stimulus pairs were the same in all three conditions, but speed of responding changed with the attentional requirements of the task. Thus a Gp pair was responded to faster when attention was directed to the global dimension, but a Pg pair resulted in a faster response in the local condition.

Table 4
Mean Reaction Time (in msec)
for "Different" Trials
with No Physical Identity
on Either Dimension

		Condition		
Target	Probe	Dual	Global	Local
Gg	Gg	556	756	653
Gp	Gp	602	678	665
Pg	Pg	572	688	644
Pp	Pp	593	702	652

A somewhat less strict view describes visual precedence as a theory about relative interference. On that view, global properties interfere with a response to local properties, whereas local properties do not interfere with global processing. That description of precedence is also contradicted by the present results. When subjects are required to attend only to the global dimension, processing speed is affected by conflicting information on the local dimension. Likewise, information from the global dimension can interfere with that on the local dimension.

These results conflict with those presented by Navon (1977, 1981a, 1981b). It has been suggested that such differences can be attributed to the fact that in Navon's study there was no basis for determining an appropriate baseline condition. The global dimension in his study, it is argued, was more discriminable than the local dimension. As Pomerantz has noted (Pomerantz and Sager,1975; Pomerantz, 1983), a reaction time advantage can be shifted from global to local by changing the salience of dimensions. The same kind of effect has been shown through the use of changes in pattern size (Kinchla and Wolfe, 1979) and in pattern distortion (Hoffman, 1983). One response to this argument is that matching discriminabilities indirectly eliminates the global precedence effect. Thus the question remains, what should be given priority: stimulus discriminability, or global precedence.

In the present study, an alternative strategy was used to establish a baseline that avoids the need for an a priori solution to that question. Rather than trying to match the global and local dimensions, comparisons focused on the relative import of these dimensions across conditions. What was important, was not an absolute differentiation between times for global and local dimensions, but the way in which it was possible to manipulate the response on those dimensions by changing the attentional or informational constraints on the task.

The three conditions indicated that changes in attentional focus can influence speed of processing for a particular pattern, as demonstrated most strikingly in the physical identity pairings (Table 1). Although target and probe were idential and were separated by only a 500 msec interval, the pattern of responding changed among attentional conditions.

Results of the "same" trials indicate that matches of good patterns result in faster RTs than matches of poor patterns. This was true, however, only for the relevant dimensions. In the identity trials, the goodness of the irrelevant dimension did not reliably affect RT. In the non-identity "same" trials (Table 2), the goodness of the irrelevant dimension did influence RT; good patterns slowed responding. At first glance this may seem counterintuitive, since good patterns normally speed processing. However, in this case, the irrelevant dimension is providing evidence for a mismatch. Thus a good mismatch may provide stronger evidence for a "different" response and thus interferes with a corrrect "same" response.

In addition, there is interference both of global matches on local responses and of local matches on global responses. Thus, the quality of information can influence speed of processing at either level.

In contrast, there were few significant effects of goodness for the "different" trials, and the results are consistent with a deadline model in which a "different" response is made if a match is not found after a specified period. As noted in the results section, the absolute values of "different" RTs indicate that there may be some small effects of an irrelevant match, similar to those for "same" trials.

These results are generally consistent with a parallel-processing associative model like that proposed by Ratcliff (1978; 1981). Evidence is accumulated over time for both a match and a non-match of probe to target. A response depends on sufficient accumulated evidence to reach a criterion. In this experiment, it can be argued that global and local information are accumulated in parallel. An identical match in the Dual condition, for example, takes roughly the same amount of time as a match in the longer of the equivalent Global and Local conditions. This argues against serial analysis of the two stimulus dimensions.

RT differences within condition, however, indicate that the rate of accumulation of evidence is dependent on stimulus goodness or information quality. Interestingly, the goodness of stimuli that matched on the irrelevant dimension did not influence the "same" RT. It may be that any positive evidence is balanced by a greater difficulty with focusing of attention. Thus a good irrelevant match would add to the evidence for a match more rapidly than a poor irrelevant match; at the same time, insofar as good patterns are more effective in capturing attention, they would tend to make attentional allocation to the relevant dimension more difficult.

The major intereference effect that was observed appears to result from response competition. Good stimuli provide evidence more quickly; when they conflict with the match on the relevant dimension they inhibit a matching response.

Of course, the kinds of matching described here, are only one part of scene analysis. As Pomerantz (1983) has noted, there are different ways to describe "global" stimuli, and positional location of elements is only one category of description. Nevertheless, the general problem of segregation and combination evidenced in our experimental stimuli is an essential component of more complex analyses. A classic case of a related problem is the blocks world that has been carefully examined in computer vision systems (Brady, 1981). This scene consists of a collection of objects which themselves may be organized into more complex objects. In that context, it could be asked, for example, if an arch is detected first and then decomposed into supports and bridge or if the supports and bridge are isolated and then used to constitute an arch. The present experiment argues that there is no single answer. It depends upon the characteristics of the components and the overall structure. If there are a number of irregular blocks that compose a regular arch, the arch will be perceived more readily. If, on the other hand, the arch itself is irregular (as in some of the architectural works of Gaudi) whereas the components are themselves more regular structures (good patterns), then the components will stand out first.

The processing explanation that may account for these data is a system that engages in parallel constraint satisfaction (Huffman, 1971; Clowes, 1971). Objects can be defined and segregated by selecting features. The features, however, can be grouped together in only certain ways, that is, there are constraints on the possible combinations of lines forming objects. If this is the kind of analysis that is performed in vision, however, then there is no strict hierarchy of perception. Rather, the source of constraint satisfaction can be thought of as the source specifying pattern information. If the global pattern provides constraint quickly, then perception can be thought of as top-down. However, if the constraints are generated by individual elements, then perception will appear bottom-up. Information precedence fits the data better than global precedence, and it also provides a framework for a reasonably parsimonious processing mechanism.

References

Boer, L.C. and Keuss, P.J.G. (1982). Global precedence as a post-perceptual effect: An analysis of speed-accuracy tradeoff functions. **Perception and Psychophysics**, 31, 358-366.

Brady, J.M. (Ed.) (1981). **Computer vision**. Amsterdam: North-Holland.

Clowes, M. (1971). On seeing things. **Artificial Intelligence**. 2(1).

Garner, W.R. (1962). **Uncertainty and structure as psychological concepts.** New York: John Wiley and Sons.

Garner, W.R. (1974). **The processing of information and structure.**, Potomac, Maryland, Lawrence Erlbaum.

Grice, G.R., Canham, L. and Boroughs, J.M. (1983). Forest before trees? It depends where you look. **Perception and Psychophysics**, **33**, 121-128.

Hoffman, J.E. (1980). Interaction between global and local levels of a form. **Journal of Experimental Psychology: Human Perception and Performance**, **6**, 222-234.

Huffman, D. (1971). **Impossible objects as nonsense sentences. In B. Meltzer & D. Michie (Eds.) Machine intelligence 6.** Edingurgh, Scotland: Edinburgh University **Press.**

Hughes, H.C., Layton, W.M. and Baird, J.C. and Lester, L.S. (1984). Global precedence in visual pattern recognition. **Perception and Psychophysics**, 35, 361-371.

Kinchla, R.A. and Wolfe, J.M. (1979). The order of visual processing: "top-down", "bottom-up" or "middle-out". **Perception and Psychophysics**, **25**, 225-231.

Lockhead, G.R. (1972). **Processing dimensional stimuli: A note. Psychological Review**, **79**, 410-419.

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

Martin, M. (1979). Local and global processing: The role of sparsity. **Memory and Cognition**, **7**, 476-484.

Miller, J. (1981). Global precedence in attention and decision. **Journal of Experimental Psychology: Human Perception and Performance**, 7, 1161-1174.

Millspaugh, J.R. (1978). Effects of array organization on same-different judgements. **Perception and Psychophysics**, 23, 27-35.

Navon, D. (1977). Forest before trees: The precedence of global features in visual perception. **Cognitive Psychology**, **9**, 353-383.

Navon, D. (1981a). The forest revisited: More on global precedence. **Psychological Research**, **43**, 1-32.

Navon, D. (1981b). Do attention and decision follow perception? Comment on Miller. **Journal of Experimental Psychology: Human and Performance, 7,** 1175-1182.

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. and Sager, L.C. (1975). Asymmetric integrality with dimensions of visual pattern. **Perception and Psychophysics, 18,** 460-466.

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

Ratcliff, R. (1978). A theory of memory retrieval. **Psychological Review, 85,** 59-108.

Ratcliff, R. (1981). Parallel-processing mechanisms and processing of organized information in human memory. In G.E. Hinton and J.A. Anderson (Eds.), **Parallel models of associative memory.** Hillsdale, NJ: Lawrence Erlbaum Associates.

Sebrechts, M.M. (1980). **On the relation between goodness and similarity: Stimulus-specific and context-specific properties.** Unpublished doctoral dissertation, Yale University, New Haven.

Sebrechts, M.M. and Garner, W.R. (1981). Stimulus-specific processing consequences of pattern goodness. **Memory and Cognition, 9,** 41-49.

Ward, L.M. (1982). Determinants of attention to local and global features of visual forms. **Journal of Experimental Psychology: Human Perception and Performance, 8,** 562-581.