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The role of wholistic/configural properties versus global properties in visual form perception

Ruth Kimchi
Department of Psychology, University of Haifa, Haifa 31905, Israel
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Abstract. A distinction has previously been proposed between global properties, defined by their position in the hierarchical structure of the stimulus, and wholistic/configural properties defined as a function of interrelations among component parts. The processing consequences of this distinction were examined in five experiments. In experiments 1-4 configural properties (closure and intersection) were pitted against component properties (line orientation and direction of curvature) and the results showed that discrimination and classification performance was dominated by the configural properties. In experiment 5 the relative perceptual dominance of type of property (configural/nonconfigural) and level of pattern structure (global/local) was examined. The results showed that classifications based on the configural property of closure were not affected at all by the level of globality at which this property varied. Global advantage was observed only with classifications based on line orientation. Taken together, the present results suggest that configural properties dominate discrimination and classification of visual forms, whereas the perceptual advantage of the global level of structure depends critically on the type of properties present at the global and local levels. These findings are also discussed in relation to findings on texture perception, and it is suggested that the perceptual system may be characterized by a predisposition for configural properties.

1 Introduction

The question whether perception is analytic or wholistic is an enduring issue in psychology. The notion of wholistic processing, which is considered to be in the spirit of the Gestalt theory, refers to the hypothesis that the initial information-processing step in the identification, discrimination, or classification of objects involves processing of wholistic properties rather than component properties. Wholistic properties are properties that depend on the interrelationships among the stimulus components (eg Garner 1978). The Gestaltist claim that the whole is different from the sum of its parts (eg Wertheimer 1967) can perhaps be captured by the notion of wholistic properties such as closure, symmetry, parallelism, and certain other spatial relations among components. Such properties are also termed configural properties and hereafter I will use these two terms interchangeably.

The global/local paradigm proposed by Navon (1977) is an attempt to test the hypothesis about the perceptual primacy of wholistic properties. The paradigm employs hierarchically constructed patterns in which larger figures are constructed by suitable arrangement of smaller figures. An example is a set of large letters (eg a large H and a large S) constructed from the same set of smaller letters (eg small Hs and small Ss). In a typical experiment within the global/local paradigm subjects are presented with such stimuli and are required to identify the larger or the smaller letter. Performance measures such as relative speed of identification and/or asymmetric interference are then used to infer global or local precedence. This paradigm is widely used, and often a finding of global advantage is taken as suggestive of the primary of wholistic properties (eg Robertson and Lamb 1991; Treisman 1986; Uttal 1988).

Despite the elegance of the global/local paradigm in controlling for many nuisance variables, I have raised several questions regarding the appropriateness of this paradigm for testing the hypothesis about the primacy of wholistic properties [see Kimchi (1992) for an extensive review]. For example, the difference between global and local properties (as operationally defined in the global/local paradigm) may be captured in terms of relative size. Furthermore, relative size alone may provide a reasonable account for obtained global advantage with hierarchical patterns (Navon and Norman 1983). Yet, the difference between wholistic and component properties is not necessarily their relative size. To distinguish, for example, the closedness of a square (a configural/wholistic property) from its component vertical and horizontal lines on the basis of their relative sizes would seem to miss the point. Rather, the essential characteristic of wholistic properties is that they do not inhere in the components, but depend instead on the interrelations among them (see also Rock 1986). Such properties are also often termed 'emergent properties' (eg Pomerantz and Pristach 1989). I refrain from using this term because of the semantic connotation of the term 'emergent'. Describing such properties as 'emerging' from the interrelations among components may imply that they are perceptually derived, although it is possible that they are directly detected by the perceptual system (see also Kimchi and Goldsmith 1992). Therefore I prefer the terms 'wholistic' or 'configural'.

In the typical stimuli used within the global/local paradigm, the larger figure is considered a higher-level unit relative to the smaller figures, which are, in turn, lower-level units. Properties of the higher-level unit are considered to be more global than properties of the lower-level units by virtue of their position in this hierarchy. Thus, the hypothesis actually tested in the global/local paradigm is that the properties of a higher-level unit are perceived first, followed by analysis of the properties of the lower-level units (Kimchi 1983, 1992; Navon 1981; Ward 1982). This is a legitimate and viable hypothesis, but it is not the same as testing the hypothesis that processing of wholistic properties of a visual object precedes processing of its component properties. For example, one may ask whether apprehension of the roundness of a face (a global property) precedes apprehension of the roundness of the eyes (a local property). But this is not the same as asking whether apprehension of a certain property defined by the interrelations among the components of the face (ie a configural property) is prior to the apprehension of component parts. Yet, it is the configural property that may be crucial for discriminating between faces.

Thus, although the terms global and wholistic are often used interchangeably, I have suggested that we distinguish between them (Kimchi 1992). Global properties are defined by their position in the hierarchical structure of the stimulus, so that properties at the higher level of structure are considered more global than properties at the lower level of structure. Wholistic or configural properties, on the other hand, are defined as a function of interrelations among component parts. It follows, then, that not all the properties which would be considered global according to the operational definition in the global/local paradigm are necessarily wholistic/configural properties because certain global properties do not depend on the spatial relations among the component parts.

Do wholistic/configural properties dominate component properties in the identification, discrimination, or classification of visual objects? Several findings reported in the literature seem to suggest the processing dominance of wholistic/configural properties such as closure, parallelism, and intersection in various information-processing tasks (eg Kolinsky and Morais 1986; Lasaga 1989; Pomerantz and Garner 1973; Pomerantz and Pristach 1989; Pomerantz et al 1977; Treisman and Paterson 1984). For example, Pomerantz et al (1977) found that () and ((were more easily discriminated from one another than (and), and that ⊿ and ⊻ were more easily discriminated from one another than / and \, findings they termed 'configural-superiority effects'. Yet, Pomerantz and Pristach (1989) and Treisman and Gormican (1988) reported some findings that led them to question the effectiveness of such properties for form and texture perception. For example, Pomerantz and Pristach (1989) found the same pattern of performance in tasks involving selective and divided attention with a set of four stimuli that varied with respect to closure and with a set of four stimuli that were identical with respect to closure (Pomerantz and Pristach, experiment 6). However, this finding does not necessarily imply that closure is not an important property for form perception. Rather, it may suggest that closure is not the only important one.

The purpose in the present study was twofold: The first purpose was to examine further the perceptual relations between configural and component properties. Experiments 1 - 4 were designed to test the hypothesis that configural properties dominate discrimination and classification of visual stimuli. The second was to examine the processing consequences of the proposed distinction between global properties and wholistic/configural properties. In experiment 5 I examined the relative perceptual dominance of level of stimulus structure (global/local) versus type of property (configural/nonconfigural).

2 Overview of experiments 1 - 4

In order to examine the perceptual relations between configural and component properties I employed a logic similar to the one proposed by Lasaga (1989). A pattern of performance in discrimination and classification tasks with a set of four visual stimuli varying in simple, nonconfigural property was obtained. The discrimination performance reveals the degree of perceived interstimulus similarity between the stimuli in the set, and the classification performance reveals which grouping maximizes perceived intragroup similarity and minimizes perceived intergroup similarity. Then a pattern of performance in discrimination and classification tasks with a set of four stimuli defined on spatial relations among these simple stimuli was obtained. These stimuli were similar/dissimilar to each other in their component properties, in their configural properties, or in both. A comparison between the two patterns of performance allows an evaluation of the relative perceptual dominance of the two types of properties. If the discrimination between stimuli that have dissimilar configural properties is always easier than discrimination between stimuli that have similar configural properties, irrespective of the discriminability of their component properties, and if classification according to configural properties is the easiest one, then processing dominance of configural properties can be inferred.

The stimuli used in experiment 1 were simple lines varying in orientation (horizontal, vertical, and two diagonal lines). Authors of previous studies have suggested that processing of oblique lines is more difficult than processing of vertical or horizontal lines [the 'oblique effect' (Appelle 1972; Essock 1980)]. Lasaga and Garner (1983) showed that discrimination between two diagonal lines was poorer than discrimination between any other possible pair of lines, and that the classification that involved grouping of the two diagonal lines together and the horizontal and vertical lines together was the easiest one. In experiment 1 I attempted to replicate these findings in order to follow the aforementioned logic of the present experiments.

The stimuli used in experiment 1 were grouped to form the set of stimuli used in experiment 2 (square, diamond, +, and ×). Lasaga (1989) reported reaction-time data for discrimination and classification tasks with a similar set of four stimuli, all of which consisted of physically connected lines. Her data seem to indicate processing dominance of wholistic/configural properties. However, Lasaga claimed that such processing dominance is likely to occur only with connected stimuli, and not with stimuli consisting of disconnected components. I argue, on the other hand, that when both configural and component properties are available for the task at hand, configural properties dominate processing, regardless of the physical 'connectedness' of the stimulus components. To test this hypothesis the stimuli used in experiment 2 were similar to the ones used by Lasaga, but all the stimuli consisted of disconnected line components.

Experiments 3 and 4 employed the same logic as in experiments 1 and 2 with different stimulus sets in order to increase the generalization of the findings.

3 Experiment 1

3.1 *Method*

3.1.1 *Subjects.* Eighteen students from the University of Haifa, fourteen women and four men aged between 20 and 27 years, participated in this experiment for course credit. All had normal vision.

3.1.2 *Apparatus.* The experiment, including stimulus presentation, was controlled by an Apollo DN4000 workstation.

3.1.3 *Stimuli.* The stimuli were four lines varying in orientation: a vertical line, a horizontal line, a left diagonal (45° counterclockwise from the vertical), and a right diagonal (45° clockwise from the vertical) (see figure 1). Each stimulus subtended 0.46 deg of visual angle for length.

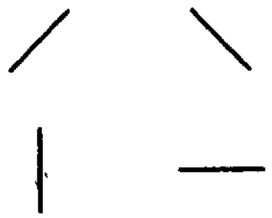

Figure 1. The stimulus set used in experiment 1.

3.1.4 *Design and procedure.* Nine different tasks were used. In each task subjects were instructed to assign each stimulus to one of two groups. The stimuli were presented one at a time and a two-choice speeded response was required to be given by moving a small lever up or down. In the discrimination tasks, only two stimuli were used, and the two stimuli were assigned to different responses. In the classification tasks all four possible stimuli were used, and two of the stimuli were assigned to each of the two responses. There were six discrimination tasks (according to the six possible different pairings of the four stimuli) and three classification tasks. Each task consisted of a block of fifty-two experimental trials preceded by sixteen practice trials, with each stimulus in the subset occurring on an equal number of trials. The response assignment for the stimuli and the order of the tasks were counterbalanced across subjects.

Each experimental trial began with the appearance of a fixation dot for 500 ms. After an interval of 500 ms the stimulus appeared at the center of the screen and stayed on until subject responded. 2000 ms were allowed for the response. Subjects were informed about the relevant stimulus set and the response assignment at the beginning of each task, and were encouraged to respond as quickly and as accurately as possible. The experiment lasted about 45 min.

3.2 *Results*

Mean correct reaction times and percentage errors for the different tasks are presented in table 1. Two separate repeated-measures analyses of variance (ANOVAs) were performed, one for the discrimination tasks and one for the classification tasks.

As may be seen in table 1, the discrimination between the two oblique lines tended to be the slowest one, but this difference did not reach statistical significance. The one-factor repeated-measures ANOVA performed on the classification data indicated a significant effect of task ($F_{2,34} = 18.41$, $p < 0.0001$, for reaction times; $F_{2,34} = 4.03$, $p < 0.03$, for percentage errors). A posteriori comparisons by means of Duncan's procedure revealed that grouping of the horizontal and vertical line together and the two diagonal lines together was significantly faster and more accurate than the two other ways of grouping. These results seem to replicate those of Lasaga and Garner (1983).

Table 1. Mean reaction time and percentage errors for the discrimination and classification tasks in experiment 1 (V vertical, H horizontal, L left oblique, R right oblique).

Task	Reaction time/ms	Error/%
Discrimination tasks		
V/H	516	2.54
R/L	537	2.01
V/L	520	1.13
V/R	512	1.83
H/L	525	1.54
H/R	519	1.56
Classification tasks		
RL/VH	553	2.16
VL/HR	676	7.76
VR/HL	678	10.56

4 Experiment 2

4.1 *Method*

4.1.1 *Subjects.* Eighteen students from the University of Haifa, thirteen women and five men aged between 18 and 28 years, participated in the experiment for course credit. All had normal vision. None had participated in the previous experiment.

4.1.2 *Stimuli.* The simple stimuli used in experiment 1 were grouped to form another total set of four stimuli that was used in experiment 2. The relevant groupings were those which produced stimuli which differed in highly discriminable component properties, but shared configural property (eg a square and a diamond), and those producing stimuli which shared component property, but differed in configural property (eg a square and a +). The stimuli were square, diamond, +, and ×. All stimuli were disconnected (see figure 2). Each stimulus subtended about 0.64 deg of visual angle in height and width.

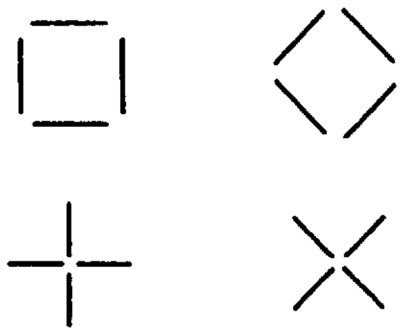

Figure 2. The stimulus set used in experiment 2.

4.1.3 *Apparatus, design, and procedure.* The apparatus, design, and procedure were the same as those of experiment 1.

4.2 *Results*

Mean reaction times and percentage errors for the different tasks are presented in table 2. One-factor ANOVA performed on the discrimination data indicated a significant effect of task ($F_{5,85} = 6.36$, $p < 0.0001$) for reaction times only. Duncan's a posteriori comparisons revealed that the two slowest discriminations were between square and diamond, and between + and ×, presumably because of the similarity in a configural property in each of these pairs. All the other discriminations were equally fast, regardless of the discriminability of the component properties as revealed in experiment 1.

One-factor ANOVA performed on the classification data indicated a significant effect of task ($F_{2,34} = 50.53$, $p < 0.0001$, for reaction times; $F_{2,34} = 5.68$, $p < 0.008$, for percentage errors). A posteriori comparisons revealed significant differences between the three tasks. The fastest classification involved grouping of the square and diamond together and the + and × together, presumably on the basis of configural properties. The next fastest classification involved grouping the square and + together and the diamond and × together, presumably on the basis of the component properties. These two classifications were significantly faster and more accurate than the classification that involved grouping the square and × together and the diamond and + together.

Table 2. Mean reaction time and percentage errors for the discrimination and classification tasks in experiment 2 (S square, D diamond).

Task	Reaction time/ms	Error/%
Discrimination tasks		
S/D	516	2.03
+/×	531	2.22
S/+	486	1.04
S/×	486	1.54
D/+	494	0.83
D/×	490	2.26
Classification tasks		
SD/+×	491	1.34
S+/D×	608	4.43
S×/D+	675	15.35

4.3 *Discussion: Experiments 1 and 2*

The pattern of performance obtained in experiment 2 was not predicted by the pattern of performance obtained in experiment 1. The classification performance in experiment 1 indicated that the classification that involved grouping of the horizontal and vertical lines together and the two diagonal lines together was significantly faster than the two other ways of groupings. Granted that classification performance is a function of both intragroup similarity and intergroup dissimilarity, the classification performance in experiment 1 led to the prediction that a discrimination between a stimulus consisting of vertical and horizontal lines and a stimulus consisting of oblique lines would be easier than a discrimination between a pair of stimuli that have similar component lines, and that the easiest classification would be the one that involves grouping of the square and + together and the diamond and × together. Contrary to this prediction, the two most difficult discriminations involved stimulus pairs with one stimulus consisting of horizontal and vertical lines and the other consisting of oblique lines (square versus diamond, and + versus ×). While the two stimuli in each of these pairs differ in component properties, they have similar configural property (closure in the first, and intersection in the second). Therefore, the difficulty in the discrimination may be attributed solely to the similarity in the configural property in each of these pairs. In addition, the discrimination between a pair of stimuli that differed in configural property was as easy whether or not they differed in component properties. For example, mean reaction time for the discrimination between square and + was identical to that for the discrimination between square and × (see table 2), despite the fact that the first pair shared component properties and the second pair did not. Thus, the discrimination performance in experiment 2 suggests that configural properties dominated processing above and beyond any differences in the discriminability of the components.

The classification performance in experiment 2 also suggests the processing dominance of configural properties because the classification that was presumably based on configural properties was the easiest one. Note that the next easiest classification was the one that was presumably based on component properties. This finding suggests that when configural properties are not effective for the task at hand, information-processing tasks can be performed on the basis of component properties, but there is a significant cost of time relative to performance based on configural properties.

The pattern of results obtained in experiment 2 with disconnected stimuli was similar to the one reported by Lasaga (1989) with connected stimuli. Therefore, this pattern of performance cannot be accounted for by 'connectedness'. Rather, these findings seem to suggest that discrimination and classification performance is dominated by configural properties.

5 Experiment 3

5.1 *Method*

5.1.1 *Subjects*. Eighteen students from the University of Haifa, fourteen women and four men aged between 20 and 25 years, participated in this experiment for course credit. All had normal vision. None had participated in the previous experiments.

5.1.2 *Stimuli*. The four stimuli used in experiment 3 were four curved lines varying in direction of curvature (right, left, up, down). The stimuli are presented in figure 3. Each stimulus subtended 0.38 deg of visual angle for length.

Figure 3. The stimulus set used in experiment 3.

5.1.3 *Apparatus, design, and procedure*. The apparatus, design, and procedure were the same as those of experiment 1.

5.2 *Results*

Mean reaction times and percentage errors for the different tasks are presented in table 3. One-factor repeated-measures ANOVA performed on the discrimination data did not indicate significant differences between the tasks. The ANOVA performed on the classification data indicated a significant effect of task ($F_{2,34} = 15.58$, $p < 0.0001$, for reaction times; $F_{2,34} = 6.78$, $p < 0.0033$, for percentage errors). Duncan's a posteriori comparisons revealed that the easiest classification involved grouping of the two vertically aligned lines (right and left direction of curvature) together and the two horizontally aligned lines (up and down direction of curvature) together.

Table 3. Mean reaction time and percentage errors for the discrimination and classification tasks in experiment 3.

Task	Reaction time/ms	Error/%
Discrimination tasks		
(/)	573	3.32
⌣/⌢	560	1.43
(/⌣	566	2.91
(/⌢	546	1.24
)/⌣	564	2.64
)/⌢	537	1.84
Classification tasks		
()/⌣⌢	579	3.69
(⌣/)⌢	682	6.44
)⌣/(⌢	742	11.43

6 Experiment 4

6.1 *Method*

6.1.1 *Subjects.* Eighteen students from the University of Haifa, fourteen women and four men, aged between 21 and 25 years, participated in this experiment for course credit. All had normal vision. None had participated in the previous experiments.

6.1.2 *Stimuli.* The four stimuli used in experiment 4 are presented in figure 4. Each curved line subtended 0.38 deg for length, and the narrowest gap between the lines subtended 0.16 deg.

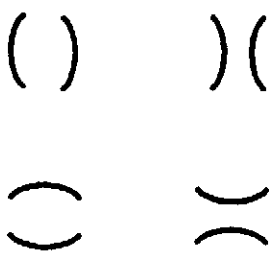

Figure 4. The stimulus set used in experiment 4.

6.1.3 *Apparatus, design, and procedure.* The apparatus, design, and procedure were the same as those of experiment 1.

6.2 *Results*

Mean reaction times and percentage errors for the different tasks are presented in table 4. One-factor ANOVA performed on the discrimination data indicated a significant effect of task ($F_{5,85} = 3.94$, $p < 0.003$, for reaction times; $F_{5,85} = 4.02$, $p < 0.003$, for percentage errors). Duncan's a posteriori comparisons revealed that the most difficult discrimination was between)(and ≍ .

The ANOVA performed on the classification data also indicated a significant effect of task ($F_{2,34} = 44.79$, $p < 0.0001$, for reaction times; $F_{2,34} = 20.53$, $p < 0.0001$, for percentage errors). A posteriori comparisons revealed that the two easiest tasks were the classification that involved the grouping of ( ) and ⊂ together and)(and ≍ together, and the classification that involved grouping of ( ) and)(together and ⊂ and ≍ together.

Table 4. Mean reaction time and percentage errors for the discrimination and classification tasks in experiment 4.

Task	Reaction time/ms	Error/%
Discrimination tasks		
( )/)(	483	3.99
⊂/≍	490	1.85
( )/⊂	506	4.63
( )/≍	498	2.30
)(/⊂	498	3.15
)(/≍	539	5.52
Classification tasks		
( ))(/⊂≍	560	7.41
( )⊂/)(≍	518	3.83
)(⊂/( )≍	768	18.63

6.3 *Discussion: Experiments 3 and 4*

Generally speaking, the results of experiments 3 and 4 were similar to the ones obtained in the first pair of experiments. Once again, the pattern of performance obtained with the components (experiment 3) did not allow us to predict the pattern of performance obtained with the configurations (experiment 4). The classification performance in experiment 3 led to the prediction of an easy discrimination between a stimulus consisting of the vertically aligned lines and a stimulus consisting of the horizontally aligned lines, and that the easiest classification would be the one that involves grouping of the stimuli consisting of the vertically aligned lines together and the stimuli consisting of the horizontally aligned lines together. Contrary to these predictions, the most difficult discrimination was between)(and ≍ , and the easiest classification involved grouping of ( ) and ⊂ together and)(and ≍ together. The latter classification was presumably based on the configural property of closure/nonclosure. The next easiest classification in experiment 4 involved grouping of ( ) and)(together and ⊂ and ≍ together. This finding may suggest that classification based on component properties (ie vertically versus horizontally aligned lines) was as easy as classification based on configural properties. However, with these stimuli the verticality/horizontality of the components coincides with the verticality/horizontality of the stimulus as a whole. Therefore, performance may well be accounted for by the verticality/horizontality of the configurations rather than that of the components.

Taken together, the findings of experiments 1–4 indicated the relative processing dominance of closure and intersection rather than line orientation and direction of curvature. These findings converge with previous findings (eg Pomerantz et al 1977) and are seen to suggest that configural properties rather than component properties dominate human discrimination and classification performance.

7 Experiment 5

Experiment 5 was designed to examine the relative perceptual dominance of level of structure (global/local) and type of property (configural/nonconfigural). In order to do so it was necessary to manipulate these two factors orthogonally. With Navon's (1977) type of hierarchical stimuli it is possible to construct stimuli in which different types of properties are present at the global and the local levels of the stimulus.

Thus, experiment 5 employed stimuli that varied in configural and nonconfigural properties, on the global or the local levels.

If configural properties are invariably favoured by the perceptual system, then classification based on configural properties should be easier than classification based on nonconfigural properties, regardless of the level of structure at which these properties are present. If, on the other hand, the perceptual system invariably prefers the global over the local level of pattern structure, then classification based on the global level should be easier than classification based on the local level, regardless of the properties present at each level. Different patterns of performance should reflect an interaction between level of pattern structure and type of property.

7.1 *Method*

7.1.1 *Subjects.* Sixteen students from the University of Haifa participated in this experiment for course credit. There were ten women and six men, aged between 18 and 33 years. All had normal vision. None had participated in the previous experiments.

7.1.2 *Stimuli.* Four sets of four stimuli each were created by orthogonally combining type of property (configural/nonconfigural), level of pattern structure (global/local), and congruency between the two levels (in terms of type of property). The configural property was closure/nonclosure, and the nonconfigural property was line orientation (oblique/nonoblique). Two sets—the congruent sets—consisted of stimuli in which the same type of property (either closure/nonclosure or oblique/nonoblique) was present at the global and the local levels (see figures 5a and 5b). The other two sets—the incongruent sets—consisted of stimuli in which a different type of property was present at the global and at the local level (ie closure/nonclosure at the global level and oblique/nonoblique at the local level, or vice versa; see figures 5c and 5d). The global square subtended 1.11 deg of visual angle, the global diamond subtended 1.27 deg, the global + subtended 1.27 deg, and the global × subtended 1.11 deg. The global line subtended about 1.49 deg of visual angle for length. Each local square subtended 0.16 deg, and each local diamond subtended 0.22 deg. Each local line subtended 0.16 deg of visual angle for length.

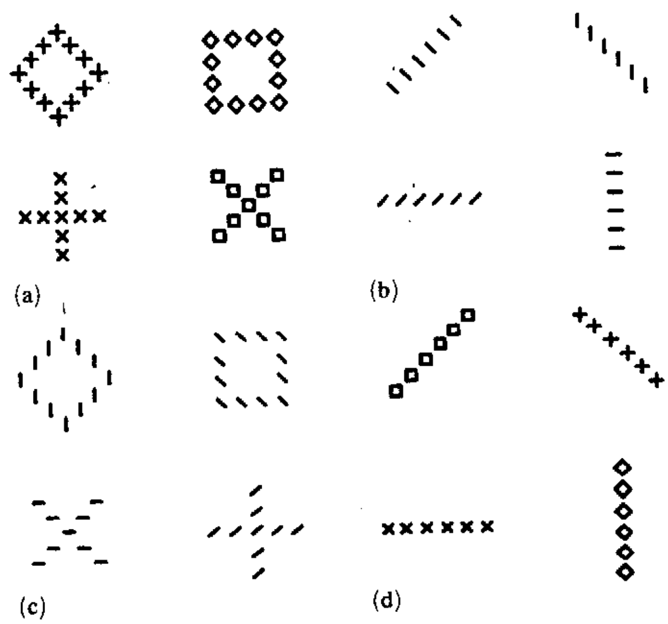

Figure 5. The four stimulus sets used in experiment 5.

7.1.3 *Design and procedure*. The experiment employed a completely within-subject, three-factor design: task (global and local classification), type of property (configural/nonconfigural), and congruency. All factors were combined orthogonally. There were two speeded classification tasks. One task—the global classification task—required classification of the four stimuli in a set into two groups on the basis of the variability present on the global level of the stimuli. For stimulus sets a and c the property involved in the global classification was configural (closure/intersection): subjects were required to give one response whenever either the global square or the global diamond appeared and the other response to either the global + or the global ×. For stimulus sets b and d the property involved was nonconfigural (oblique/nonoblique): subjects were required to give one response whenever either of the two global oblique lines appeared and the other response to either the global horizontal line or the global vertical line. The other task—the local classification task—required classification of the four stimuli in a set into two groups on the basis of the variability present on the local level of the stimuli. For stimulus sets a and d the property involved in the local classification was configural: subjects were required to give one response whenever either the local square or the local diamond appeared and the other response to either the local + or the local ×. For stimulus sets b and c the property involved was nonconfigural: subjects were required to give one response whenever either of the two local oblique lines appeared and the other response to either the local horizontal line or the local vertical line.

Subjects performed each task with each set of stimuli in separate blocks. Altogether there were eight blocks of sixty-four experimental trials each, preceded by twenty-four practice trials, with each stimulus in the set occurring on an equal number of trials. At the beginning of each block subjects were instructed about the stimulus set and the stimulus-response mapping. The response assignment for the stimuli and the order of the blocks were counterbalanced across subjects. All the other aspects of the procedure and the apparatus were identical to those of the previous experiments.

7.2 *Results*

Mean reaction times and percentage errors for the performance on the classification tasks are presented in table 5. The reaction-time and error data were analyzed by a three-factor (task × property × congruency) repeated-measures ANOVA. The analysis for the reaction-time data indicated a significant effect of task ($F_{1,15} = 8.71$, $p < 0.01$), a significant effect of type of property ($F_{1,15} = 36.92$, $p < 0.0001$), and a significant interaction between task and type of property ($F_{1,15} = 10.42$, $p < 0.006$). The effect of congruency was not significant, and none of the interactions involving this factor was significant ($F < 1$ in each case). Mean response times as a function of task and type of property (across congruency) are presented in figure 6. The error data showed similar effects to those of the reaction time, but only the effect of type of property reached statistical significance ($F_{1,15} = 9.77$, $p < 0.007$). Error rates were very low (an overall mean of 2.66%), and there was no indication of speed-accuracy trade-off. Therefore, error data will not be discussed further.

A breakdown of the task × property interaction revealed that classification based on closure/intersection was faster than classification based on line orientation for the two tasks ($F_{1,15} = 28.25$, $p < 0.0001$, and $F_{1,15} = 29.34$, $p < 0.0001$, for global and local classification, respectively). However, global classification based on line orientation was significantly faster (by an average of 77 ms) than local classification based on line orientation ($F_{1,15} = 32.47$, $p < 0.0001$), whereas global classification based on closure/nonclosure was virtually the same as local classification based on closure/nonclosure (504 ms and 516 ms, respectively; $F < 1$).

An examination of the performance with the different stimulus sets showed no significant difference between global and local classifications for stimulus set a ($F < 1$) or for stimulus set d ($F_{1,15} = 2.33$, $p > 0.14$). Global classification was significantly faster than local classification for stimulus set b ($F_{1,15} = 6.79$, $p < 0.02$) and for stimulus set c ($F_{1,15} = 42.69$, $p < 0.0001$). Thus, regardless of which property, configural or nonconfigural, was present at the global level of the stimulus, global advantage was observed only with stimulus sets in which line orientation was present at the local level of stimuli, and no advantage (global or local) was observed with stimulus sets in which closure was present at that level.

Table 5. Mean reaction time and percentage errors in experiment 5.

Property	Global		Local	
	reaction time/ms	error/%	reaction time/ms	error/%
Congruent stimuli				
Closure	512	1.44	510	2.38
Line orientation	576	3.22	643	4.24
Incongruent stimuli				
Closure	495	1.36	522	2.75
Line orientation	555	2.51	642	3.91

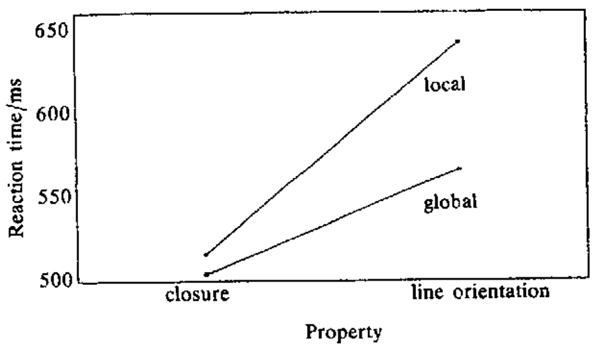

Figure 6. Experiment 5: reaction times for global and local classifications as a function of type of property.

7.3 *Discussion*

The main finding of experiment 5 was that classification based on closure/nonclosure was not affected at all by the level of structure (global or local) at which this property varied, whereas classification based on line orientation was easier when this property varied at the global level than when it varied at the local level of structure.

None of the variables found to affect global/local advantage (see Kimchi 1992) was operating in the present experiment. Rather, the characteristics of the present stimuli were the same as those of stimuli that tend to produce global advantage in the global/local paradigm: the overall size of each stimulus was less than 7 deg of visual angle (eg Kinchla and Wolfe 1979), the larger stimuli were not composed of few sparse elements (eg Martin 1979), the larger and the smaller figures did not differ in 'goodness' (eg Hoffman 1980), and the global/local classification was not confounded with retinal location (eg Grice et al 1983). Yet, the present results clearly showed that the presence or absence of global advantage depended on the property involved in the classifications. Global advantage was observed only when the classifications involved line orientation (oblique/nonoblique). When the classifications involved closure/ nonclosure, no global or local advantage was observed. These findings seem to suggest that configural properties (eg closure, intersection) are salient to the perceptual system, regardless of level of globality. Only nonconfigural properties such as line orientation benefit from a higher level of globality.

From the point of view presented in this paper, the finding that configural properties were not affected by level of globality provides further converging evidence for the notion of processing dominance of configural properties. One may argue, however, that the present pattern of results reflects nothing more than a difference in discriminability between the specific properties employed, namely, that closure is more discriminable from intersection than are oblique lines from nonoblique (ie horizontal and vertical) lines, and that lower level of globality is more detrimental for the less discriminable property, for example, because of relative size. My claim is that configural properties may be inherently more discriminable than nonconfigural properties, thus reflecting a predisposition of the human perceptual system rather than an arbitrary choice of the investigator. It is perhaps not accidental that in an attempt to equate the discriminability of the global and local levels, Pomerantz and Sager (1975) used hierarchical stimuli that varied in a nonconfigural property at the global level and in a configural property at the local level (large × and + composed of small × s and circles).

Further research is needed to support the argument regarding the inherent discriminability of configural properties. There are, however, several findings reported in the literature that seem to suggest its viability. Studies on texture perception have demonstrated that the property of line orientation produces robust segregation when orientation differences are present in the array, with superior segregation for horizontal and vertical lines and vertical or horizontal and diagonal lines than for diagonal lines (eg Beck 1982; Callaghan et al 1986). Closure and intersection also have been found to produce easy, effortless segregation. For example, a group of triangles is effortlessly detectable ('pops out') in a field of arrows, and a group of + s is effortlessly detectable in a field of L s (eg Williams 1992). Interestingly, however, the effectiveness of line orientation for texture segregation is reduced when the elements in the array have similar properties such as intersection and closure (eg a group of × s is not as easily detectable in a field of + s as is a group of diagonal lines in a field of vertical lines; Beck 1982). It seems then that similarity in configural properties overrides differences in nonconfigural property (even those differences that produce the superior segregation in an array of single-line elements), but not vice versa (eg + s and L s).

Regardless of whether texture and form perception involve different or similar perceptual processes (Callaghan et al 1986; Kimchi and Palmer 1985; Pomerantz and Pristach 1989), the similarity between the findings on texture perception described above and the present and previous findings on form perception is quite striking. Form discrimination and classification and spontaneous texture segregation seem to be dominated by configural properties. This may suggest a predisposition of the perceptual system for such properties.

8 General discussion

The findings in the present experiments seem to provide evidence that the proposed distinction between wholistic/configural properties, defined as a function of interrelations among component parts, and global properties, defined by their position in the hierarchical structure of the stimulus, has 'psychological reality'.

In order to test the hypothesis about the perceptual primacy of wholistic/configural properties it is necessary to pit wholistic/configural properties against component properties. In experiments 1 - 4 I attempted to do so by pitting the configural properties of closure and intersection against the component properties of line orientation and direction of curvature. The findings of these experiments converge with previous findings (eg Lasaga 1989; Pomerantz et al 1977) and are seen to suggest that configural

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properties dominate discrimination and classification of visual forms. This is not to say that component, nonconfigural properties are not available for classification and discrimination. Rather, my claim is that when both properties are present in the stimuli and can be used for the task at hand, performance would be dominated by configural properties. Furthermore, the present results indicated that the pattern of performance obtained with the configurations was not predicted by the pattern of performance obtained with their component properties. This finding seems to be in line with a basic tenet of the Gestalt view that a specific perceptual whole is qualitatively different from the complex that one might predict by considering only its parts (Wertheimer 1967).

Whereas the findings of experiments 1-4 indicated the processing dominance of configural properties, the results of experiment 5 showed that global properties do not necessarily dominate local properties in information-processing tasks. Global advantage was observed with stimuli that varied in line orientation, but not with stimuli that varied in closure/intersection.

The finding that the presence or absence of global advantage depended critically on the type of property (configural or nonconfigural) present at the global and the local levels of structure cannot be accounted for by the notion of global precedence (Navon 1977). Rather, it clearly suggests that positing perceptual priority of the global level of stimulus structure as a rigid perceptual law is hardly tenable. In addition, if the notion of wholistic processing refers to the perceptual dominance of wholistic properties, and global properties are not necessarily wholistic, then one should be cautious in making inferences about wholistic processing from the processing advantage of the global level of structure (see also Kimchi 1992).

Leeuwenberg and Van der Helm (1991) also claim that dominant properties are not always global. According to the descriptive minimum-principle approach proposed by Leeuwenberg and Van der Helm, the specification of dominant properties can be derived from simplest pattern representations, and it is suggested that the highest hierarchical level in the simplest pattern representation, the 'superstructure', dominates classification and discrimination of visual forms. The 'superstructure' is not necessarily global or larger. However, the finding of experiment 5 seems to pose a problem for Leeuwenberg and Van der Helm's approach because for the stimuli used in experiment 5 the 'superstructure' coincides with the global level of structure, yet the results showed that the global level is not invariably dominant.

The similarity between the present and previous findings on form perception and the findings on texture perception regarding the dominance of configural properties (section 7.3) may suggest that the human perceptual system is characterized by an inherent predisposition for configural properties. This hypothesis, however, should await further research with other potential configural properties.

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