THE PRECEDENCE OF GLOBAL PROCESSING IN SYMMETRY PERCEPTION

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It is possible to devise two-dimensional symmetry patterns exhibiting reflection, and rotation, which can be studied at two structural levels of the patterns. Firstly, there is the global structural level, defined by the two-dimensional point group specifying the whole pattern and, secondly, there is the local structural level, defined by smaller two-dimensional point groups contained within the pattern. Hence there are two sources of symmetry information which could be utilized by the human visual system in the perception of symmetry. Utilization of information at the global structural level of the pattern implies that the perceptual processes are organized so that they proceed from global structuring of a pattern towards a more detailed analysis of its component parts. On the other hand, utilization of information specified at the local structural level of the pattern, implies that the perceptual system builds up a pattern from an analysis of these component parts.

Recent research has provided evidence for both local and global precedence in perception. Evidence for the precedence of global processing originates in the demonstrations of the Gestalt psychologists, who proposed that the nervous system is organized so as to respond to the 'Gestalt' or overall configuration of a stimulus pattern (Kohler, 1929; Wertheimer, 1958). Similarly, Navon (1977) has argued for global precedence by proposing that global processing is completed before a more local analysis occurs. Recently, however, Kinchla and Wolfe (1979) have shown that the precedence for global processing shown by Navon, shifts to a precedence for local processing as the overall size of the stimulus is increased. Evidence for more locally directed processing comes from Pomerantz and Sager (1975), who showed that subjects are better at ignoring global rather than local forms. Yet, other results show that neither level can be completely ignored (Boer & Keuss, 1982; Hoffman, 1980; Miller, 1981).

The following study tests the hypothesis of global precedence in perception against that of local precedence, by investigating the relative contribution of symmetry information available at the local and global structural levels of the pattern, to the degree of symmetry perceived. It is postulated that if global processing has precedence in perception, then the degree of

perceived symmetry will be specified by symmetry information available at the global structural level of the pattern. If, however, local processing has precedence, then the symmetry information available at the local structural level of the pattern will specify the degree of symmetry perceived. Four different two-dimensional symmetry patterns were created from bilaterally symmetric sequences of differently sized white dots placed against a black background. The first pattern was created by repeating a single such sequence of 16 dots, in both the horizontal and vertical directions, thereby forming a two-dimensional pattern having a four-fold rotation axis and four mirror lines intersecting at its center (4mm). This symmetry structure defined at the global level, is consistent with that of the smaller two-dimensional point groups comprising this pattern, which also have the classification, 4mm (see Figure 1). The second and third patterns were created from two different bilaterally symmetric dot sequences, each of which was comprised of 8 dots. In the second pattern, these sequences extend in the horizontal and vertical directions, thereby forming two-dimensional point groups, half of which have two mirror lines intersecting at the two-fold rotation axis (2mm) and the other half have four mirror lines intersecting at the four-fold rotation axis (4mm). These point groups were reflected about the horizontal and vertical axes to form a larger two-dimensional point group having the classification, 4mm (see Figure 2). In the third pattern, the order of occurrence of the bilaterally symmetric dot sequences used in the second pattern was reversed for the sequences extending in the horizontal direction. The result of this was to produce two-dimensional point groups which are the same as those in the preceding pattern, but which are differently arranged relative to each other. Thus the reflection of these groups about the horizontal and vertical axes produced a larger two-dimensional point group having the classification, 2mm (see Figure 3). Thus both the second and third patterns specify the same symmetry structure at their local structural level, but in both instances this symmetry structure is not consistent with that defined at the global level of the patterns. The fourth pattern was created by combining the bilaterally symmetric sequences of dots used in the preceding patterns. The result of this was to produce two-dimensional point groups having two mirror lines intersecting at the two-fold rotation axis (2mm). These groups were reflected about the horizontal and vertical axes to form a larger two-dimensional point group having the classification, 2mm (see Figure 4). Thus, as in the case of the first pattern, the symmetry structure defined at the global level of this pattern is consistent with that defined at its local level. It is, however, different from that of the first pattern,

and is the same as that defined at the global level of the third pattern.

These four patterns were shown to 28 subjects who were asked to rank them for symmetry, from the least symmetric to the most symmetric. It was predicted that the first two patterns or the last two patterns, which have the same globally defined symmetry structure, would be perceived as equally symmetric if global processing has precedence in perception. On the other hand, if local processing has precedence, then it would be the second and third patterns that would be perceived as equally symmetric, as these patterns have the same locally defined symmetry structure. Results showed that the patterns which differed significantly from each other were those having the same locally defined symmetry structure and those specifying a different symmetry structure at the global level. The patterns which were not differentiated from each other on the basis of perceived symmetry were the first two patterns and also, the last two patterns. These results support the hypothesis that global analysis of a pattern precedes a more local or fine-grained analysis. In addition, they show that it is symmetry information available at the global structural level of a pattern that is utilized by the visual system in the perception of symmetry. In the realm of art, there is an apparent intuitive awareness of this. A work by the Op artist, Dieter Hacker, provides a good example. In his "Cubes" (1963), the symmetries defined at the local structural level of the composition are perceived secondary to the global effect of rhythmic movement created by the reversible figure illusion (see Figure 5).

Bibliography

Boer, L., & Keuss, P. (1981). Global precedence as a postperceptual effect: An analysis of speed-accuracy tradeoff functions. Perception and Psychophysics, 31, 358-366.

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

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

Kohler, W. (1929). Gestalt psychology. NY: Liveright.

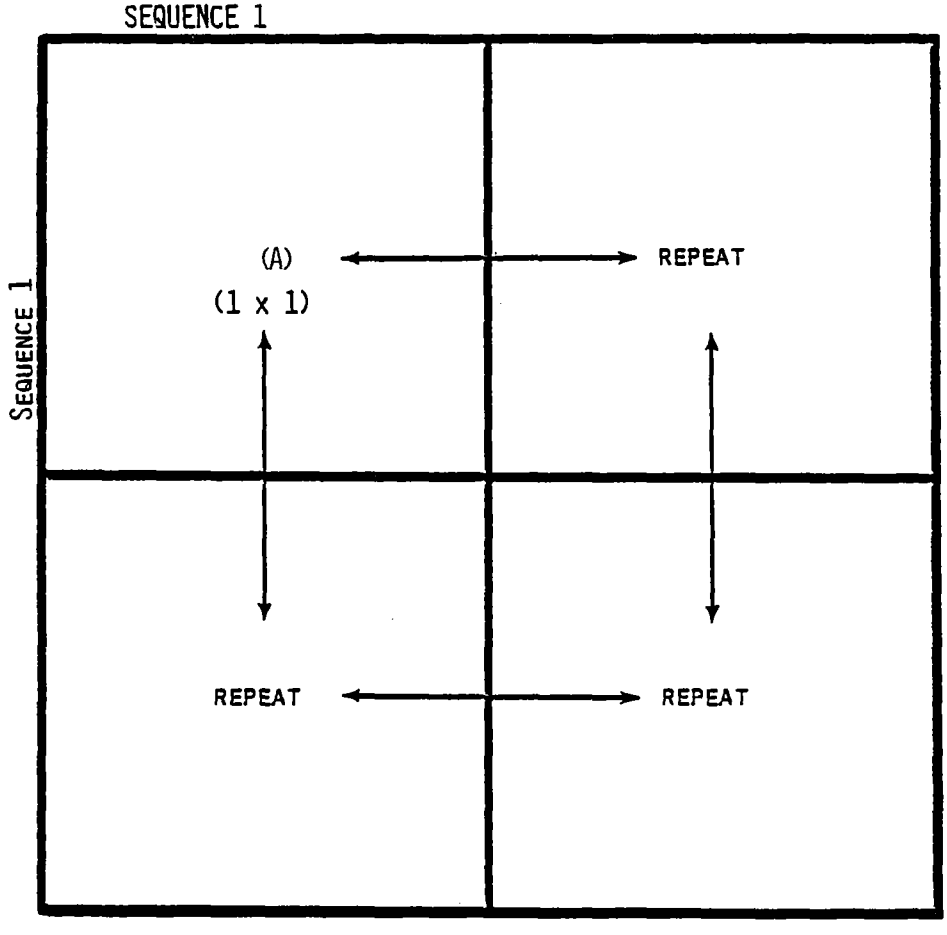
Miller, J. (1981). Global precedence in attention and decision. Journal of Experimental Psychology: Human Perception and Performance, 7, 1161-1174.

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

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

Wertheimer, M. (1958). Principles of perceptual organization. In D. C. Beardslee & M. Wertheimer (Eds.), Readings in perception. Princeton, NJ: Van Nostrand-Reinhold. (Originally published in German, 1923)

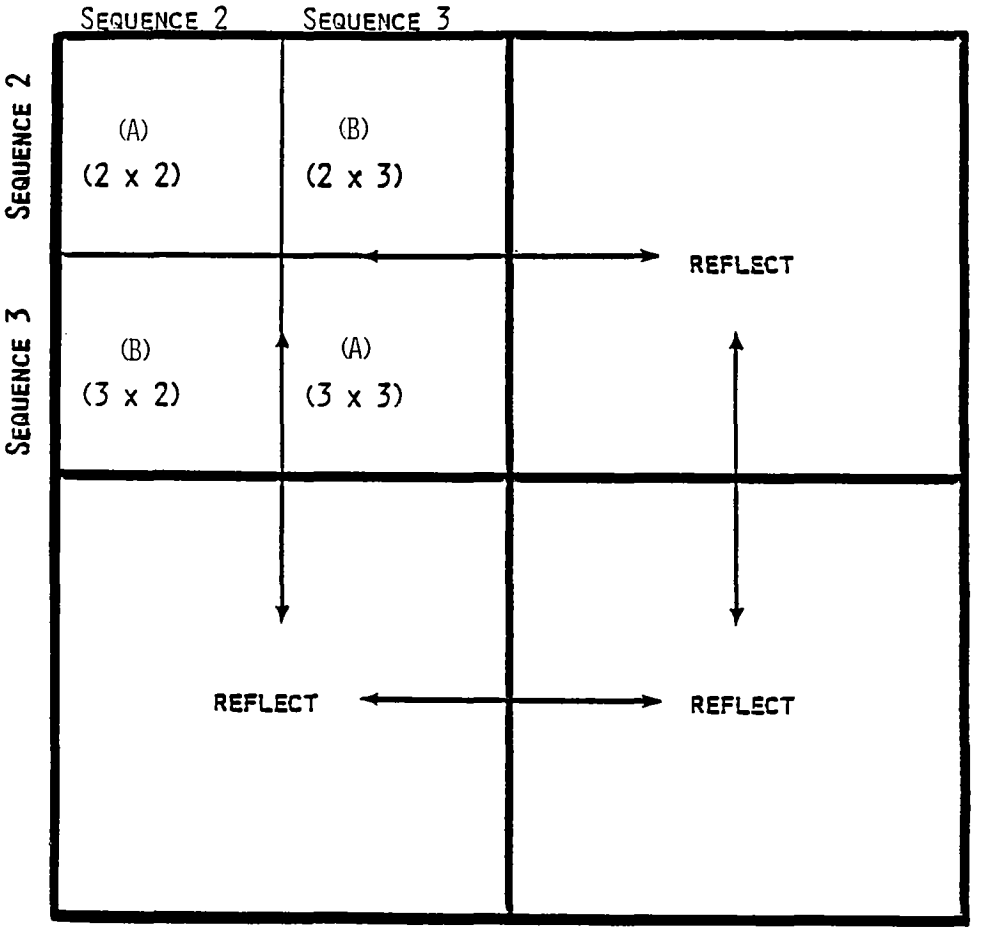
FIGURE 1



(A) LOCAL SYMMETRY PATTERN HAVING A FOUR-FOLD ROTATION AXIS AND FOUR INTERSECTING MIRROR LINES AT ITS CENTER (4MM).

THE GLOBAL SYMMETRY PATTERN HAS THE SAME SYMMETRY STRUCTURE AS THE LOCALLY DEFINED PATTERNS (4MM).

FIGURE 2

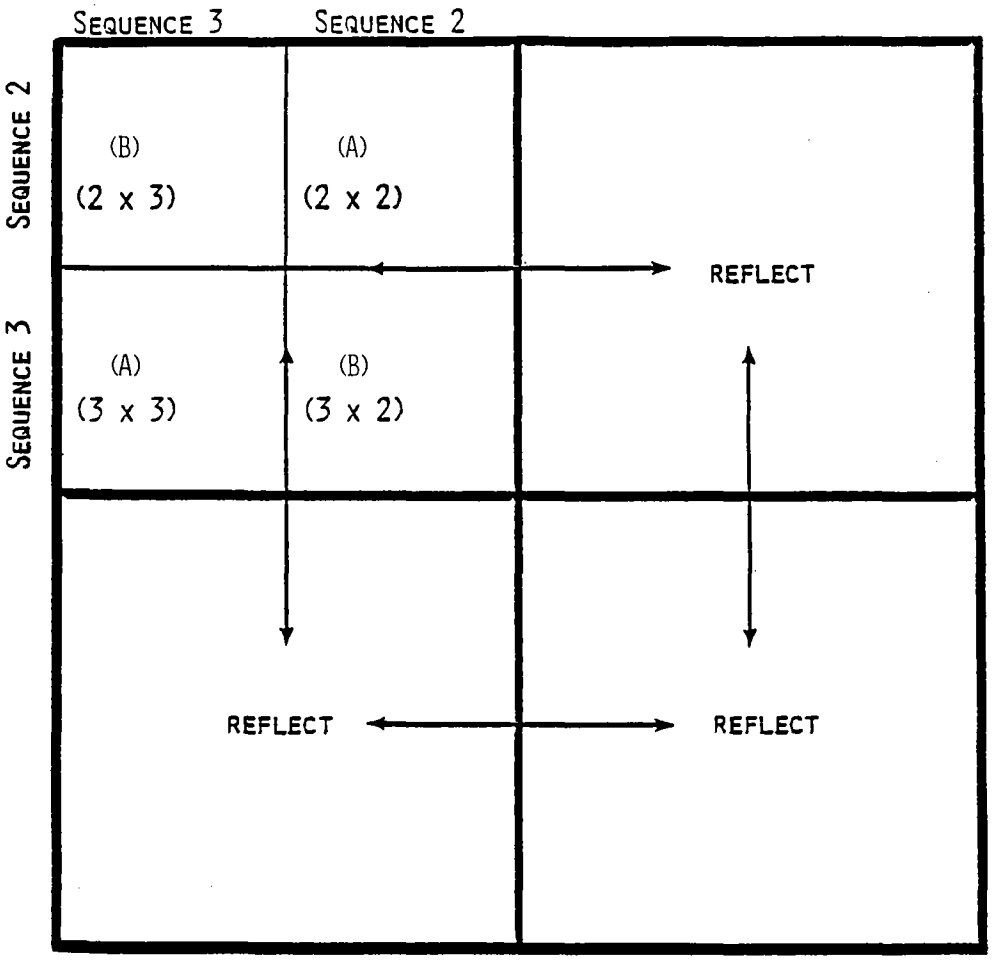


(A) LOCAL SYMMETRY PATTERN HAVING A FOUR-FOLD ROTATION AXIS AND FOUR INTERSECTING MIRROR LINES AT ITS CENTER (4MM).

(B) LOCAL SYMMETRY PATTERN HAVING A TWO-FOLD ROTATION AXIS AND TWO INTERSECTING MIRROR LINES AT ITS CENTER (2MM).

THE GLOBAL PATTERN HAS SYMMETRY 4MM.

FIGURE 3

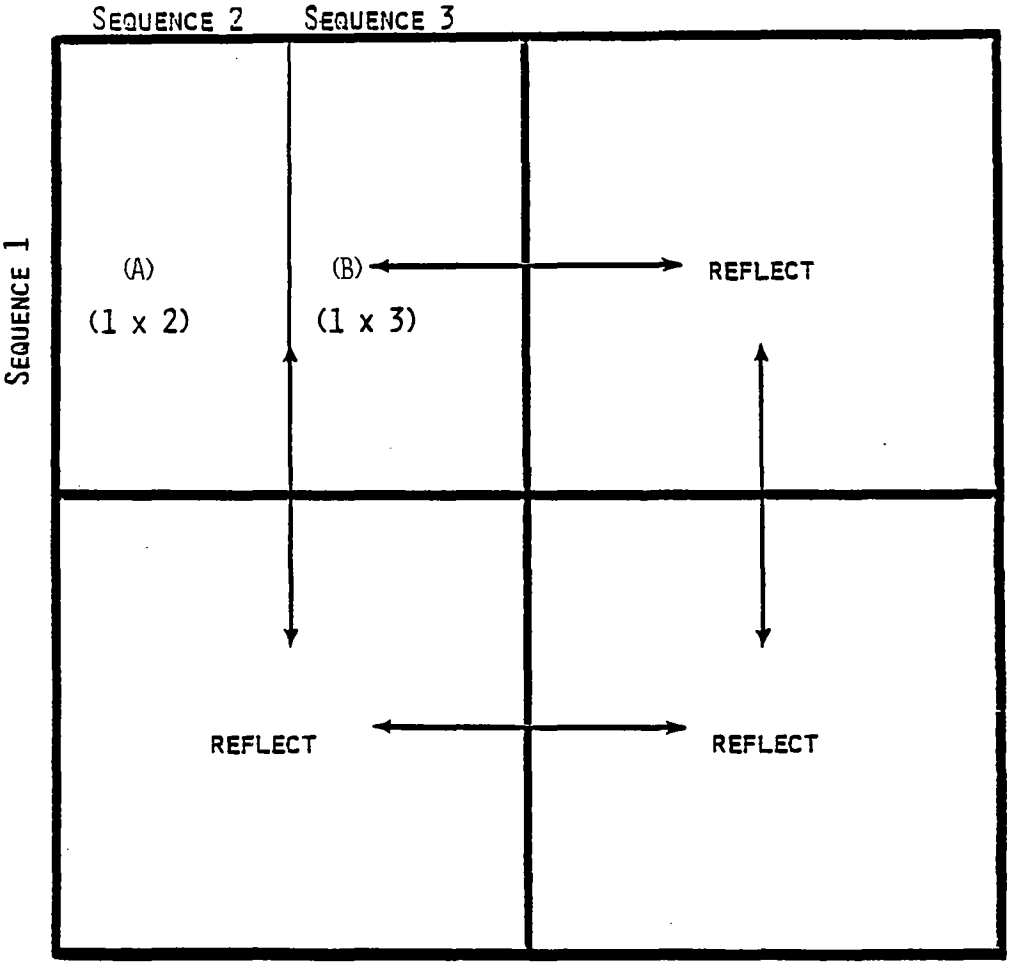


(A) LOCAL SYMMETRY PATTERN HAVING A FOUR-FOLD ROTATION AXIS AND FOUR INTERSECTING MIRROR LINES AT ITS CENTER (4MM).

(B) LOCAL SYMMETRY PATTERN HAVING A TWO-FOLD ROTATION AXIS AND TWO INTERSECTING MIRROR LINES AT ITS CENTER (2MM).

THE GLOBAL PATTERN HAS SYMMETRY 2MM.

FIGURE 4



(A AND B) LOCAL SYMMETRY PATTERNS HAVING A TWO-FOLD ROTATION AXIS AND TWO INTERSECTING MIRROR LINES AT THEIR CENTERS (2MM).

THE GLOBAL PATTERN HAS SYMMETRY 2MM.

FIGURE 5

DIETER HACKER "CUBES" 1963, SERIOGRAPH 25 X 25 IN.