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Notes and Comment

Group movement produced by the short-range process

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In his original analysis of the characteristics of the short-range process in apparent movement, Braddick (1974) noted that "the pairing of [random] dots in successive exposures, yielding motion detection and hence perceptual segregation, is limited to a spatial range of about a quarter of a degree of visual angle." Using what has now come to be called the Ternus display (Ternus, 1938; see Figure 1), Pantle (1975; Pantle & Picciano, 1976) and Petersik (1975; Petersik & Pantle, 1979) shortly thereafter discovered another manifestation of the short-range process, end-to-end movement, which also seemed to operate over a limited spatial range. End-to-end movement occurs when the observer perceives the two overlapping dots in the alternating frames shown in Figure 1 as stationary, with a single "outside" dot moving from end to end. As Braddick and Adlard (1978) and Pantle and Petersik (1980) have pointed out, the short-range process operates in this case by signaling the stationarity of the overlapping elements. To demonstrate the limited spatial range of end-to-end movement, Pantle and Petersik (1980) perturbed the exact locations of "overlapping" elements in the Ternus display and found that misalignments on the order 16′ of arc were sufficient to eliminate reports of end-to-end movement (i.e., sufficient to prevent operation of the short-range process). These data, along with a reinterpretation of some older studies (see Braddick, 1974) suggested, in 1980, that the short-range process had a fixed retinal limit of 12′-20′ of visual angle. More recently, the "quarter-of-a-degree" figure has obtained empirical support in an experiment that used only two apparent-movement stimuli (Larsen, Farrell, & Bundesen, 1983).

Despite the promulgation of evidence to support the fixed-retinal-limit position with respect to the integration distance of the short-range process, some early studies failed to replicate the 15′ (or so) limitation. For example, Lappin and Bell (1976) obtained data showing that the integration limit of the short-range process increased with increases in display and element sizes in random-dot displays. Subsequently, Baker and Braddick (1982) performed a more controlled replication of Braddick's original work and concluded that the displacement limit of the short-range process grows larger with increasing retinal eccentricities. In a similar vein, Petersik, Pufahl, and Krasnoff (1983) replicated the work of Pantle and Petersik (1980), but varied the size of the Ternus stimuli, and found that the perturbation range of the end-to-end movement sensation increased with increasing element size. Thus, by the time of this writing, it would appear that for some the pendulum has swung, or is swinging, to the conclusion that the displacement limit (integration range) of the short-range process does not have a fixed value, but one that depends upon the size of the stimulus elements, the part of the retina stimulated, or both.

I have come to favor the Ternus display as a device to distinguish short-range from long-range processing because both processes yield well-defined, easily distinguishable percepts with it. In short, the perception of movement of the whole, that is, group movement, has been associated with stimulus conditions that favor the long-range process, and hence has been thought to be a long-range phenomenon. On the other hand, the perception of a single dot moving from end to end around (or through) two stationary center dots, that is, element movement, has been associated with stimulus conditions that favor the short-range process, and hence has been interpreted as a short-range phenomenon. Here I report evidence, originally discovered in 1975 by Pantle, myself, and other members of his laboratory, that group movement can be produced by the short-range process. At the same time, I propose to re-open the question of the quarter-of-a-degree limitation on the short-range process.

The demonstration of the above principles relies upon a means of presenting *all of the dots* in the Ternus display within the same, roughly 15′-visual-angle, spatial range. This was first achieved by carefully preparing tachistoscopic cards with very small, precisely aligned dot stimuli so that the retinal distance separating the leftmost dot on one card from the rightmost dot on the other would not exceed 15′. More recently, we have programmed an

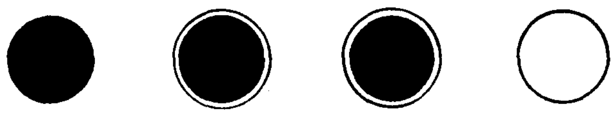

Figure 1. A schematic example of the stimuli used to produce the Ternus display. Stimulus elements for one frame are presented as solid dots; those for the second frame, as outline dots. In the actual display, the dots would be the same size and contrast. When the stimuli and interstimulus distances are relatively large, alternation of these frames at short interstimulus intervals (<40 msec) tends to result in the perception of end-to-end movement, in which the overlapping dots are seen as stationary and the end dot as moving. Alternation at longer interstimulus intervals (>60 msec) tends to result in the perception of group movement, in which the collection of three dots is seen to move from side to side as a whole.

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Apple II+ microcomputer to create two graphics frames, each containing three lighted pixels separated from one another by one dark pixel, to produce the necessary two Ternus frames. With either method of presentation,[1] we have discovered that the only two percepts available to observers (given ISIs in the range of 5-100 msec) are (1) group movement, and (2) four stationary, but perhaps flickering, dots. The group-movement percept dominates at most ISIs; for any individual observer, the group-movement percept is absent (and the four-dot percept present) only when the outer two dots appear subjectively simultaneous. Over the last 10 years, I have repeated this demonstration, using both tachistoscope and computer, with at least 60 psychology students, always with the same results.

Two aspects of these demonstrations are particularly important: (1) Even when ISI is selected to favor the short-range process, alternation of these small Ternus stimuli leads to the subjective experience of group movement. This is true as long as all four of the stimulus dots lie within the same roughly 15′-arc region, and it indicates that the short-range process is matching individual stimulus elements with their corresponding partners (based on location within the group) in the alternating frames; that is, the homologous parts within the two Gestalten retain phenomenal identity (to use Ternus's language). Yet, it is precisely this percept that is yielded by the long-range process when larger stimuli (and larger separations) are used. (2) The effect described above is strongest when viewing is parafoveal or peripheral, although it is still quite robust with foveal viewing. This aspect of the demonstration suggests that the retinal limit of the short-range process, if indeed there is one, increases with more eccentric viewing. However, our unsystematic observations to date suggest that this group-movement effect with small stimuli does not occur when the total area subtended by the stimuli is much greater than 15′-20′ (the larger area occurring in the periphery).

One theoretical implication of this demonstration is that there is no necessary one-to-one relationship between the activity of a putative perceptual process (i.e., the short-range process) and the subsequent phenomenal experience of an observer. (A further example of this principle is seen when comparing the effects of short- and long-range processing in random-dot displays vs. the Ternus display: short-range processing results in the perception of a group—for example, a correlated square—with random-dot stimuli but single-element movement with the Ternus stimuli; long-range processing results in random element movement with random-dot stimuli but coordinated group movement with the Ternus stimuli.) A second implication is that there may be some validity to the quarter-of-a-degree limit to the short-range process after all. Is it possible that the apparently short-range phenomena observed with stimuli of various (relatively large) sizes and different eccentricities are really due to an "intermediate-range process," or some cooperative activity of the conventional short- and long-range processes (cf. Petersik, Hicks, & Pantle, 1978)?

REFERENCES

Baker, C. L., & Braddick, O. J. (1982). The basis of area and dot number effects in random dot motion perception. *Vision Research*, **22**, 1253-1259.

Braddick, O. J. (1974). A short-range process in apparent movement. *Vision Research*, **14**, 519-527.

Braddick, O. J., Adlard, A. (1978). Apparent motion and the motion detector. In J. Armington & B. Wooten (Eds.), *Visual psychophysics and physiology* (pp. 417-426). New York: Academic Press.

Cavanagh, P., & Anstis, S. M. (1980). Visual psychophysics on the APPLE II: Getting started. *Behavior Research Methods & Instrumentation*, **12**, 614-626.

Lappin, J. S., & Bell, H. H. (1976). The detection of coherence in moving random-dot patterns. *Vision Research*, **16**, 161-168.

Larsen, A., Farrell, J., & Bundesen, C. (1983). Short- and long-range processes in visual apparent movement. *Psychological Research*, **45**, 11-18.

Pantle, A. J. (1975, May). *A multi-stable movement display: Evidence for two separate motion systems in humans*. Paper presented at the annual meeting of the Association for Research in Vision and Ophthalmology, Sarasota, FL.

Pantle, A., & Petersik, J. T. (1980). Effects of spatial parameters on the perceptual organization of a bistable motion display. *Perception & Psychophysics*, **27**, 307-312.

Pantle, A., & Picciano, L. (1976). A multistable movement display: Evidence for two separate motion systems in human vision. *Science*, **193**, 500-502.

Petersik, J. T. (1975, November). *Two types of stroboscopic movement in the same visual display*. Paper presented at the Annual Meeting of the Psychonomic Society, Denver, CO.

Petersik, J. T., Hicks, K. I., & Pantle, A. J. (1978). Apparent movement of successively generated subjective figures. *Perception*, **7**, 371-383.

Petersik, J. T., & Pantle, A. J. (1979). Factors controlling the competing sensations produced by a bistable stroboscopic motion display. *Vision Research*, **19**, 143-154.

Petersik, J. T., Pufahl, R., & Krasnoff, E. (1983). Failure to find an absolute retinal limit of a putative short-range process in apparent motion. *Vision Research*, **23**, 1663-1670.

Ternus, J. (1938). The problem of phenomenal identity. In W. D. Ellis (Ed.), *A sourcebook of Gestalt psychology* (pp. 149-160). London: Routledge & Kegan Paul.

NOTE

1. To control interstimulus interval with the display system of the Apple II+ microcomputer, we have employed a hardware modification described by Cavanagh and Anstis (1980). With this modification, we can obtain interstimulus intervals as low as 16 msec without the problem of "interleaving" frames during raster scanning.

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