# Bilateral apparent haptic movement[1]

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*When Os are permitted to manipulate the interstimulus onset interval (ISOI) to obtain optimal apparent movement between two ipsilateral vibrotactile stimuli, a consistent quantitative relation between ISOI and stimulus duration appears. The present report describes conditions for movement between contralaterally-placed stimuli, and shows that whereas movement is qualitatively incomplete, the aforementioned relation is still evident. The results are discussed in the light of recent work in both visual apparent movement and complex patterns of stimulation on the skin.*

The conditions for good apparent movement on the skin have been explored in recent years by several investigators (DeHardt, 1961; Gibson, 1963; Kotovsky & Bliss, 1963; Sherrick & Rogers, 1966; Sherrick, 1968; Sumby, 1955), most of whom reported obtaining good movement when repetitive electrical or mechanical stimuli were presented under appropriate conditions. In addition, Sherrick (1968) reported that variation of distance between two vibrotactile stimuli on the skin did not have a significant effect, for optimal movement, on the interstimulus onset interval (ISOI). This result is at variance with Korte's law of the direct proportional relation of time between stimuli and distance between stimuli (Korte, 1915) in optimal visual apparent movement. Recent work by Kolers (1964), however, suggests a similar deviation from Korte's law for visual apparent movement between 0.75 and 5.25 deg of angular separation.

Qualitative changes in the character of movement with increasing stimulus separation on the skin were readily perceived by all of Sherrick's Os, who reported feeling "... good movement, but it lost 'clearness' in the center as the distance increased (1968, p. 338)." The distance at which such effects appear is 20 to 35 cm, magnitudes that can be obtained on the thigh without spanning joints while at the same time stimulating relatively well-fleshed surfaces. An interesting question arises if the ultimate separation between sites is made, viz.: when stimuli are presented to contralateral extremities, will movement be perceived, and will it occur at ISOI values comparable to those obtained in the ipsilateral condition? The visual analogue of this experiment has been carried out qualitatively by Ammons and Weitz (1951), who presented to their Os appropriately-timed flashes separated by 10 deg of visual angle under four viewing conditions: (a) monocularly, same hemiretina, (b) monocularly, opposite hemiretinas, (c) binocularly (haploscopic), heteronymous retinas, and (d) binocularly (haploscopic), homonymous retinas. The various conditions were designed to evaluate differentially the effects of interaction on the retina and interaction within one cerebral hemisphere. When Os were instructed to report the presence of visual movement, they did so more frequently for the monocular than for the binocular conditions, without regard for retinal locus. Moreover, when movement was reported in the binocular conditions, it was usually complicated and ambiguous. Because it was not possible to manipulate stimulus duration and ISOI with Ammons and Weitz' apparatus, there remains the chance that other temporal relations would restore good movement in those conditions in which it was infrequent. The quantitative experiment has not, however, been performed.

The present study was undertaken to answer the question raised earlier concerning the effects of contralateral stimulation and conditions for haptic movement, and is intended to provide both qualitative and quantitative accounts of such movement. The results of pilot studies suggested that when the index fingers were placed on separate mechanical vibrators so that their proximal joints were the stimulus sites and they pointed at each other but did not touch, a partial movement could be perceived at durations and ISOIs found for ipsilateral sites in earlier studies (Sherrick & Rogers, 1966; Sherrick, 1968). When the tips of the fingers touched, good full movement was immediately perceived throughout their extent. To eliminate the possibility that physical conduction of vibration was producing a third site of stimulation at the contact point of the fingers, the sites finally selected were the right dorsal forearm about 3 cm proximal to the styloid process of the ulna, and the left doral forearm, about 12 cm proximal to the styloid process. Non-corresponding sites were chosen to avoid the possibility of confusing the O by generating exosomatic phantom sensations between the limbs (v. Békésy, 1959). None was reported under any condition.

The apparatus and procedure were identical to those reported by Sherrick and Rogers (1966), except that the Os manipulated the three control switches with the foot. The apparatus permitted the O to present himself with a burst of vibration at each site, of a duration and intensity set by the E, and the ISOI controlled by the O. The O could also trigger the same burst pair with a fixed ISOI that he felt was approximately optimal movement at the beginning of the session. The fixed ISOI was the standard, to which O was encouraged to refer throughout the experiment. His task was to change the variable ISOI until in his judgment, the movement was the best possible under the conditions. If movement was partial or lacking altogether, he was instructed to search the range of the ISOI until he perceived the strongest tendency for movement or displacement of the sensations.

Three Os who had extensive experience with ipsilateral haptic movement observed for combinations of two conditions: (a) mechanical vibration of 150 Hz, or ac electrocutaneous stimulation of 1500 Hz, and (b) hands joined or hands separated. The electrocutaneous stimuli were presented through wet electrodes placed at the sites for the mechanical signals, and adjusted in intensity to have a sensory magnitude equal to that of the vibrotactile signals, which were always set to a magnitude equal to 15 dB SL re the 200 msec burst (Sherrick & Rogers, 1966). Stimulus durations of 10, 25, and 200 msec were presented at separate sessions, and each O was required to make four manipulations of the ISOI to obtain judgments of optimal movement for each condition. He was interrogated during and after the session to determine the qualitative character of the movement.

Figure 1 is a plot of ISOI vs stimulus duration for the experiment. The open circles are from results of ipsilateral stimulation obtained by Sherrick and Rogers (1966), in which good full movement was perceived by all Os for all durations. The open and filled squares are median ISOI values for contralateral mechanical vibration with the hands separated and joined, respectively. The open and filled triangles are for corresponding conditions with the electrocutaneous stimulus. It is obvious that, although absolute values are not the same from ipsilateral to contralateral conditions, the relation between ISOI and stimulus duration is preserved.

Under all conditions the Os reported a strong tendency for movement, or a partial movement, between sites of stimulation. These were more frequent for longer durations of the stimulus, but were not different in frequency for the conditions of hand placement. One O occasionally reported a weak vibrotactile movement through the hands when they were joined, and in these cases he perceived the movement as along the arms. Otherwise, all Os reported the movement as in a straight line joining the two sites. Generally, the movement consisted of a displacement perceived as traveling from the first site to a distance 3 to 6 cm away and off the body, then disappearing in mid-trajectory and beginning 3 to 6 cm away from the second site and moving toward it. Movement was most impressive for the mechanical vibration at the duration of 200 msec without regard to hand placement. Placing the arms at various distances and in various relations to one another did not seem to affect the character of the movement.

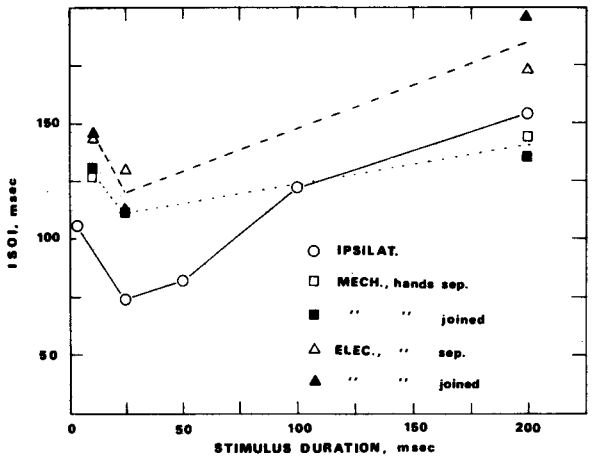


**Fig. 1. The relation between interstimulus onset interval (ISOI) and duration of the stimulus for optimal movement in 3 Os. Open circles are for ipsilateral vibrotactile stimulation of the right thigh (Sherrick & Rogers, 1966). Open and closed squares are for contralateral vibrotactile stimulation, and open and closed triangles for contralateral electrocutaneous stimulation.**

Kolers has suggested that the perception of optimal visual movement requires first, the formation of simple images, for which he believes the ISOI represents the major temporal constraint, and secondly, the process of impletion, by which he means the filling-in of the spatial gap between the two sites of excitation (1964, p. 106). The results of the present experiments, in which the time relations are preserved but impletion is absent, do not dispute this interesting hypothesis.

Von Békésy (1967) has described experiments in which a kind of impletion evolves after a protracted training period. Vibrators on the O's adducted thighs were energized by separate microphone-amplifier systems, and a loudspeaker that emitted clicks was moved slowly in the frontal plane of the microphones in a kind of "stereohaptic" presentation. After several weeks, the Os could localize the vibration in exosomatic space between the knees. Von Békésy has noted:

"By training an observer first to note the localization of the vibration when the knees are together, he can be made to perceive a sensation that moves continuously from one knee to the other. If the observer now spreads the knees apart . . . [he] will become convinced that the vibratory sensation can be localized in the free space between the knees, and he will be able to experience a displacement of the sensation . . . when an appropriate time delay . . . [between stimuli] . . . is introduced (1967, p. 223)."

The situation that von Bekesy describes may be called stereohaptic, or dihaptic, by analogy to diotic or dioptic presentations, since the sound source ultimately drives both vibrators simultaneously with only small differences in time and intensity between them. In the present experiments, the presentation of stimuli is truly dichohaptic, providing for entirely separate control of intensities, onset times, and durations. The interesting question now arises: if an O is carefully trained under the stereohaptic condition until he experiences impletion that permits precise exosomatic localizations under rigorous testing conditions, will he experience impletion under the conditions of dichohaptic movement, as in the present experiments? Further, will the quantitative relations between ISOI and duration change with the progressive impletion process?

Implied in these questions is the challenge to perceptual research made by even the friendliest of critics: what of these results is reproducible, and what is owing to "laboratory atmosphere," or the "will to believe"? Stable, reproducible results must in the long run be acquired with stable, reclaimable criteria on the part of the O. This is the pivot on which further research on the present problem, indeed on which all perceptual research, must turn.

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## NOTES

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