EFFECT OF SPEED OF MOVEMENT ON TACTUAL-KINESTHETIC PERCEPTION OF EXTENT

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The analysis of perception of extent in the visual modality has been largely restricted to a static, geometric characterization in terms of the dependency of retinal size on the physical size and distance of an object from the retinal plane ("size-distance invariance hypothesis").[1] In contrast, analysis of perception of extent in the tactual-kinesthetic modality provides the basis for a dynamic analysis of the relation between quality of organismic activity (*e.g.*, speed of movement) involved in perception, and object properties (*e.g.* size, extent) which are perceived through such activity. It is assumed that variation in quality of activity (*e.g.* fast vs. slow rate of traversing a given physical extent) makes for a difference in perceived extent.

Such an analysis was suggested by Brown a long time ago in his classic treatment of perception of extension, where he attempted to show that temporal succession of muscular activity is an essential feature of extensionality.[2] He suggested, without supporting data, that the slower the speed of traversing the extent, the greater the extent appears. This serves as the hypothesis for the present study.

Method. By means of a specially constructed apparatus, *S*'s finger and outstretched arm was moved passively, at chest level, from left to right (right to left) in a horizontal line over an extent of 40 cm. in his fronto-parallel plane. The beginning and end points of this extent were fixed symmetrically with respect to

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[1] William Epstein, John Park, and Albert Casey, The current status of the size-distance hypotheses, *Psychol. Bull.*, 58, 1961, 491-514.

[2] Thomas Brown, *Lectures on the Philosophy of the Human Mind,* 16th ed., Vol. 1, 1846, 533-548. These experiments were conducted prior to the authors' contact with Brown's work, *ibid.,* which came to their attention when an excerpt was reprinted recently in William Dember, *Visual Perception: The Nineteenth Century,* 1964, 102-113. See also C. O. Weber, The properties of space and time in kinaesthetic fields of force, this JOURNAL, 38, 1927, 597-606; and Theodora M. Abel, A comparison of tactual-kinesthetic and visual perceptions of extent among adults, children, and subnormals, this JOURNAL, 48, 1936, 269-296.

S's objective median plane. In the course of traversing the total extent *S*'s finger touched an intermediate point ("center" marker), which divided the total extent into two parts: extent of first phase (from beginning point to center marker); and extent of second phase (from center marker to end point). The apparatus was so arranged that the speed of each "phase" could be independently adjusted as either slow or fast. The task for *S* consisted in establishing equality between the first extent traversed at a particular speed (fast, slow) and the second extent traversed at the same or different speed.

Apparatus. The apparatus, schematized in Fig. 1, has a finger plate (A) which moves from left to right (right to left) from a beginning point I (III) past an intermediate point II to a terminal point III (I) along a horizontal distance of

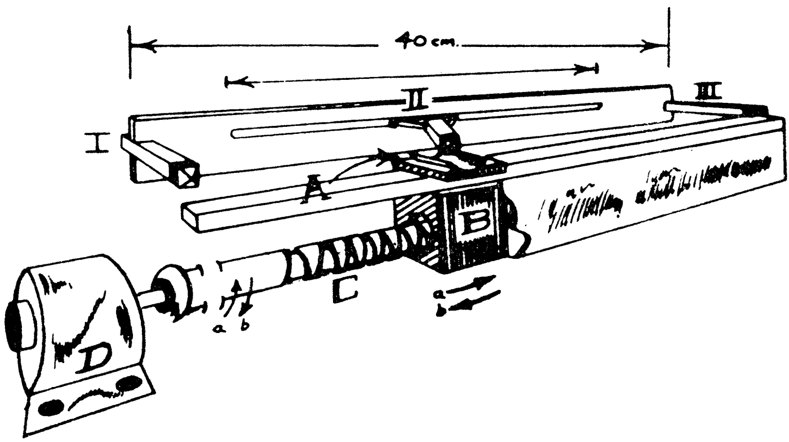

FIG. 1. DIAGRAMMATIC SKETCH OF APPARATUS.

40 cm. The finger plate was attached to a lock nut carriage (B) which was free to move along a threaded reversible screw (C), between two parallel guides. Motion was activated by a microswitch attached to the shoe of the finger holder. Intermediate point II, which served both as a center marker and as a lever switch to change speeds, was mounted on a track parallel to the line of motion of the finger, and its position could be varied in small steps to change the relative extents of the first and second phases of movement. The screw controlling speed of linear motion was moved by a DC motor (D) (115 volts; 1/15th hp). The center marker (II) could be set to shift from slow to fast speed, fast to slow speed, or to maintain movement at the same speed, slow, or fast. Two speeds of linear movement, calibrated by motion picture photography, were employed, viz., a slow speed (4 cm./sec.) and a fast speed (5 cm./sec.).

During the experiment, *S* was blindfolded and his finger, placed on the finger holder, was moved over the horizontal 40 cm. distance. At a particular point in the excursion *S* touched the center marker, which delimited two extents. *S* was required to tell *E* whether the first extent was shorter, equal to, or longer than the second. Care was taken to insure that *S* understood the instructions by having him make a judgment on a visual basis before blindfolding him for the actual trials. At the beginning of a particular trial, the first extent traversed was small (large) compared with the second extent. Following that trial, the difference in extent was reduced by 2 cm. and the next was carried out. This procedure was continued until *S* shifted his judgment from shorter (longer) to longer (shorter) for three consecutive trials. Essentially then, a procedure involving a variation of the method of limits was employed. The Point of Subjective Equality (*PSE*) was determined from the transition points between larger and equal, and between equal and smaller.

Two main test conditions were employed: speed-sequence (fast first phase followed by slow second phase; fast followed by fast; slow followed by slow; and slow followed by fast); and direction of motion (finger movement left to right and right to left). In addition to these two main conditions, a third, viz., size of initial extent, was introduced as part of the psychophysical procedure described earlier: on half of the trials the judgments began with the first extent small (10 cm.) and second extent large (30 cm.); on the other half of the trials the first extent was initially large (30 cm.) and the second extent small (10 cm.).

A repeated measurement, independent groups design with 8 *S*s (4 men; 4 women) in each of four methods-groups (speed-sequence: (a) fast-slow; (b) fast-fast; (c) slow-slow; and (d) slow-fast was employed, making a total of 32 *S*s. All *S*s were right-handed. Each *S* within a "speed-sequence group" was tested under four conditions: direction of motion (left to right; right to left) in combination with size of initial extent (first extent "small"; first extent "large"). Within each "speed-sequence" group, the order of the four conditions was systematically randomized as in a 4 × 4 Latin square, with 2*S*s, 1 man and 1 woman, in each sequence.

The measure employed in the analysis consisted of the physical distance —computed from PSE—from the beginning point to the center marker (*apparent extent of first phase*).

Results. Before considering the efficacy of the main experimental variable, the results were examined to determine whether there were over-all differences depending upon temporal order (time-error). For this purpose, the means for the "slow-slow" and "fast-fast" speed-sequence groups were examined. Since the measure employed is physical extent of first phase (extent of second phase is the remainder of the 40 cm. distance), lack of effect of temporal order would be reflected in values approximating

20 cm. Examination of the findings for the "fast-fast" and "slow-slow" speed-sequence groups (21.16 cm. and 21.61 cm. respectively) shows that in each instance, the physical extent for the first phase was made larger than that for the second phase in order to experience the total extent as divided into equal halves. When these mean values were evaluated against the hypothesis that the population mean is 20 cm., they were both significant ($p < 0.05$). Thus, the physical extent of the first phase must be made significantly greater than the physical extent of the second phase in order for the two extents to appear equal. Stated another way, when traversing a total extent of 40 cm. the first half appears smaller than the second half.

The test of the main hypothesis involves comparison of the mean apparent extent for the "fast-slow" and "slow-fast" speed-sequence groups. Independent of other factors, the hypothesis calls for the first phase of the "fast-slow" speed-sequence group to be greater than 20 cm.; and the first phase of the "slow-fast" speed-sequence group to be smaller than 20 cm. Since, as suggested above, temporal order has an over-all effect, this difference should hold only in relative terms, *i.e.,* for the measure employed—physical extent of first phase—the "fast-slow" speed-sequence group should yield a *relatively* larger value than the "slow-fast" sequence group. Analysis of variance revealed that the speed-sequence variable was significant ($F = 3.08$, 3 and 24 df). The mean for the "fast-slow" group (21.39 cm.) is significantly larger than the mean for the "slow-fast" sequence group (19.97 cm.).[3] A less conclusive secondary finding pertained to differences due to direction of arm movement. This bears on the problem of differences in tactual-kinesthetic extent resulting from movement of the arm in contralateral or ipsilateral space and should be controlled in this type of experimentation.

Discussion. In keeping with Brown's observations, the major finding of this study is that a physical extent traced at a given speed must be made relatively long in order to appear equal to the same extent traced at a slower speed. This finding has significance insofar as it augments the variety of situations in which an interrelation has been demonstrated between temporal features of stimulation and perceived spatial extent. Such space-time interactions, first demonstrated by Benussi[4] and Gelb,[5] and more recently

[3] A preliminary experiment conducted by Joseph Weinberg (Effect of speed of passive finger movement on perception of extensionality, Unpublished Master's thesis, Clark University, 1963) produced essentially the same findings with an independent group of 32 *Ss*.

[4] Vittorio Benussi, *Psychologie der Zeitauffassung*, 1913, 349.

[5] This has also been demonstrated for the tactual modality of Adhemar Gelb,

by others,[6] characteristically involve successive point stimulation, and are of two types: the *tau*-phenomenon (the shorter the physical time between successive spatially distributed flashes, the shorter the perceived distance between them) and the *kappa*-phenomenon (the shorter the physical extent between successive flashes, the shorter the apparent time). In our study analogous results were obtained with continuous motion.[7]

Taken together, these findings of space-time interaction provide a complexity which is outside the scope of traditional accounts of perception of extent: On the one hand, the traditional approach has employed a spatial model in which perceived extent is assumed to be based primarily on the retinal distribution of points of stimulation with an assumed correspondence between proximal stimulus and perceptual experience. The inadequacy of such a retinal model is particularly evident in its inability to deal with the space-time interaction, namely, the lack of functional equivalence between identical sets of spatial stimuli where temporal relations are different. An alternative way to handle the space-time problem—and to retain nonetheless the notion of one-to-one relation between proximal stimulus and perception—would be to redefine the nature of the proximal stimulus as a "spatio-temporal entity." However, this alone is not satisfactory since it raises the theoretical issue of how a single proximal stimulus (a spatio-temporal entity) may function alternatively as either the occasion for perception of a spatial property or as the occasion for perception of a temporal property.

In our own view, perception of extent is mediated by common organismic processes which provide the basis for the interaction of spatial and temporal characteristics. While we cannot as yet clearly define the nature of this common process, the present study, taken together with others on space-time interaction, indicates that this process must be conceived broadly

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Versuche auf dem Gebiete der Zeit-und Raumanschauung, *Bericht uber der VI. Kongress fur Experimentelle Psychologie,* 1914, 36-42.

[6] Harry Helson, The *tau* effect.—An example of psychological relativity, *Science,* 71, 1930, 536-537; Harry Helson and S. M. King, The *tau* effect: An example of psychological relativity, *J. exp. Psychol.,* 14, 1931, 202-217; P. E. Comalli, Jr., The effect of time on distance perception, Unpublished Master's thesis, Clark University, 1951; John Cohen, C. E. M. Hansel, and J. D. Sylvester, A new phenomenon in time judgment, *Nature,* 172, 1953, 901; Cohen, Hansel, and Sylvester, *op. cit.,* Interdependence of temporal and auditory judgments, *Nature,* 174, 1954, 642-646; Cohen, Hansel, and Sylvester, *op. cit.,* Interdependence in judgments of space, time and movement, *Acta Psychologica,* 11, 1955, 360-372; D. R. Price-Williams, The Kappa Effect, *Nature,* 173, 1954, 363-364. Some of these and other studies are presented in Paul Fraisse, *The Psychology of Time,* 1963, 136-137.

[7] It should be mentioned that continuous movement-effects were also found by G. S. Hall and H. H. Donaldson, Motor sensations on the skin, *Mind,* 1885, 557-572.

enough to allow for the possibility of interactions involving both successive point stimulation and continuous movement.[8]

SUMMARY

Variation in speed of tactual-kinaesthetic tracing a given physical extent significantly affects perception of that extent: with relatively faster (slower) speed a given extent is perceived as relatively shorter (longer).

[8] Since analogous effects have been demonstrated for distances measured in miles and for times measured in hours by John Cohen and Peter Cooper, New phenomena in apparent duration, distance and speed, *Nature,* 196, 1962, 1233-1234, it would be ideal if the conceptualization could encompass this added dimension of diversity.