A NEW PHENOMENON IN TIME JUDGMENT

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THE *tau* effect, demonstrated by Helson and King[1] in 1931, may be illustrated by the following example. If three points are marked off on the observer's skin and the interval of time between stimulating the second and third points is greater than that between the first and second, the observer reports that the distance between the second and third points is greater than that between the first and second, though in fact it may be equal or less. Geldreich[2] has devised an apparatus whereby this effect may be shown to occur with visual stimuli. These phenomena show a dependence of judgments of distances between stimuli on the time intervals separating them. The experiment to be described was designed to test quantitatively the hypothesis that judgments of temporal intervals between visual stimuli are similarly dependent on their spatial relations.

The subject sat in a dark room and observed in front of him a repeated succession of three equal flashes of light set horizontally. Each cycle of three flashes was repeated after an interval of 5/3 of the total cycle. By adjusting a lever he was able to control the timing of the flash of the centre light over a range varying from simultaneous with the first light to simultaneous with the third. That is, if the interval of time between lights 1 and 2 is designated t_1, and that between lights 2 and 3 designated t_2, he adjusted the lever until he judged t_1 as equal to t_2. The distances separating the lights could be varied by the experimenter. The shorter of the two distances remained constant at one foot and the longer distance was varied so as to give a ratio ranging from 1 : 10 to 10 : 1. If the first distance is called d_1 and the second d_2, the ratio d_1/d_2 varied from 1/10 to 10/1. The cycle of lights was repeated continuously until the subject had completed his adjustment, which he indicated by pressing a button.

Subjects made four judgments at each distance ratio : one pair with the shorter distance first, one pair with the longer distance first, one of each pair being presented with the right to left direction reversed.

In the accompanying table we show in columns (i) and (ii) the mean values of t_2/t_1, for each ratio of d_2/d_1, when $T = (t_1 + t_2) = 1{\cdot}4$ sec. In columns (iii) and (iv) the mean values of t_1 and its standard deviation are given respectively. In column (v) we show the values of t_1 corrected for time error. Time errors are effects which occur in judgments involving successive presentations of stimuli. In this case a correction is made by multiplying values of t_1 by a constant derived from the 1 : 1 ratio of distances. Column (vi) gives an estimate of the percentage effect of the phenomenon.

Similar effects were obtained with $T = 0{\cdot}6$ sec. and $T = 6{\cdot}4$ sec. Within this range of T (0·6–6·4) the effect tends to diminish as T increases. The effect is significant at all values so far measured.

It may be seen from column (vi) in this table that comparative judgments of two successive time intervals delimited by successive flashes of light are influenced by the spatial relationships of these flashes. Although the figures given in the table relate to the means for ten subjects, repeated trials with single subjects show that intra-individual variation is less than inter-individual variation. This statement is based on 6–20 trials by different subjects at each distance ratio. The standard deviations for the individual subjects range from 0·022 to 0·067 for different distance ratios when $T = 1{\cdot}4$ sec.

Mean results for 10 subjects when $T = (t_1 + t_2) = 1{\cdot}4$ sec.

(i)	(ii)	(iii)	(iv)	(v)	(vi)
$\frac{d_2}{d_1}$	$\frac{t_2}{t_1}$	t_1 (sec.)	σ_{t_1} (sec.)	t_1' (sec.)	$\frac{t_1'-t_2'}{t_1'} \cdot 100$ (percentage)
1/10	1·15	0·65	0·059	0·66	−12·1
1/8	1·22	0·63	0·058	0·64	−18·8
1/6	1·26	0·62	0·057	0·66	−12·1
1/5	1·22	0·63	0·051	0·65	−15·4
1/4	1·30	0·61	0·071	0·64	−18·7
1/3	1·37	0·59	0·089	0·60	−25·8
1/2	1·19	0·64	0·014	0·67	− 9·0
1/1	1·10	0·67	0·093	0·70	0·0
2/1	0·92	0·73	0·034	0·76	15·8
3/1	0·89	0·74	0·035	0·77	18·2
4/1	0·89	0·74	0·051	0·77	18·2
5/1	0·87	0·75	0·046	0·80	25·0
6/1	0·87	0·75	0·010	0·78	20·5
8/1	0·94	0·72	0·062	0·73	8·2
10/1	0·89	0·74	0·048	0·75	13·3

The effect is such that when the observer is adjusting the time intervals so that they appear equal he makes the time interval between the two flashes spaced farther apart shorter than the time interval between the two flashes closer together. The phenomenon that thus emerges is that when three flashes of light are successively presented and separated by equal temporal intervals, one temporal interval will seem longer as the relative distance between the corresponding flashes increases. We propose to designate this phenomenon as the *kappa* effect to distinguish it from the *tau* effect. A measure of this effect is given in column (vi). When, for example, d_2/d_1 is 1/10 there is a 12 per cent underestimation of t_1, and when d_2/d_1 is 10/1 there is a 13 per cent over-estimation.

A brief reference may be made to two further conclusions which will be more fully described elsewhere : (*a*) order of presentation ; and (*b*) effect of visual angle. The *kappa* effect is uninfluenced by the order in which the distances are presented. This fact is in conflict with the Gestalt theory of perceptual transposition.

The total visual angle subtended by the display in the experiment reported varies with the distance ratio being measured, since the shorter distance is constant at 1 ft. The decline in the effect at the extreme ratios seems to be due to the increase in visual angle. Experiments in progress show that when the distance ratio is held constant the *kappa* effect increases with decrease in the visual angle.

It would seem from the two phenomena that the spatial and temporal components of the space–time events about which judgments are made are psychologically interdependent. It may be asked whether the spatial element as such is an essential feature of this type of temporal phenomenon and whether a delimitation of the time intervals by other kinds of non-spatial stimuli such as auditory pitch might produce similar effects. If so, it would be possible to employ temporal judgments as a probe in the general study of inter-sensory phenomena, a subject which is receiving increasing attention. [Oct. 5.

[1] Helson, H., and King, S. M., *J. Exp. Psychol.*, **14**, 202 (1931).
[2] Geldreich, E. W., *Amer. J. Psychol.*, **46**, 483 (1938).