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Comparative judgment of temporal duration as a function of numerosity

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Two stimuli, each bearing a number of dark dots, were presented in sequence, and the duration of the second stimulus was judged in comparison with the duration of the first stimulus. The tendency to judge the second stimulus duration as longer than the first stimulus duration was a monotonically decreasing function of numerosity of dots of the first stimulus, and was a monotonically increasing function of numerosity of dots of the second stimulus. This monotonicity was not appreciably affected by the interval separating two stimuli.

A previous study (Mo, 1971) indicated that if each stimulus consists of a number of dots, the judgment of duration is a monotonically increasing function of the numerosity of such dots. The possibility that this monotnoicity results from attentional mediation was ruled out, primarily because such attentional factors as sudden change of numerosity or duration accentuated the tendency for overestimation of duration only with respect to an increase in numerosity, not with respect to decrease in numerosity. This inference against attentional mediation of temporal judgment was further augumented by a subsequent study (Mo & Michalski, 1972), which showed that a compound stimulus was not necessarily judged to be longer in duration than its components. However, these two studies relied on the method of psychophysical recognition, and did not address itself to possible mediation by a memory factor.

As proposed by Ornstein (1969), the memory storage model of temporal judgment assumes that judgment of temporal duration is based on the size of memory storage. As applied to psychophysical discrimination of temporal duration, this model predicts what is essentially a *negative time error* in a traditional sense. That is, when two stimuli are presented in a sequence, the duration of the second stimulus is relatively overestimated in comparison with the first stimulus, because the memory storage size of the first stimulus diminishes by the time the second stimulus is presented. Furthermore, this tendency for relative overestimation of the second stimulus duration should become accentuated if the interduration interval, i.e., the interval separating two stimuli, were increased. On the other hand, these two predictions can be derived on a similar basis from Köhler's "fading trace" theory dealing with time error in psychophysical discrimination (see Osgood, 1953, p. 55). Since the memory storage model of temporal judgment can be regarded as a case of the fading trace theory, the question of whether the monotonic relations between numerosity and temporal judgment is mediated memory wise, leads to a study of the effect of numerosity in conjunction with psychophysical discrimin tion of temporal duration.

Suppose that two stimuli, each bearing a number of dark dots, are presented in a sequence, that the task is that of judging whether the duration of the second stimulus is "longer" or "shorter" than the duration of the first stimulus, and consider the following two cases. In the first case, the number of dots of the first stimulus is variable from trial to trial and is either one, three, or five, while the number of dots of the second stimulus is constant and is three. In the second case, the number of dots of the first stimulus is three and the second stimulus either one, three, or five. If the effect of numerosity on temporal judgment is attentional, then such an effect should be more pronounced in the second case than in the first case, because by the time the second stimulus is presented, the first stimulus is no longer present to pay attention to. On the other hand, the assumption that temporal judgment is mediated by memory storage size should lead to the prediction that, as the interduration interval is increased, so is the tendency to overestimate the second stimulus duration. These two predictions can be tested.

EXPERIMENT I

Method

Nine male and 11 female undergraduates from introductory psychology courses were assigned to two groups, Group 1 and Group 2, of 10 Ss each. Each stimulus was a 21.6 x 18.1 mm rectangular white card bearing either one, three, or five dark dots. These dots were distributed randomly on each card by means of a nine-cell rectangular grid measuring 3 x 3 cm. Assignment of dots over this grid was done by using two-digit random numbers. There were altogether 20 cards. Ten cards bore three dots. Five cards bore one dot and another five cards, five dots. Stimulus was presented by means of a Lafayette U-1 electronic tachistoscope.

The procedure was typical of that of a psychophysical discrimination. Two stimuli were presented in sequence, and each S was instructed to report verbally whether the second stimulus duration was "longer" or "shorter" than the first stimulus duration in each trial. Of the total of 54 trials, the first and second stimulus durations were .50 and .55 sec, respectively, for 27 trials, and were .55 and .50 sec, respectively, for the remaining 27 trials. Trial presentation with respect to sequence of durations was random. For each trial, the interduration

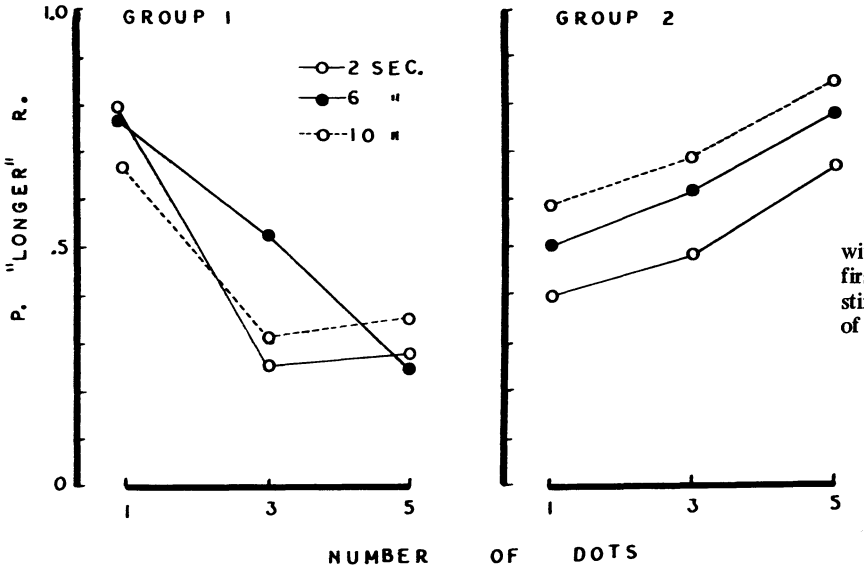

Fig. 1. Proportions of "longer" responses with respect to numerosity of dots of the first stimulus (Group 1) and the second stimulus (Group 2). Interduration intervals of 2, 6, and 10 sec.

interval was either 2, 6, or 10 sec. Each interduration interval was associated with 18 trials. The trial-to-trial distribution of the interduration interval was also random.

For Group 1, the number of dots for the first stimulus was variable while such numerosity was constant for the second stimulus. That is, for 18 trials, the first stimulus bore one dot, for another 18 trials three dots, and for the remaining 18 trials five dots, while the second stimulus bore three dots for the entire 54 trials. In corresponding fashion, for Group 2, the number of dots was constant for the first stimulus and variable for the second stimulus.

The rate of trial presentation was not rigidly controlled. But, estimating from the running time of the experiment, the intertrial interval was between 30 and 40 sec.

Results

The proportions of "longer" responses with respect to the number of dots and interduration interval are shown in Fig. 1. It is apparent that the tendency to judge the duration of the second stimulus as longer than the duration of the first stimulus is a monotonically decreasing function of the numerosity of dots of the first stimulus (Group 1: $F = 16.52$, $df = 2/72$, $p < .001$), and is a monotonically increasing function of the numerosity of dots of the second stimulus (Group 2: $F = 6.81$, $df = 2/72$, $p < .005$). As to the effect of the interduration interval, the tendency for the proportions of "longer" responses to increase as a function of the interduration interval may be detected in Group 2. However, the F-ratio analysis of this tendency did not reach a satisfactory level of significance. For both groups, it is reasonable to conclude that the effect of interduration interval on comparative judgment of the duration of the second stimulus with respect to the first stimulus is either absent or weak. As to the proportions of correct responses, they were .51, .56, and .62 with respect to one, three, and five dots for Group 1, and .60, .61, and .59 in similar order for Group 2.

In both groups, the monotonicity of the effect of numerosity on temporal judgment is well demonstrated, implying that such an effect is unlikely to be attentionally mediated. The relative absence of the effect of the interduration interval also does not fully substantiate the original prediction arising from the memory storage model. However, since there were only two durations, it is possible that comparative judgment of duration in actual sense was not made. For example, once the first stimulus of shorter duration is presented, the duration can be recognized as the "shorter" duration before the second stimulus is presented. In such a case, the effect of the interduration interval may be minimized. Introduction of more than two durations may make the effect of the interduration interval more pronounced.

EXPERIMENT II

Method

Ten male and 10 female undergraduates from introductory psychology courses were assigned to two groups, Group 1 and Group 2, of 10 Ss each. The procedure was the same as in Experiment I except that there were six stimulus durations instead of two. In each trial, stimulus durations were .30 and .33 sec, .50 and .55 sec, or .70 and .77 sec. As in Experiment I, each shorter duration was followed by its corresponding longer duration as often as the longer duration was followed by its corresponding shorter duration.

Results

The proportions of "longer" responses with respect to numerosity and interduration interval are shown in Fig. 2. As in Experiment I, the tendency to judge the second stimulus duration as "longer" is a monotonically decreasing function of the number of dots associated with the first stimulus (Group 1: $F = 4.18$, $df = 2/72$, $p < .025$), and is a monotonically increasing function of the number of dots of the second stimulus (Group 2: F

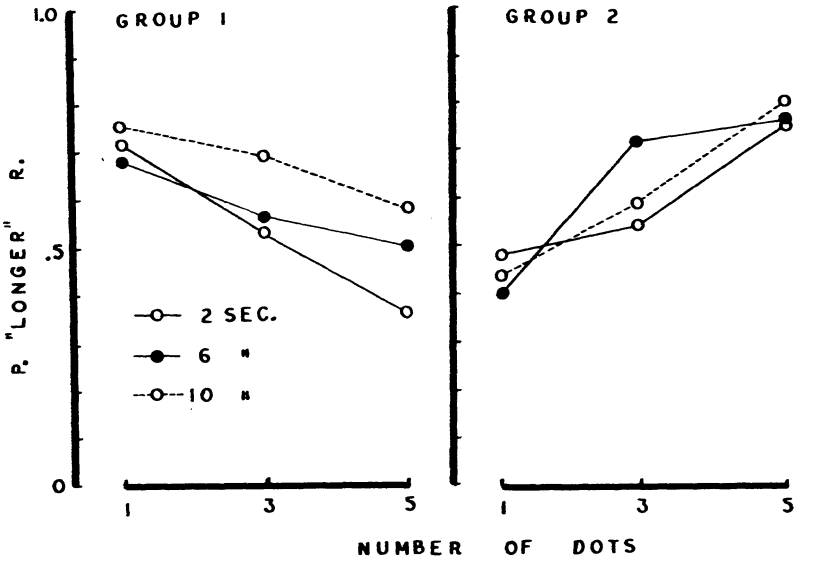

Fig. 2. Proportions of "longer" responses with respect to numerosity of dots of the first stimulus (Group 1) and the second stimulus (Group 2).

= 11.52, df = 2/72, $p < .001$). No other effects were statistically significant. The proportions of correct responses were .58, .58, and .60 with respect to one, three, and five dots for Group 1, and were .63, .61, and .54 in similar order for Group 2. In general, the results of this experiment are little different from those of Experiment I.

DISCUSSION

The relation between numerosity of stimulus elements and temporal judgment was shown to be monotonic regardless of whether such numerosity was associated with the first stimulus or the second stimulus. Also, increase of the interduration interval did not appreciably accentuate the tendency to overestimate the duration of the second stimulus in comparison with the first stimulus. Therefore, it is difficult to agrue that the demonstrated effect of numerosity on temporal judgment is mediated by an attentional factor or by a memory factor which decays over time. This difficulty probably originates from ambiguity concerning applicability of the concept of memory to temporal judgment. A pertinent question would be to ask: memory of what? One assumption which may originate from this question is that the content of memory storage is numerosity of dots. Since the maximum number of dots was five, well within the range of what may be called span of apprehension, it is reasonable to infer that numerosity of dots can be accurately perceived at the time of presentation of the first stimulus. Therefore, it is unlikely that such accurately preceived numerosity would decrease during the interduration interval. For example, is a single dot was presented, it is unlikely that, after a few seconds, the memory of the numerosity of a single dot would become less than one. Relative absence of the effect of the interduration interval on temporal judgment, then, can be viewed in terms of relative invariance of perceived numerosity during the interduration interval. In this case, the analogy of "fading trace" does not apply and the effect of numerosity may be more cognitive than sensory. The other assumption may be that the content of memory storage consists of temporal experience associated with duration. However, this assumption is circular, for it immediately raises the question as to the nature of temporal experience itself which was originally to be explained in terms of the content of memory storage. As far as comparative judgment of duration is concerned, the effect of numerosity cannot be adequately explained in terms of attentional or memory-wise mediation.

Perhaps, an alternative would be not so much to ask whether "more" attention or memory in translatable into "longer" temporal experience, but rather to ask *when* the effect of numerosity becomes an intrgral part of temporal judgment. Viewed in this manner, it is quite possible that numerosity may take its effect on temporal judgment prior to attentional or memory-wise mediation.

REFERENCES

Mo, S. S. Judgment of temporal duration as a function of numerosity. Psychonomic Science, 1971, 24, 71-72.

Mo, S. S., & Michalski, V. A. Judgment of temporal duration of area as a function of stimulus configuration. Psychonomic Science, 1972, 27, 97-98.

Ornstein, R. E. *On the experience of time.* Harmondsworth: Penguin, 1969.

Osgood, C. E. *Method and theory in experimental psychology.* New York: Oxford, 1953.

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