pairs with more trials needed to learn successive pairs. In particular, the curves for the 0-25 dB group with Conditions OA and WA suggest a laborious trial-by-trial acquisition of materials similar to what one might see with unrelated word pairs. Thus, the learning-curve data serve to demonstrate further the hypothesized qualitative differences in approach to verbal material by hearing and hearing-impaired children.

The fact that the 0-25 dB group showed the greatest effect of modality of cues is intriguing. This group is usually considered to be most like normal-hearing Ss yet performed least like the normal group in this study. Possibly auditory training, generally recommended for more severe losses, could be of benefit to these Ss also. Obviously, further research with hearing losses of this magnitude is needed.

REFERENCES

ALLEN, D. V. Acoustic interference in paired-associate learning as a function of hearing ability. Psychonomic Science, 1970, 18, 231-233.

ALLEN, D. V. Color-word interference in deaf and normal children. Paper presented at 43rd annual meeting of Midwestern Psychological Association, Detroit, Michigan, May 1971.

BLANTON, R. L., & NUNNALLY, J. C. Retention of trigrams by deaf and hearing subjects as a function of pronunciability. Journal of Verbal Learning & Verbal Behavior, 1967, 6, 428-431.

BLANTON, R. L., & ODOM, P. B. Some possible interference and facilitation effects of pronunciability. Journal of Verbal Learning & Verbal Behavior, 1968, 7, 844-846.

CONRAD, R. Acoustic confusions in immediate memory. British Journal of Psychology, 1964, 55, 75-84.

CONRAD, R., & RUSH, M. L. On the nature of short-term memory encoding by the deaf. Journal of Speech & Hearing Disorders, 1965, 30, 336-343.

McLINDEN, M. M. C. Learning with different associative cues by normal-hearing and hearing-impaired children. Unpublished data, Wayne State University, 1959.

ODOM, P. B., & BLANTON, R. L. Phrase-learning in deaf and hearing subjects. Journal of Speech & Hearing Research, 1967, 10, 600-605.

THORNDIKE, E. L., & LORGE, I. *The teacher's word book of 30,000 words.* New York: Bureau of Publications, Teachers College, Columbia University, 1944.

WICKELGREN, W. A. Acoustic similarity and intrusion errors in short-term memory. Journal of Experimental Psychology, 1965, 70, 102-108.

WINER, B. J. *Statistical principles in experimental design.* New York: McGraw-Hill, 1962.

Judgment of temporal duration as a function of numerosity

SUCHOON S. MO
University of Detroit, Detroit, Mich. 48221

In judging brief stimulus duration, change of the number of dark dots from three to one resulted in underestimation, while similar change from three to five resulted in overestimation. Such a trend of temporal judgment was accentuated when the change was less frequent, demonstrating a contrast effect. But the analogous contrast effect was also obtained when the stimulus duration itself was changed.

Several studies reviewed and discussed by Fraisse (1963) show that temporal estimation is an increasing function of such stimulus attributes as intensity, frequency, extensiveness, and complexity. Two tentative explanations were advanced by Fraisse. One is that such attributes may influence the adaptation level by functioning as contextual stimuli. The explanation is the one used in a study by Hirsch, Bilger, & Deatherage (1956) to account for *over*reproduction of temporal duration brought about by the presence of an auditory contextual stimulus. The other explanation is based on the assumption that there is a monotonic relation between the level of attention and temporal estimation so that a more intense stimulus, for example, may lead to overestimation of its duration because it is more attention-provoking (Fraisse, 1963, pp. 134-135).

Suppose that unexpected change in either a stimulus attribute or the duration itself is introduced into the experiment. Then these two explanations are incompatible, at least conceptually, with each other. With regard to the adaptation level, such a change should bring about a contrast effect in temporal estimation. On the other hand, if overestimation is due to the level of attention, then such change should bring about overestimation of duration, never underestimation. This study tests and investigates this incompatibility.

EXPERIMENT 1

Subjects

Fifteen male and 5 female undergraduates from the introductory psychology courses were assigned to two groups, G1 and G2, of 10 Ss each.

Apparatus

Each stimulus was a 4 x 5 in. 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. Altogether there were 30 cards, each set of 10 cards bearing one (N_1), three (N_3), or five (N_5) dots. Presentation of each stimulus card was conducted binocularly with a Lafayette U-1 electronic tachistoscope.

Procedure

Each S was told that there were two durations, one short and one long, and that the task was to identify and report verbally in each trial which duration was presented, short or long. These two durations were .30 and .33 sec. Following 10 practice trials, 60 trials altogether were administered in such a way that for Ss in G1, the probabilities of distribution of N_1, N_3, and N_5 were all .33, and for Ss in G2, they were .17, .66, and .17, respectively. As to the duration, the probabilities of both short and long durations were .50. The intertrial interval was about .5 min. Throughout the entire trials, Ss were not allowed to detach their faces from the eyepiece in order to ensure a uniform light adaptation. At the end of the experiment, each S was asked how many dots he saw. No S failed to judge correctly the number of dots.

Results and Discussion

The proportions of the "long" responses as a function of the number of dots are presented in Fig. 1. Using the arcsin transforms, an analysis of variance was conducted. Its results indicate that the increasing trend of such "long" judgments as a function of the number of dots is significant ($F = 11.22$, $p < .005$). Also, it is observed that this trend is more pronounced in G2 than in G1,

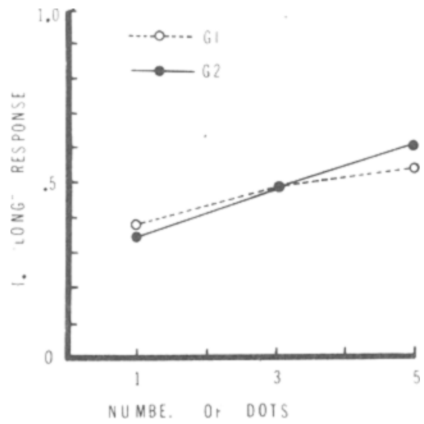

Fig. 1. The proportions of "long" responses as a function of numerosity.

implying that the infrequent change of numerosity for G2, as compared to more frequent change for G1, more or less creates a contrast effect of temporal judgment. In order to test this observation, the "slopes" of such trends of G1 and G2 were obtained by taking the sum of successive differences of the proportions of "long" responses with respect to numerosity. The difference between such slopes of G1 and G2 was significant ($t = 2.92$, $p < .01$). The overall proportions of "long" responses for G1 and G2 were .47 and .49, respectively, ruling out the possibility that the demonstrated contrast effect is due to a general shift in response bias itself. As to the proportions of correct judgments with respect to N_1, N_3, and N_5, they were: .63, .66, .63 for G1 and .61, .63, .63 for G2. This invariance of correct judgment with respect to numerosity is understandable because the probabilities of both short and long durations were the same. For example, the underestimation with respect to N_1 is merely to increase the number of correct judgments accompanying short duration and to decrease the number of correct judgments accompanying long duration. A similar argument applies to the case of overestimation. At least, the effect of numerosity on temporal judgment of duration does not involve differential sensitivity of such judgment.

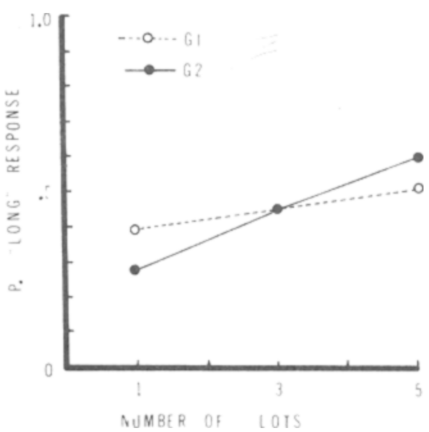

Fig. 2. The proportions of "long" responses as a function of numerosity.

Based on these observations, the assumption that over- or underestimation of duration is due to the level of attention is not acceptable. On the other hand, the concept of attention is not a well-defined one, covering phenomena ranging from selective input function to generalized nonspecific activation of performance. Perhaps one alternative is to limit the concept of attention to that of nonspecific arousal or activation. In such a case, the increase in level of attention caused by infrequent change of numerosity accentuates the existing trend, creating a contrast effect. This deduction raises the possibility that any infrequent change, not only that of numerosity itself, may also create a similar contrast effect. The next experiment was conducted to study this possibility.

EXPERIMENT 2

Method

Fourteen male and 6 female undergraduates from the introductory psychology courses were assigned to two groups, G1 and G2, of 10 each. For both groups, the probabilities of distribution of N_1, N_3, and N_5 were .33. The probabilities of the short and long durations were .50 and .50 for G1 and .25 and .75 for G2, respectively. Except for this alteration of the probabilities of numerosity and duration, the procedure was the same as that in Experiment 1.

Results and Discussion

The proportions of "long" responses as a function of numerosity are presented in Fig. 2. As in Experiment 1, the effect of numerosity was significant ($F = 7.51$, $p < .005$), but its interaction with the groups effect did not reach the 5% level of significance. For each S the "slope" was measured by taking the sum of successive differences of such proportions with respect to numerosity. The difference of the means of such slopes between G1 and G2 was shown to be highly significant ($t = 4.20$, $p < .01$). As to the proportions of correct judgments with respect to N_1, N_3, and N_5, they were .64, .66, .63 for G1 and .49, .57, .64 for G2, respectively. This interaction between the effects of numerosity and groups ($F = 3.30$, $p < .05$) at first appears to imply that differential sensitivity is affected by temporal estimation. But this speculation is unfounded, as can be seen in Fig. 3. Once the proportions are determined

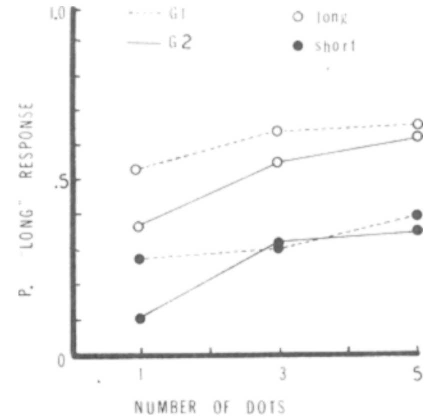

Fig. 3. The proportions of "long" responses with respect to the short and long durations as a function of numerosity.

with respect to the short and long durations, it can be seen that there is accentuation of underestimation with respect to N_1, irrespective of whether the duration is the short or long one. That is, the number of correct judgments increases with respect to the short duration and decreases with respect to the long duration. Due to the unequal sample size of these two durations, the number of incorrect judgments is more heavily weighted with respect to N_1 than to N_5. Thus, the lack of invariance of the proportions of correct judgments of G2 does not so much reflect change in differential sensitivity as it does a general tendency to underestimate the duration accompanying N_1.

In both experiments, infrequent change, whether that of the stimulus attribute or the duration itself, created a tendency for contrast and not a general tendency for overestimation. It is obvious that the state which results from such change, be it adaptation level or attention, is nonspecific and functions primarily to accentuate the existing trend of temporal estimation. This inference is even more plausible because the contrast effect of temporal judgment obtained in these two experiments cannot be deduced from the assumed contrast effect of the stimulus attribute itself for two reasons: Every S correctly identified the number of dots, and the infrequent change of the number of dots from three to one would not alter the judgment of numerosity of a single dot.

REFERENCES

FRAISSE, P. *The psychology of time.* New York: Harper & Row, 1963.

HIRSCH, I. J., BILGER, R. C., & DEATHERAGE, B. H. The effect of auditory and visual background on apparent duration. American Journal of Psychology, 1956, 69, 561-574.