Continuity of exposure length effects in tachistoscopic perception¹

BETH RAYMOND AND MURRAY GLANZER

NEW YORK UNIVERSITY

It has been claimed that the number of units reported by Ss remains invariant over the range of exposure durations 15 to 500 msec. Four sets of observations under various experimental conditions were carried out to test this claim. The results are univocal: there are continuous, systematic increases in number of units reported with increase in exposure duration.

Sperling (1960, p. 6) has presented evidence that the number of letters reported from six- or eight-letter tachistoscope displays is invariant at about 4.5 letters over the range 15 to 500 msec. He cites earlier work by Schumann (1904) in support of this invariance. This lack of relationship between amount reported and exposure time for the range 15 to 500 msec. is cited again, with reference made to new data, in Sperling (1963). One set of data that does show an increase in number of letters correctly reported as a function of exposure duration in the range 10 to 200 msec. is interpreted as due to postponement of a post-exposure interference or masking field (p. 25).

Invariance of performance has specific theoretical significance for Sperling in his emphasis on the role of memory. It also has general significance in that it leads to the rather surprising implication that the performance is discontinuous, that it rises someplace in the range of 0 to 15 msec., that it forms a plateau in the range 15 to 500 msec. and that it may rise again at some longer exposures. Such a function seems anomalous and calls for further investigation.

Method

Four experiments or sets of measurements were carried out to determine whether such an invariance existed. The measurements were carried out on a three-field NYU tachistoscope (Karlin, 1955) with the presentation material covering a 2-degree visual angle. The brightness of the stimulus field was 3 ft.-L. When an illuminated pre- and post-field were used, they were approximately 2 ft.-L. The Ss were six undergraduate and two graduate students. The following conditions were run (outcomes are indicated in the figures): (A) One S, stimulus material 8-place binary numbers, 900 trials equally distributed over 50, 100, 200, 400, 800 and 1600 msec. exposures, pre- and post-field illuminated (See A of Fig. 1). (B) Since the binary numbers display rather special organizational characteristics (Glanzer & Clark, 1963), a similar set of observations was made using arrays of eight consonant letters. The letters for each array were chosen at random with the restriction that no letter could appear more than twice in an array. Three

Ss again run with pre- and post-field illuminated, had 80 trials each, distributed equally over 50, 100, 200 and 400 msec. exposures. (See B of Fig. 1). (C) Since there was a possibility of afterimages, tests were made with a masking stimulus present in the pre- and post-field. The masking stimulus consisted of three lines of a random series of typewriter keyboard symbols, +, #, ?, etc., with the middle line in the same position as the letters. Two Ss were given 320 trials each with letters as stimuli under the procedure outlined (in B) above, except that a masking stimulus was used. (See C of Fig. 1). (D) Since Sperling (1963) notes that the condition of the pre- and post-field is important, observations were also made with the pre- and post-field dark. Two Ss under the same conditions as B except that the pre- and post-field were not illuminated; one S was given 320 trials, the other, 160. (See D of Fig. 1).

Results

Under all four sets of observations, there is a continuous increase in the performance over the range 50 to 400 msec. Only one S, MN, failed to show an increase in number of units correct with each increase in exposure. For that S the number correct at 50 and 100 msec. was the same. The reason for the evidence of invariance found by Sperling may lie in the special conditions of his experiments.

Fig. 1. Plots of number of units correct as a function of exposure duration: A, 150 observations per point, pre- and post-field light; B, 20 observations per point, pre- and post-field light; C, 80 observations per point, pre- and post-field masked; D, 40 observations per point, for MM; 80 observations per point for EB, pre- and post-field dark. Each S is plotted separately.

Discussion

The findings on the change in performance as a function of exposure disagree with Sperling's.² The performance shows continuous changes as exposure duration increases. The findings indicate an upper limit of four to five letters reported from arrays of letters. These findings agree with Sperling's. The results for the binary numbers, which fall well above the range of four to five units, do not really contradict the latter findings. It is known that binary numbers permit grouping or encoding (Glanzer & Clark, 1963) and that they therefore follow somewhat more complicated laws.

If the presentation procedure used is particularly favorable or if it tends to promote afterimages, maximal or asymptotic performance could be approached over a considerable range of exposure times. This may be the condition that was obtained in the Sperling and the Schumann experiments. Even near asymptote, however, sufficient measurement gives evidence of changes with increased exposure (see A). However, even though apparent invariance may be found under some experimental conditions, it certainly is not

general. The general case is one in which there is a continuous change of performance when exposure time is varied.

References

- Glanzer, M., & Clark, W. H. The verbal loop hypothesis: binary numbers. *J. verbal Learn. verbal Behav.*, 1963, 2, 301-309.
- Karlin, L. The New York University Tachistoscope. *Amer. J. Psychol.*, 1955, 462-466.
- Schumann, F. Die Erkennung von Buchstaben und Worten bei momentaner Beleuchtung. In: *Bericht über den ersten Kongress für experimentelle Psychologie*. Leipzig: Barth, 1904. Pp. 34-40.
- Sperling, G. The information available in brief visual presentation. *Psychol. Monogr.*, 1960, 74, No. 11 (Whole No. 498).
- Sperling, G. A model for visual memory tasks. *Hum. Factors*, 1963, 5, 19-31.
- Sperling, G. Successive approximations to a model for short-term memory. *Proc. 18th Int. Congr. Psychol.*, Moscow, 1966, Amsterdam: North Holland Publishing Co., in press.

Notes

1. This study was carried out under Research Contract DA-49-193-MD-2496, U. S. Army Medical Research and Development Command, Department of the Army. We thank Julian E. Hochberg for his critical reading of an earlier draft of the paper.
2. Since preparation of this paper, Sperling (in press) has presented data that show continuity of the effect of exposure duration on the perception of letters (10 to 200 msec.).

The A test: A simplification of the t test for correlated samples by Robert Zenhausern

A statistically identical version of the correlated "t" test was compared with the latter. Method of calculation, determination of significance, and advantages were discussed.

A frequently used experimental design involves testing the same Ss under two conditions. Statistically, this is usually handled through the use of a correlated t test, based on the differences between the two scores for each individual. A typical formula, found in Ferguson (1966), is as follows:

$$t = \frac{\sum D}{\sqrt{N \sum D^2 - (\sum D)^2 / N - 1}}$$

where D refers to the signed differences between the two conditions for one S.

A statistically identical, although much simpler, formula has been developed by Sandler (1955). The modification, designated the A test, is calculated as follows:

$$A = \frac{\sum D^2}{(\sum D)^2}$$

where D has the same meaning as in the t test.

An examination of the formula makes it evident that the smaller the A value, the more significant the difference, since $\sum D$ increases as the scores for one condition are consistently greater or smaller than the scores from the other condition. The A values needed for significance can be determined from the t value

needed for significance through the use of the following conversion:

$$t = \sqrt{\frac{N-1}{AN-1}}$$

where N is the number of Ss and t is the value needed for significance. Tables of A appear in Sandler's (1955) article and McGuigan's (1960) book.

There are two main advantages to the "A" test: (1) The calculations are simple. (2) The A test is actually more accurate than the correlated t test, since rounding errors are non-existent in the A test.

The only disadvantage of the "A" test is the relative scarcity of tables of A. A one-time calculation of these values, however, will solve this problem. Furthermore, as the test becomes better known, tables of A will be more available. For some reason, this test is virtually unknown among psychologists, and seems to have been mentioned only by McGuigan (1960). The A test is a simple, more accurate version of the correlated t test. It should be taught in all elementary statistics courses and ultimately replace the relatively cumbersome "t."

References

- Ferguson, S. A. *Statistical analysis in psychology and education*. New York: McGraw-Hill, 1966.
- McGuigan, F. J. *Experimental psychology*. Englewood Cliffs: Prentice-Hall, 1960.
- Sandler, J. A test of significance of the difference between the means of correlated measures, based on a simplification of student's "t". *Brit. J. Psychol.*, 1955, 46, 225-226.