

Use of tone offset to facilitate reaction time to light onset*

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Four Ss participated in a visual discriminative reaction time (RT) task to explore the phenomenon of intersensory facilitation. Previous research has indicated that RT to a joint visual-auditory event is more rapid than RT to the visual component alone, even when the auditory component is noninformative. In the present study, a tone offset was used in place of the usual affirmative event (click). The results indicated that RT was more rapid when the tone offset in conjunction with the occurrence of the visual event as compared to when the tone remained on throughout the trial. The effect was comparable in magnitude to that obtained in prior studies using an affirmative auditory event.

Previous research (Morrell, 1968; Bernstein, 1970; Bernstein, Rose, & Ashe, 1970) has shown that visual discriminative reaction time (RT) is more rapid when a short (10 msec), intense (100 dB or more) tone burst (click) occurs in temporal proximity to the reaction signal. The difference in RT to the visual (V) and combined visual-auditory (VA) stimulation is systematically related to such factors as the intensity of the components of VA, S's degree of preparation, and the interstimulus interval separating the onsets of V and A. The resulting phenomenon dates back to Todd (1912) and is termed "intersensory facilitation of reaction time." In the present experiment, a relatively simple question was posed: Can the effect be obtained when the auditory event (A) is an offset of a preexisting tone, rather than the onset of a tone.

SUBJECTS

Two female (BM and KK) and two male (NP and LD) paid students were recruited from a junior-level introductory psychology course at the University of Texas at Arlington. They were inexperienced in RT both from the standpoint of participation and the issues involved, unlike prior Ss in this series.

PROCEDURE

Each trial began with the onset of a tone. At the end of a 2-sec foreperiod delay (FPD), one of four equiprobable events occurred ($\pm 2\%$ randomization error). On a visual-auditory (VA) trial, a spot of light appeared for 100 msec and the tone simultaneously offset. The tone then reonset for an additional 2.9 sec. On a visual (V) trial, the spot of light came on as in a VA trial, but the tone remained on continually for an additional 3 sec.

*Supported by NIMH Grants 12530 and 17030 and by a Liberal Arts Organized Research Fund grant to the senior author. The authors wish to acknowledge the comments of Mr. Victor Ashe.

Auditory (A) and blank (-) trials were analogous to VA and V trials, respectively, but the spot did not appear. Thus, time from initial tone onset to final tone offset was always 5 sec. On half of the trials (VA and A), the tone offset for 100 msec after the tone had been on for 2 sec.

VA and V trials were "go" trials requiring reaction; A and - trials were "no-go" or catch trials requiring inhibition. Because the onset of the spot of light was independent of the tone offset, the latter conveyed no information regarding response choice.

All Ss were practiced for a minimum of 2 h before experimental data were gathered. The data to be reported were based upon from 274 to 291 observations per trial type. Approximately 200 RTs were obtained per session, exclusive of warm-up.

APPARATUS AND STIMULI

E and S were seated in adjacent rooms in a new Life Science Building. Visual stimulation was presented in a Scientific Prototype Model GB three-field tachistoscope. The blank field contained a fixation cross cut from an opaque mask that remained on continually. The stimulus spot was a hole cut in an opaque mask that subtended 20 min of arc and appeared in one exposure field superimposed upon the fixation cross. On A and - trials, the bulbs illuminating the spot were turned off, and

Table 1
Mean and Standard Deviation of RT to VA and V Trial Types, Separately for Each S and as a Composite

Subject	Trial Type			
	VA		V	
	\bar{X}	S	\bar{X}	S
NP	194	30	216	27
BM	194	32	228	30
LD	225	37	261	36
KK	220	37	247	33
Composite	208		238	

the circuitry was left intact. The second exposure field was not used. Both the fixation cross and spot were approximately 10 fL. The tone was a 100-dB, 1,000-Hz sinusoid generated by an RCA Model WA-44c signal generator, amplified by a Scott Model 99-A monaural amplifier and delivered binaurally through Koss PRO-4 headphones. S's response was a right-hand telegraph key depression. External white masking noise was used as a precaution, but was barely audible through the headphones. A Hunter delay timer was used to control tone offset.

RESULTS

Means and standard deviations for V and VA trials are presented in Table 1, separately for each S and as a composite. As can be seen, there is a mean difference of 30 msec across Ss favoring RT on VA as opposed to V trials. This difference is highly consistent across Ss, ranging from 22 to 36 msec. A conservative inferential test, a Treatment by Ss analysis of variance, was significant [$F(1,3) = 20.4$, $p < .05$], so no further inferential tests were run.

One lesser trend is that the standard deviations were slightly, but consistently, larger for VA as opposed to V trials. This is contrary to the usual dependence of RT variability upon the mean. Finally, the error rate was too low to provide meaningful data analysis. No S made a false alarm on - trials and two of four Ss made no false alarms on A trials (LD and KK). The remaining Ss (NP and BM) had respective inhibition probabilities of .986 and .950 on A trials. These two findings suggest that A had other effects and will be explored further.

DISCUSSION

The data clearly demonstrate that RT was more rapid when V was accompanied by tone offset, demonstrating that the effect can be obtained with both the occurrence and the offset of tone. In other words, RT is a function of total stimulus change, even when stimulus components change in different directions.

The effect is also of a magnitude consistent with prior Studies. Bernstein, Rose, & Ashe (1970) used a dimmer (1 fc) V event and a design with fewer catch trials (there were no - trials). A was the occurrence of a 10-msec 100-dB tone. Increases in the intensity of the V event decrease the intersensory effect (Bernstein, 1970). Conversely, the larger percentage of catch trials in the present study decreases S's readiness to respond (Bernstein, Blake, & Clark, 1970), which, in turn, enhances the intersensory effect (Bernstein, Rose, & Ashe, 1970).

It is thus reasonable to assume that the methodological differences between the

Bernstein, Rose, & Ashe (1970) and present studies are largely offsetting. Then, the 30-msec difference in RT found in Table 1, which was obtained with a 2-sec fixed FPD, is consistent with the 24-msec difference obtained with a .5-sec fixed FPD and the 44-msec difference obtained with a 5.5-sec FPD in the earlier study.

REFERENCES

BERNSTEIN, I. H. Can we see and hear at the same time? Some recent studies of intersensory facilitation of reaction time. In A. F. Sanders (Ed.), *Attention and performance*.

Vol. III. Amsterdam: North Holland, 1970 (in press).

BERNSTEIN, I. H., BLAKE, R. R., & CLARK, M. H. Sensitivity and decisional effects in the psychological refractory period. *Perception & Psychophysics*, 1970, 7, 33-37.

BERNSTEIN, I. H., ROSE, R. R., & ASHE, V. M. Preparatory state effects in intersensory facilitation. *Psychonomic Science*, 1970, 19, 113-114.

MORRELL, L. K. Temporal characteristics of sensory interaction in choice reaction times. *Journal of Experimental Psychology*, 1968, 77, 14-18.

TODD, J. W. Reaction to multiple stimuli. *Archives of Psychology*, New York, 1912, 3, No. 25.

Verbal learning and retention by amnesic patients using partial information*

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Amnesic patients can remember pictures and words over several days if they are given visually fragmented information about them in the retention test. The present study shows that learning and retention occur when the partial information about words is in the form of whole letters. The results tend to discount an interpretation in terms of spared "perceptual learning" in such patients.

Amnesic patients are not amnesic under all circumstances. For example, it has been reported (Corkin, 1968) that the acquisition and retention of motor skills are possible (although evidently not normal) in one patient (H.M.) with bilateral hippocampal lesions. The same patient could also learn very simple visual and tactile maze problems (Milner, Corkin, & Teuber, 1968). The present authors (Warrington & Weiskrantz, 1968a) also found that amnesic patients could retain items presented in a particular form even if such items are not usually retained with conventional testing methods. The procedure, which recalls some earlier "prompting" experiments by Williams (1953), required the S to identify fragmented drawings of pictures or words. Amnesic Ss require progressively fewer cues to identify the drawings. Significant

retention can be demonstrated over days and perhaps even over weeks, whereas conventional methods yield significant retention over minutes at best. The same method also yielded significant retention in Patient H.M. when tested by Milner, Corkin, & Teuber (1968).

Milner (1968) appears to interpret the progressive improvement with the incomplete picture method as a kind of "perceptual learning," and considers that motor learning and perhaps certain forms of perceptual learning may be spared in amnesic patients. The present experiment is designed to determine whether or not the method of providing incomplete information can be extended to verbal material presented in such a way that no perceptual strain is placed upon the S. Instead of using visually displayed words that are randomly fragmented so that even individual letters are not readily identified on first exposure, we used the first two or three whole letters of five-letter words. There was thus no degradation of any particular letter; the Ss had to use perceptually complete verbal subunits of a word to identify the whole word.

SUBJECTS

Ss were three amnesic patients, all of whom were included in our previous studies. One had a right temporal lobe excision (Dimsdale, Logue, & Piercy, 1964); the other two were cases of Korsakoff psychosis. Clinical details of the amnesic patients can be found elsewhere (Cases 1, 5, and 7 in Weiskrantz & Warrington, in press). There were four control Ss, approximately matched in age and intelligence, who were hospitalized for noncerebral neurological pathology.

PROCEDURE

Three lists of eight words were drawn from the AA list of the Thorndike-Lorge (1944) word count. The S was first shown the first two letters of the five-letter word on a card, and asked to guess the word. If he could not do so, he was shown the first three letters. If he still could not identify the word, he was shown the complete word. Each list of eight words was presented in the same sequence until the S could identify every word in the list by seeing only the first two letters. A trial was defined as a presentation of the entire list of eight words, and the error score was defined as the number of additional cards (other than the cards with just the two letters) required for identification of the words. The letters were strong black capitals, 1½ in. tall, printed with a felt pen on white cards, 5 x 8 in.

After learning the list to a criterion of two errorless trials, the S returned to his ward activities and was retested after 1 h, using the identical procedure. Each S was tested on 3 successive days with three different lists of words. The score for each S on any particular trial was the average of his performance on all three lists for that trial. Savings scores were calculated for each by comparing average-errors performance on the first relearning trials with average-errors performance on the first learning trials, according to the formula (Learning - Relearning)/(Learning + Relearning). Also, the mean number of trials to criterion for each S was calculated for learning and relearning sessions.

RESULTS AND DISCUSSION

The results are summarized in Fig. 1, which shows the mean error scores for each group for the first 10 trials of learning and relearning. The general pattern of results is similar to that found with fragmented pictures and words. The amnesic Ss show rapid learning to the criterion, although not as rapid as controls ($p = .057$ by Mann-Whitney U test). Every savings score in both groups was positive ($p = .008$ by the signs test) but the controls show significantly greater savings ($p = .028$ by Mann-Whitney U test). Patients are significantly slower than controls in relearning to criterion ($p = .028$ by

*We gratefully acknowledge the cooperation of Dr. R. T. C. Pratt throughout the course of this research. Support was given by the Medical Research Council of Great Britain.

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