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# REPETITION EFFECT AND SHORT-TERM MEMORY[1]

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2 experiments are reported which attempted to determine the basis of the "repetition effect," i.e., the observed shorter reaction time (RT) for repeated events than for nonrepeated events. The 1st experiment was designed to determine whether the effect was due primarily to peripheral response facilitation, or primarily to more central coding effects. By employing a condensing task in which the same response was made to 2 different stimuli, it was concluded that the effect was not due to peripheral response facilitation, but appeared to be more central in origin. The 2nd experiment tested the hypothesis that the repetition effect resulted from short-term activation of the S-R memory trace. Some support was found for this prediction. It was found that the repetition effect declind with increasing intertrial interval (ITI) over a range in which decline in short-term memory (STM) is typically reported, and that RT for both repeated and nonrepeated events increased with increased ITI, indicating that increased fading of the memory trace occurred in both conditions.

In a choice reaction time task, the reaction time (RT) for a repeated event is faster than for a nonrepeated or new event—i.e., one which is different from the immediately preceding event (Bertelson, 1961, 1963, 1965; Hyman, 1953). Bertelson has named this phenomenon the "repetition effect." Recently it has been suggested (Kornblum, 1967) that this phenomenon may underlie the observation that mean RT increases linearly with transmitted information, since under most circumstances with an increase in the number of choices there is a decrease in the number of repetitions. Because this phenomenon could therefore play a very important role in the relationship between RT and transmitted information, these experiments attempted to provide some understanding of the basis of the repetition effect.

Two experiments are reported here. The first experiment was done to determine whether the locus of the repetition effect was central or peripheral in origin. The effect would be considered a peripheral one if after making a response there was some peripheral motor facilitation for a short period of time, so that a second response which was identical to the first could be made more quickly. On the other hand, the origin would be considered central, if after making a particular stimulus-response pairing, it was the S-R bond or memory trace which remained activated, such that when the stimulus was presented again it was not necessary to make an entire search through memory for the correct response as long as the S-R bond was still active. This activation could correspond to the reverberating circuit postulated by Hebb (1961) as the basis of short-term memory (STM).

To differentiate between these two possibilities a condensing task was employed (Posner, 1964) which permitted a two-to-one mapping of stimuli to responses. Four stimuli were presented, two requiring one response and two

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requiring a second response. Since the same response is made to two different stimuli, it is possible to examine the repetition effect as a function of repetition of a particular response (two different stimuli, same response) or as a function of the repetition of a particular S-R coding (same stimulus, same response). If the effect is primarily peripheral in origin, repetition of the response should account for most of the effect. If it is a more central phenomenon, the repetition effect should be greatest when the same S-R code is repeated.

This problem has been examined previously by Bertelson (1965), who concluded that the effect was primarily peripheral in origin. However, in his experiment some confounding was possible. The *S*s pressed a left key if the Stimuli 2 or 4 were presented and a right key if the Stimuli 5 or 7 were presented. Bertelson found that the repetition of the response was the main determinant, since, e.g., RT to a 2 following a 4 was almost as fast as to a 2 following a 2, while both were much faster than to a 2 following a 5 or 7. However, it is possible that *S*s coded the information in the form: even digit, left; odd digit, right, so that either a 2 or a 4 activated the identical S-R code. This experiment therefore reexamined the situation, attempting to eliminate any such confounding.

The second experiment which is reported here attempted to trace the time course of the repetition effect, to determine whether it was similar to that found in STM studies.

## Experiment I

### *Method*

*Subjects.*—Twenty *S*s took part in this experiment. They were all enrolled in the introductory psychology course at the University of Toronto and participated in the experiment as part of their course requirement.

*Apparatus.*—Stimuli were presented by an on-line read-out device, which permitted presentation of the numbers 0-9. Only the numbers 1 and 2 were used in this experiment. The color of the background could be manipulated as well, permitting either a red or green background. The stimulus subtended a visual angle of 9.5°. A small orange neon bulb, situated 2½ in. above the visual display, served as a warning signal. Reaction time from onset of the stimulus display to the pressing of a key was measured to the nearest .01 sec. by a Cramer clock. The RT keys consisted of four push buttons, only two of which were used in this experiment. The *S* and *E* were seated next to one another in a booth which was separated by a divider so that *S*'s vision of *E* was entirely occluded. A random noise generator with a range of 20 kc was used to provide white noise. This noise was presented to *S* through earphones and provided an effective mask of any extraneous sounds in the room.

*Procedure.*—Each *S* attended one 1-hr. session. A two-to-one mapping of stimuli to responses was employed in the condensing task. Four stimuli were presented: a Red 1, a Green 1, a Red 2, or a Green 2 (the color refers to the background), while only two responses were used—pressing the left key with the left forefinger or the right key with the right forefinger. The *S*s were instructed to press the left key if either a Red 1 or a Green 2 was presented, and the right key if either a Red 2 or a Green 1 was presented. Hence, it was necessary to pay attention to both stimulus attributes of color and number.

The warning signal was presented for 1 sec., followed after a 1-sec. interval by a 1-sec. presentation of the stimulus. Prior to the experiment, each *S* was given 12 practice trials. In the experiment proper, each of the four stimuli was presented 50 times in random order, giving a total of 200 trials. There was an intertrial interval of about 4 sec. between offset of the stimulus and presentation of the next warning signal.

### *Results and Discussion*

Response errors were very rare; where they occurred the stimulus was repeated at the end of the series. Consequently, the RT measures which are presented are for correct responses only.

Reaction times to each signal (excluding the very first) were analyzed into three conditions: (*a*) Identical—repetition of the same stimulus (e.g., Red 1 following Red 1), (*b*) Equivalent—repetition of the same response to two different stimuli (e.g., Red 1 following Green 2), (*c*) Different—different stimulus and different response (e.g., Red 1 following Red 2).

This classification corresponds to that employed by Bertelson (1965). The mean RTs for the three conditions were as follows: identical, 807 msec.; equivalent, 937 msec.; and different, 875 msec. Analysis of variance indicated a significant difference among conditions, $F$ (2, 38) = 15.31, $p < .001$, and a Duncan's multiple comparisons test revealed that the difference between each pair of conditions was significant.

It may be seen, comparing the identical and the different conditions, that the usual repetition effect is found—RT is faster to a repeated item (807 msec.) than to a nonrepeated item (875 msec.). The question of interest is whether the equivalent condition more closely resembles the identical or the different conditions. If it is like the identical condition, this would support a peripheral origin hypothesis. On the other hand, if it more closely resembles the different condition, it would appear that the effect is of more central origin. As may be seen above, RT in the equivalent condition is *greater* than both the identical and the different conditions. This suggests that the repetition effect is *not* peripheral in origin and that in fact repetition of the same response to a different signal may cause some additional inhibition. This may be due to a slight reluctance on the part of *S*s to make the same response to a new signal immediately after having made that response to a different signal. Thus, it appears that the origin of the repetition effect is quite central.

## Experiment II

One hypothesis to account for the repetition effect may be based upon STM effects. Considerable evidence suggests that when a stimulus is presented, *S* appears to go through a search process to select a response (Hyman, 1953; Sternberg, 1966). This search continues at least until the correct S-R pairing has been made. To account for the repetition effect it might be assumed that after the pairing has been made, the particular S-R trace which was selected remains activated for a short period of time. Consequently, when the same stimulus is presented again, it is easier to select the correct S-R trace, and it may not be necessary to go through the entire search again. If, in fact, the repetition effect is due to the activation of a short-term trace similar to that postulated to underlie short-term verbal memory, then as the interval between presentations is increased there should be increased fading of the memory trace or perhaps increased interference by other traces, and hence there is increased likelihood that *S* will initiate a search process to select the correct response. Consequently, with a longer intertrial interval (ITI) the difference between RT to repeated and nonrepeated events should decline. Since there is greater necessity of going through the search on each trial, one would also expect mean RT to increase as ITI is increased. While previous experiments have found a decreased effect with intervals up to 1 sec. between the release of the response key and the presentation of the next signal, (Bertelson, 1961; Bertelson & Renkin, 1966; Hale, 1967) this experiment examined the intertrial interval effect over a range in which STM for verbal items has been shown to decline, namely 3–18 sec. (Peterson & Peterson, 1959).

*Method*

*Subjects.*—Twenty-five *S*s, drawn from the same pool as in Exp. I, participated in this experiment.

*Apparatus.*—The same apparatus was employed as in the above experiment, the only difference being that now all four push buttons were used.

*Procedure.*—A four-choice RT task was used in this study which employed a one-to-one mapping of stimuli to responses. The four stimuli employed were the same as in Exp. I: Red 1, Red 2, Green 1, and Green 2. The *S*s were instructed to respond with the left hand if the stimulus was red, and with the right hand if the stimulus was green. The forefinger was used if the number was 1, and the middle finger if the number was 2. Hence, color was mapped to hand, and number was mapped to finger.

The warning signal and the stimulus were each presented for 1 sec. There was a 1-sec. foreperiod between the offset of the signal and the onset of the stimulus display. Three ITIs i.e., the interval between offset of the stimulus on one trial and onset of the warning signal on the next trial, were employed: 2, 6, and 10 sec. Consequently, the total elapsed interval between onset of two successive stimulus displays varied from 5 to 13 sec.

Order of presentation of conditions was randomized and counterbalanced within *S*s by presenting the three conditions in one random order during the first half of the session and then presenting them in the reverse order during the second half of the session. Thus, a given *S* might receive the conditions in the order 6, 2, 10; 10, 2, 6. There was about a 1-min. break between conditions and a 5-min. break between halves. In each half of the experiment, each stimulus was presented 12 times in random order during each interval, giving a total of 48 trials per interval for each half of the experiment, and a total of 96 trials per interval condition. At the beginning of the session, which lasted approximately 1 hr., *S* was given several practice trials to familiarize him with the situation. Prior to each condition *S* was shown the ITI that would be employed.

*Results and Discussion*

The mean RT for repeated and nonrepeated events at each ITI is shown in Fig. 1. In no case was a RT longer than the shortest (2 sec.) ITI employed.

It may be seen that RT for repeated events was in all cases faster than for nonrepeated events. A repeated-measures analysis indicates this difference to be significant, $F\ (1, 24) = 25.3, p < .001$. This is in accordance with the repetition effect which is typically found in such situations.

The question of interest is whether the difference between repeated and nonrepeated events declines with increasing ITI. Examination of Fig. 1 indicates that the difference does in fact decrease over the range of ITIs employed in this study, and the analysis of variance indicates that the Interval × Repetition Effect is significant, $F\ (2, 48) = 5.3, p < .01$. This finding supports the prediction of a STM theory of the repetition effect, for as the ITI is increased, there is increased fading of the S-R trace, and consequently increased likelihood of *S* being forced to initiate a search process to find the correct response associated with a given stimulus for repeated events as well as for nonrepeated events.

Some additional support for this theory is provided by the significant in-

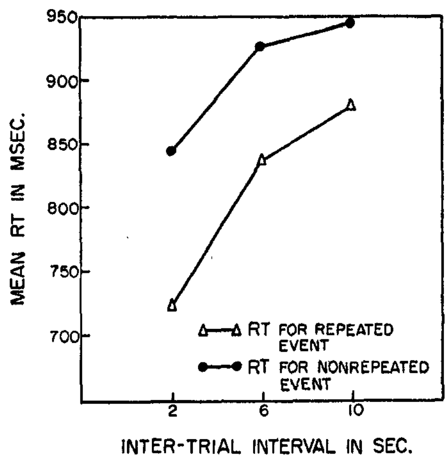


Fig. 1.—Mean RT for repeated and nonrepeated events as a function of intertrial interval.

crease in RT for both repeated and nonrepeated events with increasing ITI. This suggests that at shorter ITIs there is still some activation of the memory trace even for nonrepeated events, so that it is not necessary to initiate the search process on each trial. However, with increased ITI the increased fading necessitates going through the entire search more and more frequently.

To test the generality of the findings the experiment was repeated with a two-choice task, and similar results were found.

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