JOURNAL OF THE EXPERIMENTAL ANALYSIS OF BEHAVIOR VOLUME 6, NUMBER 3 JULY, 1963

EFFECTS OF A CONCURRENT TASK ON FIXED-INTERVAL RESPONDING IN HUMANS[1]

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Subjects pressed a telegraph key to illuminate a meter dial on which pointer deflections appeared at fixed intervals. Upon detecting a deflection they were required to press another key to reset the pointer to zero. This detecting and resetting operation reinforced the behavior of pressing the light-flashing key (*i.e.*, the observing responses). The usual pattern of responding on the light-flashing key was a long pause following the reinforcement and an abrupt transition to a steady response rate toward the end of the interval. When the subjects were required to perform a concurrent subtraction task, the pattern of responding changed in varying degrees, ranging from complete loss of typical fixed-interval behavior to a slight shortening of the post-reinforcement pause. These effects were attributed to the disruption of the self-produced verbal chains (counting or reciting) that ordinarily govern human behavior on this schedule.

Prolonged exposure of an organism to a fixed-interval (FI) schedule of reinforcement typically leads it to develop a pause in responding immediately after the reinforcement has been delivered (Skinner, 1938). This pause is followed by an acceleration in response rate until the rate reaches a value that is maintained until the next reinforcement. The length of the initial pause can be increased considerably by giving the organism an external "clock", *i.e.*, "a stimulus some dimension of which varies systematically with time, usually measured from the preceding reinforcement," (Ferster and Skinner, 1957, p. 724; see also Skinner, 1953). An increase in pause length was produced by superimposing a light upon a key that the pigeon pecked and making the light change in size from a small spot just after the reinforcement to a line ¾ in. long at the end of the interval. (See also Segal, 1962.)

Azrin (1958) and Long (1962) have shown that humans will quickly learn to use such an external cue if one is furnished. For example, Azrin's subjects (*S*) had to make observing responses to detect signals presented on a 180-sec FI schedule of reinforcement. When given a distinctive cue during the last 15 sec of each interval, they limited their responses to that period. But even without external discriminative stimuli, human *S*s on an ordinary FI schedule frequently show a very long pause after reinforcement, just as though they had been given a clock (Azrin, 1958; Bullock, 1960; Holland, 1957, 1958b; Laties and Weiss, 1960; Stoddard, Sidman, and Brady, reported in Sidman, 1962; Weiner, 1962). One reason for this may be that the human *S* can produce a chain of responses that can itself serve as a clock in regulating his behavior; *e.g.*, counting at a reasonably constant rate and beginning to respond only when the count has reached a particular value; or, reciting other verbal material and starting to respond on the light-flashing key when a particular amount of this material has been emitted. Indeed, Bullock (1960) and Taber (1961) report observing this type of behavior in *S*s working on FI schedules. But this alone does not prove that such behavior has anything to do with the pause after reinforcement. As Dews (1962) stated: "To establish a sequence of responses . . . as constituting mediating behavior . . . it is not sufficient to demonstrate that the sequence is consistent and *could* so function; it must be explicitly demonstrated

[1]Supported by grants B-865 from the National Institute of Neurological Diseases and Blindness and MY-3229 from the National Institute of Mental Health, National Institutes of Health.

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that changes in the sequence . . . prevent mediation." This paper describes what happens to FI behavior when *Ss* cannot easily produce the verbal chains that may have been mediating the post-reinforcement pause.

METHOD

The apparatus and general procedure have been described in detail elsewhere (Laties and Weiss, 1960). The *S* worked on an observing behavior task similar to that described by Holland (1957, 1958b). He was instructed to reset periodic deflections of a pointer on a meter "as quickly as possible" by pressing a telegraph key. For five *Ss* a deflection occurred 100 sec after the previous reset and, if the pointer was not reset to zero by *S*, it remained deflected for 10 sec before being cancelled automatically (FI 100 sec, limited hold 10 sec). One subject, *S*6, was run on FI 150 sec, limited hold 15 sec. Each *S* was paid $2.50 per hr. The *Ss* were told that one cent would be subtracted from this sum for each second that the pointer remained deflected. They worked in a darkened room. In order to see whether or not the pointer was deflected, *S* had to press a second telegraph key. Each time the key was pressed with a force of 1675 g, the meter face was illuminated for .13 sec. This great amount of force was used in order to generate rapid formation of the temporal discrimination (Azrin, 1958; Holland, 1958c). Responses on the light-flashing key (observing responses) were recorded on counters and a cumulative recorder located in a separate room. Holland (1957, 1958b) has shown that the light-flashing responses are reinforced by detections of the deflected pointer.

Five *Ss*, all young adult males, were told that while performing the observing behavior task they would be required on occasion to do successive subtractions of the numbers 17, 16, 15, 17, 16, 15, 17, . . . starting at 1000, announcing the remainders aloud, *e.g.*, "1000, 983, 967, 952, 935, 919, . . ." *etc.* The *S* was instructed to go back to a number five higher than his previous starting point after passing zero and to continue subtracting until told to stop. The experimenter would start this behavior by calling "Start subtracting" over a microphone connected to a loudspeaker in the *S*'s room. These five *Ss* were well practiced on the particular schedule of reinforcement used here and had been told how frequently deflections appeared and how long they remained. In addition, *S*4 and *S*5 had had 30 min practice on the concurrent subtraction task. The experimental session was started with five of the 100-sec intervals during which no subtraction was required. Immediately after the reset of the fifth deflection, the *S* was instructed to start his subtractions. He was told "Stop" after the 16th interval, "Start again" after the 27th, and "Stop" after the 38th. The procedure used with the sixth *S* will be described below. The *Ss* were not permitted to wear watches. The subtractions were monitored but not recorded.

RESULTS

The initial five intervals and the first interval after each change in condition are not included in the first analysis in order to minimize the importance of the stimulus change itself (Azrin, 1958). Three blocks of 10 intervals each will be considered. During the first (intervals 7 through 16) and third (intervals 29 through 38) the *Ss* did the subtractions. The second (intervals 18 through 27) served as a control. Responses were allocated to counters representing successive tenths of the 100-sec interval with responses made during the limited hold counted as falling in the last tenth. These distributions, for the three blocks of 10 intervals, are expressed in Table 1

Table 1
Index of Curvature

Subject	*Intervals*		
	7-16*	18-27	29-38*
1	.55	.72	.59
2	.03	.60	.29
3	.59	.70	.45
4	.38	.59	.53
5	.82	.88	.78
MEAN	.47	.70	.53

*Concurrent subtractions.

as the Index of Curvature (I) and have been computed from the formula given by Fry, Kelleher, and Cook (1960). This measure indicates the magnitude and direction of curvature of the cumulatively plotted FI performance. A constant response rate yields $I = 0$. The maximum absolute value of I when 10 subdivisions are used to compute it is .90, positive values being associated with a positively-accelerated distribution and negative values with a negatively-accelerated distribution.

The Index was always lower for blocks of intervals during which the *S* performed concurrent subtractions, but the way in which the decrease occurred varied widely. The changes for *S*1 and *S*5 arose from slightly shorter pauses after reinforcement. Otherwise, their performance remained unaffected. When questioned after all experiments had been completed, these two *S*s reported having counted during control periods. When required to do the concurrent task, they used, with obvious success, the size of the remainder as a cue to where they were in the interval.

More extensive changes occurred with the other three *S*s, whose records are shown in Fig. 1. The concurrent task almost completely abolished *S*2's post-reinforcement pause (Fig. 1, top). When the subtractions ended, the pause after reinforcement reappeared. When subtraction began for the second time, the pause disappeared again; this time, however, the effect was only temporary and the pause reappeared after *S* had responded steadily through several intervals. This *S* counted during the control periods and reported that he also tried to count during the concurrent task. It is apparent that this counting did not aid him until his second experience with the subtraction task. *S*3's usual high terminal rate fell steeply during his first block of intervals on subtraction (Fig. 1, middle). The long pauses and high rates returned under the control conditions. As can be seen in the figure, this *S*'s performance was quite variable after he started to subtract a second time. He reported that he had counted during control periods but had not attempted anything specific while subtracting. *S*4 usually showed an abrupt start of the terminal rate following a long pause (Fig. 1, bottom). His record shows how the regularity disappeared during the initial subtraction. His performance was affected only slightly, however, during the second subtraction period. This *S* reported having recited a passage from Shakespeare when not subtracting. During the concurrent task he attempted to use the number of subtractions he had done as a guide to where he was in the interval.

The Index of Curvature has been computed for each interval for the records reproduced in Fig. 1. These have been plotted in Fig. 2 and the Index seems to quantify the curvature fairly well, falling down, as Fry, *et al.* (1960) pointed out it does, on intervals with a small number of responses.

A sixth *S* was put through a somewhat different procedure. He was not instructed as to the interval schedule in effect but was given practice on FI 150 sec limited hold 15 sec, until he developed a stable temporal discrimination. This took only one 65-min session. The record labelled "A" in Fig. 3 shows his initial performance at his next session. During the next 10 intervals (record "B"), he worked under instructions to do successive subtractions of either 5s or 17s, alternating from interval to interval as indicated in the figure. The effect was substantial. His Index of Curvature dropped from .77, which it was for record "A", to .44. Which number was used as subtrahend did not matter; *I* was .44 for each considered alone. It became .73 for the control record collected next and shown at "C". Another control record was taken a week later and is reproduced at "D". His baseline performance was completely recovered, *I* being .74. This time, *S* was required to perform the same concurrent activity demanded of the original five *S*s subtracting successively the numbers 17, 16, 15, 17, 16, *etc.* This led to a decrease in *I* to .57 for the record shown at "E". When questioned after the experiment, he said he had counted during the control periods and had tried to use the place to which he came in his subtractions as a cue during the concurrent task.

DISCUSSION

Interfering with a person's ability to continue using previously learned verbal chains alters his pattern of responding on an FI schedule of reinforcement, generally increasing the pattern's resemblance to that of lower animals. By Dews' (1962) criteria (see Introduction) such a result supports the notion that these chains mediate the temporal discriminations in this situation. We propose that the presence of this mediating behavior is an important factor in accounting for the formal similarities found when adult human FI behavior is compared to the behavior of lower animals on FI schedules with added clocks. For discussion of the role of response chains

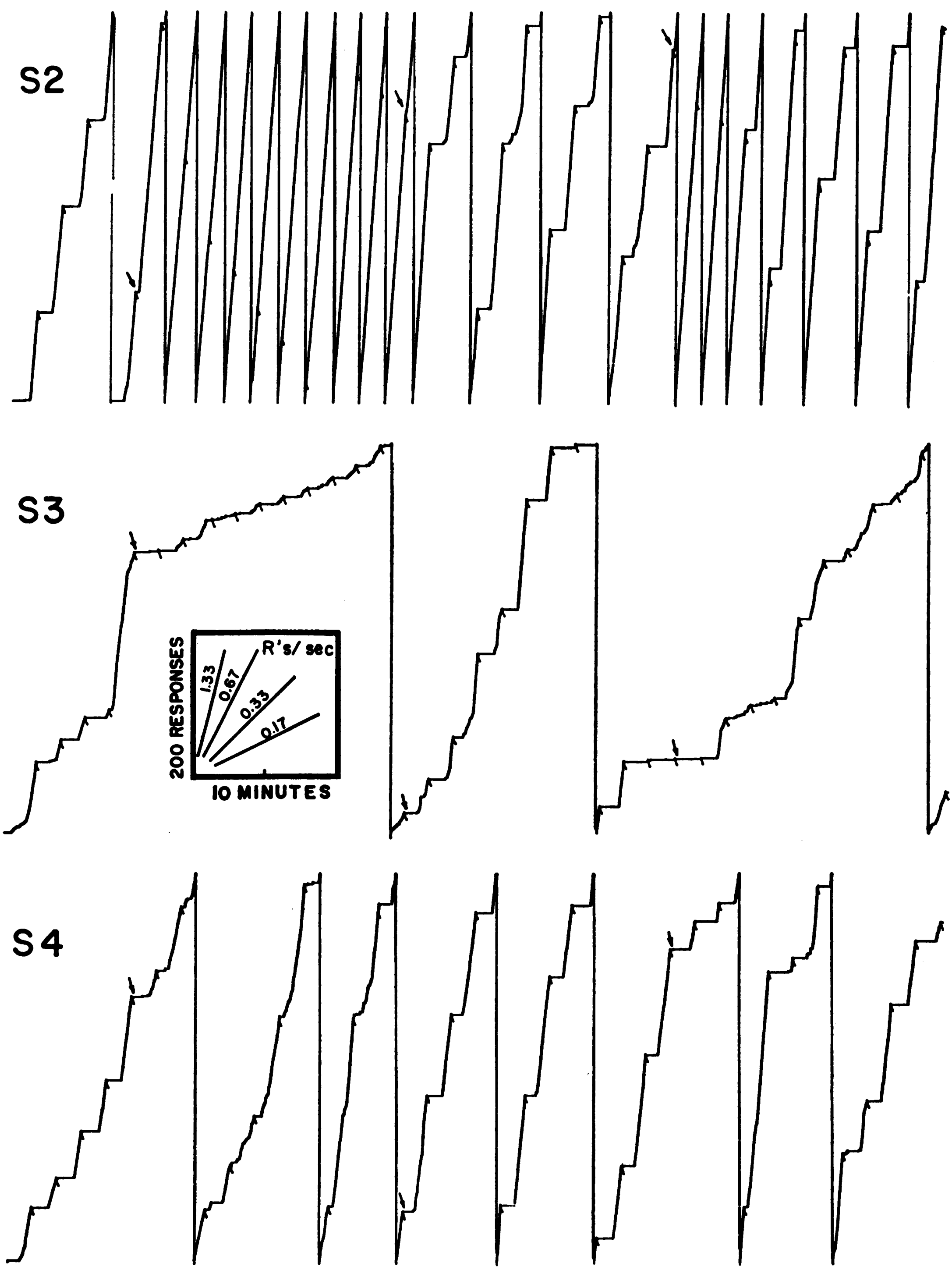

Fig. 1. Cumulative response records for *S2*, *S3*, and *S4* on an FI 100 sec, limited-hold 10-sec schedule of reinforcement. The three arrows on each record indicate the first introduction of the concurrent subtraction task at the beginning of the 6th interval, its cessation at the beginning of the 17th, and its reintroduction at the beginning of the 28th interval.

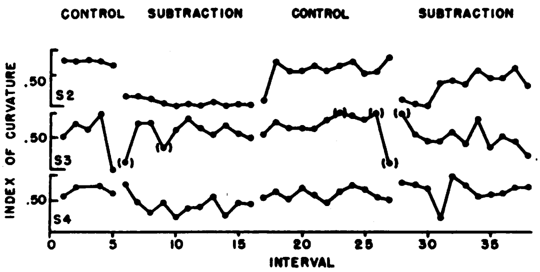

Fig. 2. Indices of Curvature for S2, S3, and S4 on an FI 100 sec, limited-hold 10-sec schedule of reinforcement. Points based on fewer than 10 responses are enclosed in parentheses.

in the performance of lower animals on temporally defined schedules, see Dews (1962), Hodos, Ross, and Brady (1962), and Segal (1961).

We have shown previously that requiring humans to perform a concurrent subtraction task increases the variability of their performance on the DRL schedule, one on which reinforcement comes only if *S* waits at least a minimum specified time between responses (Laties and Weiss, 1962; *cf.* Segal, 1961, for an analogous experiment on rats). We have noted, as did Dews and Morse (1958), that *S*s working on such schedules usually count or recite, and it seems likely that the effect of concurrent activity is due to interference with such mediating responses. Counting also can come to control the pattern of responding on

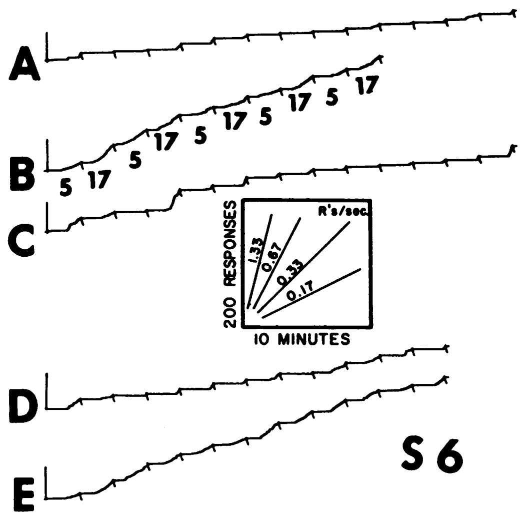

Fig. 3. Cumulative response records for *S*6 on an FI 150 sec, limited hold 15-sec schedule of reinforcement. A, C, and D are control records; during B and E, concurrent subtractions were performed. See text for a complete description of the procedure.

fixed-ratio schedules (Holland, 1958a). The present observations demonstrate that such verbal chains are important in determining the response pattern on still a third type of simple reinforcement schedule. They again point up both the ubiquity and the importance of covert mediating behavior in the operant behavior of man (*cf.*, *e.g.*, Bruner and Revusky, 1961; Goss, 1961; Hefferline, 1962; Luria, 1961).

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Received October 11, 1962