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PRECURRENT CONTINGENCIES: BEHAVIOR REINFORCED BY ALTERING REINFORCEMENT PROBABILITY FOR OTHER BEHAVIOR

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The present study explored the effects of a precurrent contingency in which one (precurrent) activity increased the reinforcement probability for another (current) activity. Four human subjects responded on a two-key computer mouse. Each right-key press was reinforced (points exchangeable for money) with .02 probability. In one condition (no precurrent contingency), pressing the left key had no scheduled consequence; in another condition (precurrent contingency), pressing the left key increased the reinforcement probability for right-key responding to .08 for 15 s. Initial exposure to the precurrent contingency resulted in acquisition of precurrent left-key responding for 3 subjects, but for the 4th subject a special contingency was required. Right-key responding occurred at a high stable rate across the conditions. Changeovers to left-key responding dropped to near zero when the precurrent contingency was absent and were maintained at enhanced levels when the precurrent contingency was present. Contacts with the left key consisted of short response runs. Right-key responses were more frequently emitted within 15 s of a left-key response when the precurrent contingency was present, an efficient adaptation to the contingency. Continued research on precurrent behavior may produce insights into complex phenomena such as autoclitics and self-control.

Key words: precurrent behavior, precurrent contingency, changeover, current behavior, free operant, probability schedule, key press, humans

Interresponse relations have been the focus of much research in recent years, especially competition between responses in terms of response and time allocation under the concurrent-operant paradigm (Catania, 1966; Davison & McCarthy, 1988; de Villiers, 1977). Of course, many other types of relations are possible. For example, given one response that is a part of a four-term contingency (i.e., establishing operation, discriminative stimulus, operant response, reinforcer), another response can facilitate the effects of that contingency by altering one or more of the components. Research in the experimental analysis of behavior contains many examples of facilitative relations, although they are not often linked. Some of these include sample-specific behavior enhancing match-to-sample performance (e.g., Blough, 1959; Cohen, Brady, & Lowry, 1981; Cohen, Looney, Brady, & Aucella, 1976; Parsons, Taylor, & Joyce, 1981; Torgrud & Holborn, 1989), collateral behavior improving performance under differential reinforcement of low rates (DRL) (e.g., Laties, Weiss, Clark, & Reynolds, 1965; Laties, Weiss, & Weiss, 1969), changeover behavior increasing overall reinforcement frequency for main-key responding under certain concurrent schedules (e.g., Catania, 1966; see Skinner, 1950, p. 211), and rule-stating raising the likelihood of other appropriate verbal behavior (e.g., Guevremont, Osnes, & Stokes, 1988) and nonverbal behavior (e.g., Ziegler, 1987).

In his interpretative analyses of complex human behavior, Skinner often discussed such facilitative interresponse relations. Initially, he wrote in terms of a "controlling response" altering variables so as to change the probability of a "controlled response" (1953, p. 231). In later works, the term "precurrent behavior" was emphasized; this type of behavior "changes either our environment or ourselves in such a way that 'consummatory' behavior occurs" (1968, p. 121), "makes subsequent behavior more effective" (1968, p. 124), and "furthers the reinforcement of subsequent behavior" (1969, p. 137).

To be consistent with Skinner and previous research reports in the area (e.g., Parsons et al., 1981; Torgrud & Holborn, 1989), we will retain the vocabulary of precurrent behavior.

This experiment was part of a dissertation submitted by the first author in partial fulfillment of the requirements for the PhD degree in psychology from the University of Victoria. Portions of the data were presented at the 1990 convention of the Northern California Association for Behavior Analysis in San Francisco, and the 1992 convention of the Association for Behavior Analysis in San Francisco. We thank Tom Allen for computer assistance, and Bram Goldwater for helpful comments during the research. Requests for reprints should be sent to David Polson, Counselling Services, University of Victoria, P.O. Box 3025, Victoria, British Columbia V8W 3P2, Canada.

We will use the term *precurrent contingency* to refer to an interresponse relation in which one (precurrent) response alters a condition or conditions controlling another (current) response. This relation can be either facilitative or impeding, although we will focus on the former. A defining and possibly important feature of precurrent behavior is that it does not directly produce the reinforcer; rather, reinforcement is mediated through another (current) behavior of that same organism.

How might one response facilitate another? One possibility, and the focus of Skinner's discussions, is for the emission of precurrent behavior to increase the likelihood of current behavior, as in self-control (1953), creative thinking (1953, 1968), and problem solving (1969). This typically involves changing the antecedent conditions that control the current behavior. For example, when asked "Who is that behind you?" the precurrent actions of turning and looking "generate a discriminative stimulus in order to emit a particular name" (1969, p. 142). Another possibility, and the focus of the present research, is for the emission of precurrent behavior to enhance reinforcement of current behavior. Examples are provided by certain types of autoclitics (Skinner, 1957). Suppose that prefacing the mand "Close the door" with the descriptive autoclitic "I demand" increases the likelihood that the listener will comply; "the autoclitic which describes the speaker's behavior could be omitted, but the [current] response would be less effective on the listener" (1957, p. 315). In the present framework, "I demand" functions as verbal precurrent behavior that alters the reinforcement for the verbal current behavior of manding "Close the door."

Precurrent contingencies involve a succession of precurrent and current behavior. Response sequences have often been interpreted in terms of chaining, but as Catania (1992, pp. 123–125) has noted, they are not always amenable to such an analysis. Consider an example of a two-link response chain, in which one (precurrent) behavior is said to produce a stimulus change that occasions the next (current) behavior, which then leads to the reinforcer. A rat's lever presses produce the sound of food delivery; this sets the occasion for approach to the food cup, which then leads to the consumption of food. Approaching the food cup without previously pressing the lever will never produce food; that is, the current behavior cannot be reinforced without the precurrent behavior being emitted beforehand. But this represents only one possibility: In many situations, the current behavior can be reinforced in the absence of the precurrent behavior, and the function of the precurrent behavior is to alter its reinforcement parameters, as in the previous example of the autoclitic. Furthermore, explicit stimulus changes produced by the precurrent behavior that occasion the current behavior are not always readily apparent, as again the previous example of the autoclitic demonstrates. In sum, a response chain is one restricted case, among many, of a precurrent contingency.

It is not surprising that a precurrent-current response sequence develops when that is the only way to obtain the reinforcer. What happens, though, when the conditioning context is such that the current behavior sometimes produces the reinforcer and the precurrent behavior never does so, but the precurrent behavior can improve reinforcement for the current behavior? Or, what results when the current behavior has already been conditioned through reinforcement, and then the opportunity for precurrent behavior that improves this reinforcement is introduced? In contexts such as these, is the precurrent behavior acquired? Skinner (1953, 1957, 1968, 1969) suggested that precurrent behavior may be automatically reinforced by its initial effects, but that such cases are probably rare (see, e.g., Blough, 1959); rather, reinforcement provided by the verbal community directly contingent upon precurrent behavior is often required before the precurrent contingency might take effect (cf. Parsons et al., 1981).

The research to be presented here is best described as a development of method to answer the questions posed above. It is a beginning attempt to bring the bare essentials of precurrent contingencies into the laboratory and discover measures that are sensitive to changes in performance produced by those contingencies. Similar previous unpublished research[1] was used as a starting point for the present procedure and parameters. Briefly, we exposed 4 human subjects to two response keys. Right-key presses were reinforced with .02

[1] Taylor, D. C. (1980). *Precurrent operants: Behavior affecting reinforcement probability.* Unpublished masters thesis, University of New Mexico, Albuquerque.

probability. Sometimes a precurrent contingency was present in which each left-key response increased this probability to .08 (or maintained the increase) for 15 s. The increase in reinforcement probability was not explicitly signaled; thus, left-key responding was programmed to alter reinforcement but not exteroceptive antecedents for right-key responding. We were concerned with how performances would be affected by presenting or removing this contingency.

METHOD

Subjects

Four students enrolled in a behavioral psychology course at the University of Victoria participated after the instructor solicited volunteers in class.

Apparatus

The experiment was conducted in a sound-attenuating chamber that contained a chair and a table holding the apparatus. The apparatus included a Zenith® Data Systems computer (Model 2F-158-42) that controlled the contingencies and stored the resultant data and a computer mouse (Logitech® Serial Mouse Model C7-3F-9F) that functioned as the response manipulandum. Although the mouse contained three keys, at all times during the experiment one key was covered. Pressing the right key intermittently advanced a money counter on the computer screen; pressing the left key had no scheduled effect or functioned to alter the reinforcement schedule for right-key responding, depending on the phase of the experiment. Counts were never delivered contingent on left-key responses. Reinforcer delivery entailed the computer emitting a 0.3-s beep and the counter incrementing by $0.005.

Procedure

The subject was seated at the table in the experimental chamber. The computer mouse was situated within easy reach. The computer monitor faced the subject and displayed the following message: "Session begins when money box appears." To begin a session, the experimenter pressed a key on the keyboard and exited the chamber, leaving the door partially open. This key press produced a 2-s beep and a small box in the middle of the screen that surrounded the characters "$0.000." During a session, the experimenter could hear, but not see, the subject. A session ended with another 2-s beep and the monitor displaying the flashing statement: "Session completed. Please wait for experimenter." When the experimenter returned, the subject was presented with a form that read, "Briefly describe what you think was happening during this session." The reply was to be written underneath the question. (Copies of these reports are available from the first author.)

Two 20-min sessions were scheduled per experimental day, with an intervening break of approximately 10 min. Between sessions, the subject was asked to wait in another room while the computer stored the data to diskette. At the end of a day's two sessions, the subject was paid the full amount earned during those sessions. Each subject was promised a dollar bonus for each day of participation, to be received at the end of the experiment contingent upon at least 6 days of participation.

Reinforcement contingencies. Reinforcement for right-key responding was programmed according to a constant probability schedule. In the resting normal state, the probability of reinforcement for each right-key response was .02. When the precurrent contingency was present, each left-key response produced (or extended if in progress) a changed state for 15 s, during which the reinforcement probability for right-key responses was .08. When the precurrent contingency was not present, left-key responses had no scheduled effect and the reinforcement schedule for right-key responding remained unaltered. In a pilot study,[2] conditioning of left-key responding did not occur when the precurrent contingency consisted of left-key responses doubling the reinforcement probability for right-key responding from .04 to .08 for 15 s; this result contrasted with earlier unpublished research (see Footnote 1).

Instructions. Immediately prior to Session 1, the subject read the following printed instructions:

> It is possible to earn money by manipulating the computer mouse. Do not press the covered button on the computer mouse. Do not move the mouse. The amount of money you have

[2] Polson, D. A. D. (1989, May). *Precurrent operants.* Poster presented at the Association for Behavior Analysis 15th annual convention, Milwaukee, WI. (Abstract reprinted in *Experimental Analysis of Human Behavior Bulletin,* 1989, *27*(2), p. 31)

earned at any given time will be displayed on the computer monitor. When the screen prints "END OF SESSION," wait for the experimenter to return and write down the amount of money you have earned. Today there will be one session, approximately a 10 minute break, and then another session. Following today's second session you will be paid the total amount earned during both sessions. During a session, do not leave your seat without first informing me. I will be within hearing distance in the other room. If you have a watch, please leave it with me and it will be returned to you following today's two sessions. THE OBJECTIVE IS TO EARN AS MUCH MONEY AS YOU CAN.

The experimenter then asked for and answered questions related to the task. The printed instructions were always present in the experimental chamber for reference.

Design. The experiment consisted of two main phases: the absence of the precurrent contingency (A) and the presence of the precurrent contingency (B). Phase changes occurred at the start of a new session. Subjects S1 and S2 began the experiment under Phase A, and Subjects S3 and S4 started under Phase B. At least one reversal was planned for each subject, but S1 discontinued participation before this was accomplished. A special conditioning session (C) was conducted for S4 following Phase B1; the details of this procedure are provided in the Results.

RESULTS

A summary of important data is included in Table 1. Schedule checks for the obtained reinforcement probability under the normal and changed states in each session indicated close approximations to the scheduled values. Four dependent variables were drawn from Table 1, which together provide a sensitive account of each subject's performance.

Left-Key (Precurrent) Responding

Two of the dependent variables involved left-key responding, which, with the precurrent contingency operational, functioned as the precurrent behavior. First, total changeovers from right-key to left-key responding per session are considered for all 4 subjects in Figure 1. Changeovers dropped to near zero when the precurrent contingency was absent (A phases), whereas relatively high levels developed and were maintained when the precurrent contingency was present (B phases). Near-zero levels of changeovers were not obtained for S2 in Phase A2, but a reduction did occur following an increasing trend in Phase B1.

The major exception to this finding was for S4 in Phase B1 (Sessions 1 through 6): Despite the presence of the precurrent contingency, changeovers (and left-key responses) became progressively less frequent, to the point that only four changeovers were observed in Sessions 5 and 6. To induce more contacts with the left key and the precurrent contingency, a special contingency was temporarily introduced for Session 7: The reinforcement probability for right-key responding in the normal state was reduced to zero, and as before, each left-key response changed the probability to .08 for 15 s. Thus, right-key responding could not be reinforced unless a left-key response had occurred at least once within the prior 15 s. Figure 1 shows that the effect of this new contingency was to enhance the frequency of changeovers, which was maintained across Phase B2 after the regular precurrent contingency was reinstated in Session 8.

The second dependent variable considers what subjects did after changing over to the left key. The mean left-key run prior to the resumption of right-key responding was calculated by dividing total left-key responses by total changeovers in a session. This measure is also displayed in Figure 1. (If the subject began the session by responding on the left key, then the first left-key run would not represent a changeover from right-key to left-key responding; thus, when this happened, the mean left-key run calculation excluded the number of left-key responses on this first run from total left-key responses.) Although there was some variability between and within subjects, left-key runs were typically brief: S1, S2, and S3 usually averaged below 10 responses per changeover, and S4 usually averaged below 20 responses per changeover. The most dramatic change across phases was demonstrated by S1, who reduced mean left-key runs from eight or nine responses per changeover in Phase A1 sessions to the minimum of one in Phase B1 sessions.

Right-Key (Current) Responding

The two other dependent variables involved right-key responding, the current behavior that

directly produced the reinforcer. First, right-key response frequency per session is plotted in Figure 1 alongside the two measures of left-key responding. In general, right-key response frequency increased across the first few sessions, regardless of the condition, and remained constant for the rest of the experiment, in spite of either presenting or removing the precurrent contingency at various points.

The second measure of right-key responding concerns the proportion of total right-key responses in each session emitted within 15 s of a left-key response. With the precurrent contingency present, this represents the proportion of right-key responses emitted under the higher probability state (i.e., under the changed state). For convenience, we will refer to this proportion as an efficiency index, because a right-key response was more likely to produce a reinforcer if it was emitted under the changed state. Note, however, that in the absence of the precurrent contingency, right-key responding was always reinforced under the normal state and thus was no more or less efficient in the present sense when it occurred within 15 s of left-key responses. Figure 2 plots efficiency across every session for the 4 subjects. It reveals greater efficiency for each subject when the precurrent contingency was present. Efficiency dropped to near zero in all A phases but one. That one case involved S2, who demonstrated a reduction in efficiency in Phase A2 following an increasing trend in Phase B1, but not to the low levels previously observed in Phase A1.

Cumulative Records

Figures 3 and 4 show cumulative records for left-key and right-key responding for S1 and S2, respectively, during the initial session when the precurrent contingency was absent (Session 1) and during sessions of first contact with the precurrent contingency (S1, Session 6; S2, Sessions 6 and 7). At the bottom of each subject's records is an event record. When the precurrent contingency was present (B phases), the up position indicates that the normal state was active, and the down position indicates that the changed state was active. When the precurrent contingency was absent (A phases), the down position simply indicates periods of time within 15 s of a left-key response. The event record provides additional information: Although the left-key cumulative record may be flat in places, left-key responding did not go undetected because the event record necessarily extended under the down position (see Arrow 1 in Figure 3) or switched from up to down (see Arrow 2 in Figure 3) whenever a left-key response was emitted. Reinforcers appear as blips above each record to illustrate their temporal relation to both left-key and right-key responding.

Figures 3 and 4 reveal that with no precurrent contingency in Session 1, both S1 and S2 came to respond at a high stable rate on the right key as left-key responding diminished to zero. (For S1, the pattern of emitting left-key responses only at the beginning of the session was repeated in Sessions 2 and 3, but was not observed in any Phase B1 session.) Both subjects contacted the precurrent contingency for the first time in Session 6. Figure 3 shows that S1 changed to a sustained higher rate of left-key responding later (11.8 min) in that session. Figure 4 shows that although S2 emitted intermittent bursts of left-key responding throughout Session 6, sustained higher rate left-key responding was not observed until toward the middle (7.6 min) of Session 7. For both subjects, right-key responding shows minimal disruption as consistent higher rate left-key responding developed.

Figure 5 presents cumulative records for S3 and S4 during Session 1 when the precurrent contingency was present. For S3, left-key responding was maintained throughout the session, but no set pattern can be seen. Although fluctuations in right-key responding are apparent, stable high-rate right-key responding became the norm in the next session (not shown). For S4, maintenance of left-key responding was not observed; no left-key response was emitted during the final 6.1 min of the session. Consistent with other subjects, however, stable high-rate right-key responding was observed.

Figure 5 also shows the cumulative records for S4's special conditioning session (Session 7), during which the normal probability of reinforcement for right-key responding was zero but changed to .08 for 15 s following each left-key response. With this contingency in place, left-key responding occurred early in the session, as did right-key responding and reinforcement; this was followed by extended periods without left-key responses, during which reinforcement was necessarily absent. Then, during the remaining 3.5 min, left-key

Table 1

Left-key and right-key responses, changeovers from right-key to left-key responding (CO), reinforcers, and the obtained probability of reinforcement under the normal and changed states in each session for all subjects.

Session	Left-key responses	Right-key responses[a]	CO	Reinforcers[a]	Obtained p (rft)	
					Normal[b]	Changed[b]
Subject S1						
Phase A1 (no precurrent contingency)						
1	234	3,459 (362)	28	55 (4)	.016	.011
2	130	4,959 (206)	15	102 (5)	.020	.024
3	64	5,409 (180)	6	125 (5)	.023	.028
Phase B1 (precurrent contingency)						
4	0	5,028 (0)	0	101 (0)	.020	
5	0	3,546 (0)	0	73 (0)	.021	
6	26	3,895 (1,031)	26	134 (80)	.019	.078
7	45	4,770 (2,348)	42	250 (205)	.019	.087
8	39	4,928 (2,266)	38	219 (168)	.019	.074
Subject S2						
Phase A1 (no precurrent contingency)						
1	248	5,462 (816)	27	109 (24)	.018	.029
2	247	6,086 (968)	49	134 (23)	.022	.024
3	20	6,891 (89)	1	145 (4)	.021	.045
Phase B1 (precurrent contingency)						
4	0	6,939 (0)	0	129 (0)	.019	
5	0	6,933 (0)	0	139 (0)	.020	
6	80	6,683 (1,165)	20	206 (99)	.019	.085
7	163	6,860 (2,299)	34	286 (197)	.020	.086
8	174	6,892 (3,432)	50	334 (270)	.018	.079
9	158	7,148 (4,661)	64	423 (381)	.017	.082
10	207	6,964 (4,632)	59	426 (383)	.018	.083
11	285	7,007 (5,400)	77	482 (446)	.022	.083
12	382	6,732 (4,762)	89	391 (354)	.019	.074
Phase A2 (no precurrent contingency)						
13	352	6,608 (3,137)	52	118 (55)	.018	.017
14	391	6,494 (3,015)	50	127 (61)	.019	.020
15	225	6,699 (3,106)	41	147 (68)	.022	.022
16	254	6,623 (2,750)	37	122 (51)	.018	.018
Subject S3						
Phase B1 (precurrent contingency)						
1	1,269	1,216 (941)	160	84 (80)	.015	.085
2	1,641	2,828 (2,687)	305	199 (197)	.014	.073
3	440	5,225 (2,599)	96	268 (211)	.022	.081
4	629	5,633 (4,059)	283	353 (319)	.022	.079
5[c]	411	5,513 (2,859)	106	264 (224)	.015	.078
6	333	5,127 (1,550)	41	205 (134)	.020	.086
7	666	5,445 (2,750)	64	264 (212)	.019	.077
Phase A1 (no precurrent contingency)						
8	527	5,123 (1,538)	47	100 (33)	.019	.021
9	101	5,906 (572)	14	124 (9)	.022	.016
10	4	5,953 (144)	2	116 (7)	.019	.049
Phase B2 (precurrent contingency)						
11	718	5,795 (3,149)	58	282 (233)	.019	.074
12	710	5,899 (3,215)	92	300 (238)	.023	.074
13	850	4,840 (3,403)	97	314 (290)	.017	.085
14	499	5,663 (2,768)	61	287 (220)	.023	.079
Phase A2 (no precurrent contingency)						
15	72	5,856 (384)	10	108 (7)	.018	.018
16	0	6,573 (0)	0	130 (0)	.020	

Table 1 (*Continued*)

Session	Left-key responses	Right-key responses[a]	CO	Reinforcers[a]	Obtained p (rft) Normal[b]	Obtained p (rft) Changed[b]
Phase B3 (precurrent contingency)						
17	7	6,142 (156)	2	132 (15)	.020	.096
18	0	6,344 (0)	0	121 (0)	.019	
19	260	6,336 (1,908)	46	225 (148)	.017	.078
20	817	5,998 (4,843)	135	402 (377)	.022	.078
21	1,066	5,241 (4,747)	193	381 (372)	.018	.078
Subject S4						
Phase B1 (precurrent contingency)						
1	137	2,334 (274)	15	61 (17)	.021	.062
2	184	3,854 (132)	6	84 (10)	.020	.076
3	40	5,317 (137)	4	123 (11)	.022	.080
4	19	5,544 (72)	1	106 (7)	.018	.097
5	0	5,826 (0)	0	104 (0)	.018	
6	4	5,469 (60)	1	109 (5)	.019	.083
Phase C (special conditioning session)						
7	559	4,147 (1,289)	31	91 (91)	.000	.071
Phase B2						
8	819	4,690 (2,151)	34	259 (203)	.022	.094
9	872	4,773 (2,963)	58	279 (242)	.020	.082
10	827	5,442 (3,251)	45	317 (265)	.024	.082
11	649	5,600 (2,820)	42	306 (232)	.027	.082
12	593	5,766 (2,556)	34	260 (196)	.020	.077
Phase A1 (no precurrent contingency)						
13	441	6,608 (1,854)	28	130 (42)	.021	.023
14	112	5,834 (414)	6	109 (7)	.019	.017
15	51	5,822 (259)	3	109 (3)	.019	.012
Phase B3 (precurrent contingency)						
16	451	5,341 (1,914)	28	235 (168)	.020	.088
17	545	5,487 (2,431)	36	255 (197)	.019	.081
18	564	5,357 (2,421)	34	260 (211)	.017	.087
19	520	5,516 (2,315)	33	251 (192)	.018	.083

[a] Parentheses indicate events within 15 s of left-key responses.
[b] Changed values indicate p(rft) within 15 s of a left-key response and normal values indicate p(rft) at other times.
[c] Due to error, only total left-key and right-key responses and reinforcers were recorded; other figures are projected based on data available from initial 430 s only.

responding increased and was maintained, and reinforcement became more frequent and constant.

Figures 6 and 7 display cumulative records for S3, showing the effects of repeated removals and presentations of the precurrent contingency. The precurrent contingency was inoperative for the first time in Session 8. Figure 6 shows that the step-like pattern of responding on the left key seen during the final 10 min of Session 7 was disrupted by this change: Left-key responding gradually diminished across Sessions 8 and 9 to the point that only one left-key response was counted during the latter half of Session 9. Right-key responding shows minimal alteration across these three sessions. The precurrent contingency was subsequently reintroduced in Session 11. Figure 7 reveals that left-key responding occurred early in that session and was maintained; this was a substantial change from the previous session (not shown), during which only four left-key responses were emitted. The precurrent contingency was then withdrawn a second time in Session 15. Figure 7 shows that the effect was more immediate than the first time the precurrent contingency was removed: After the first minute, left-key responding was almost nonexistent, in contrast to significantly higher rates in the previous session (not shown).

DISCUSSION

The precurrent contingency specified that each left-key response increased the reinforcement probability for right-key responding from

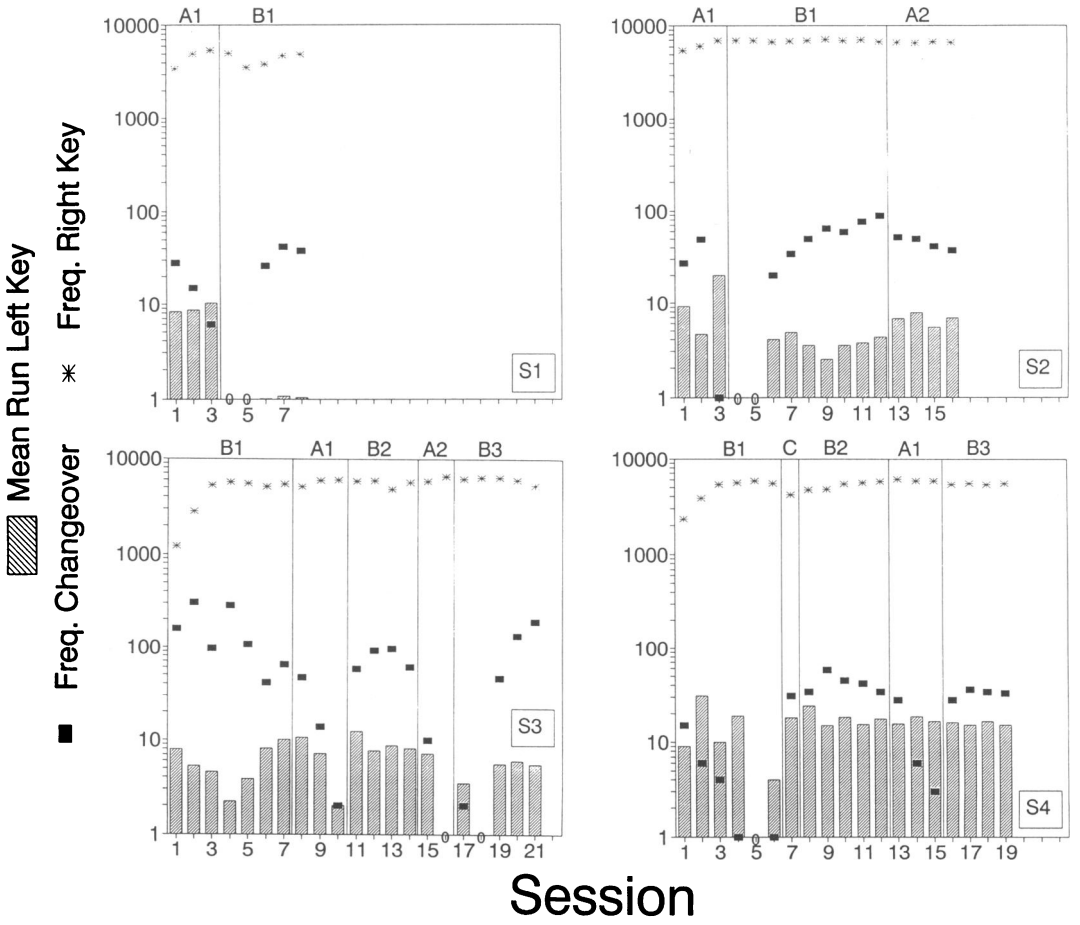

Fig. 1. Changeover frequency (per 20-min session) to left-key responding (filled rectangles), the mean left-key run length (bars), and right-key response frequency (per 20-min session; asterisks) in each session for all 4 subjects. The precurrent contingency was absent during A phases and was present during B phases. For S4, a special conditioning procedure was used in the C phase (see text). Zero points are indicated by circles on the x axis.

.02 to .08 (or maintained the increase) for 15 s. Right-key responding was little affected by the presence or absence of this contingency: A high stable rate developed early and was maintained throughout the experiment, regardless of the condition. In contrast, left-key responding was affected: When there was a precurrent contingency, either initially (for S3) or following its absence (for all subjects), high-rate right-key responding was frequently interrupted by changeovers to the left key; when there was no precurrent contingency, either initially (for S1 and S2) or following its presence (for S2, S3, and S4), these changeovers declined, often to near zero. All subjects performed so as to increase the proportion of right-key responses emitted within 15 s of a left-key response when doing so would result in a greater probability of reinforcement for right-key responding (i.e., when the precurrent contingency was present). Overall, these results suggest that left-key responding was a function of the precurrent contingency placed upon it.

Taking into account changeovers to the left key along with the mean left-key run data provided a more detailed account of each subject's precurrent behavior than did left-key response rate. First, this analysis revealed that on average, response runs on the left key were typically short, a further indicator of efficient responding. Second, changes in the structure of responding across phases were more readily

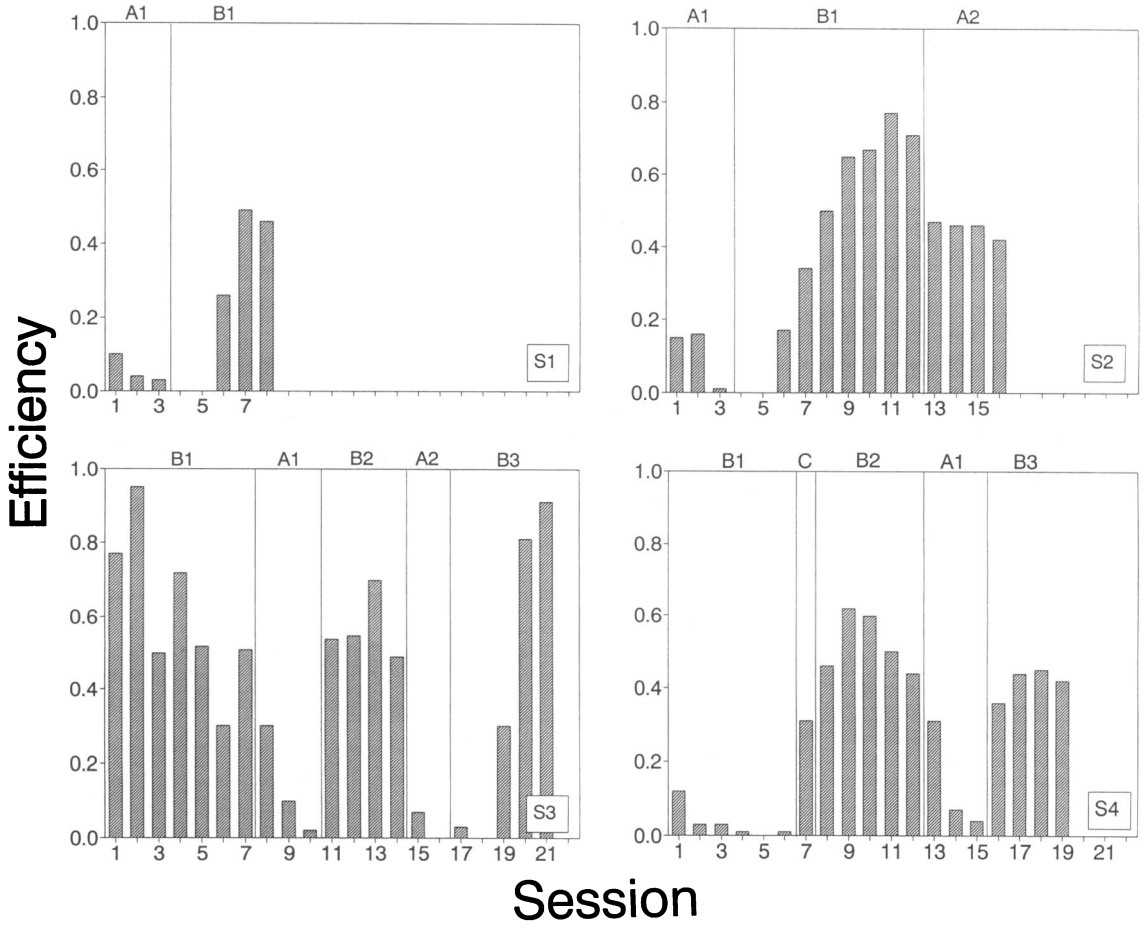

Fig. 2. The proportion of right-key responses emitted within 15 s of a left-key response (efficiency) in each session for all 4 subjects. With the precurrent contingency present, this index represents the proportion of right-key responses emitted under the higher reinforcement probability changed state. Other details as in Figure 1.

apparent. For example, we might conclude from Table 1 that introducing the precurrent contingency in Phase B1 for S1 attenuated precurrent left-key responding if we were to consider only left-key response frequency. Once the precurrent contingency was contacted in Phase B1, however, there were more changeovers to the left key, and the lower left-key response rates in Phase B1 sessions are accounted for by substantially shorter left-key runs. Results such as these caution against considering only rate as an indicator of change for precurrent responding under the present paradigm. Visual inspection of cumulative records proved to be indispensable in this regard (see Skinner, 1976). Future, more sophisticated analyses might examine the resistance to change of stable patterns of precurrent and current responding. Such an approach may ultimately provide a more sensitive indicator of the "strength" of behavior (cf. Nevin, 1979).

Initial contact with the precurrent contingency in Phase B1 resulted in the conditioning of precurrent left-key responding for 3 of the 4 subjects (S4 being the exception). Pilot work in our laboratory has shown that the absence of reinforcement for current behavior immediately following precurrent behavior can reduce precurrent responding with the same precurrent contingency in operation (see Footnote 2). Further analysis of S4's data revealed that when right-key responses were emitted within 2 s of a left-key response in Sessions 1 through 3, the obtained reinforcement probability was

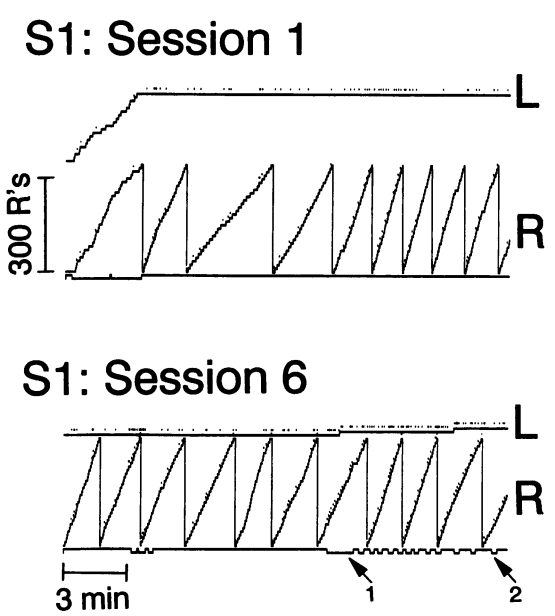

Fig. 3. Cumulative records of left-key (L) and right-key (R) responding for S1 during Session 1 when no precurrent contingency was present and during Session 6 when the precurrent contingency was first contacted. Reinforcers appear as blips above each record to illustrate their temporal relation to both left-key and right-key responding. When in the down position, the event record at the bottom of each session's records represents periods of time within 15 s of a left-key response; if there was a precurrent contingency, then the down position also indicates that the changed state was active and the up position indicates that the normal state was active. Arrow 1 shows that the changed state was extended, and Arrow 2 shows that the changed state was initiated, both indicating the emission of a left-key response even though the left-key record appears to be flat.

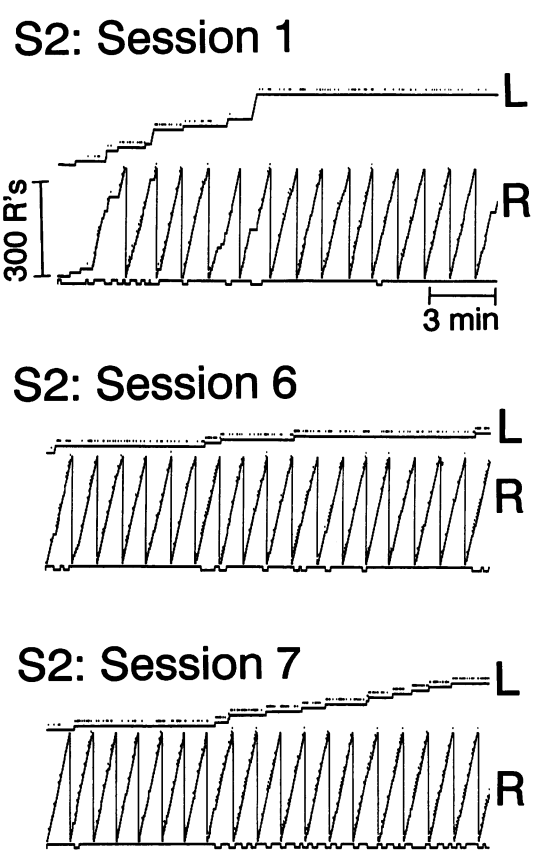

Fig. 4. Cumulative records of left-key (L) and right-key (R) responding for S2 during Session 1 when no precurrent contingency was present, during Session 6 when the precurrent contingency was first contacted, and during Session 7 after repeated contact. Other details as in Figure 3.

only .023, not the programmed value of .08. Perhaps left-key responding was not maintained in these initial sessions because it produced no effect on the obtained reinforcement for right-key responses emitted immediately afterwards. This possible explanation for the lack of conditioning of precurrent behavior should be addressed by further study. For example, with a changeover delay as part of the precurrent contingency, a precurrent response would have two consequences: an immediate timeout from reinforcement and a subsequent greater-than-normal reinforcement probability. Will the subject emit precurrent behavior that first worsens the current behavior's effectiveness before making it better than normal? Does there have to be an overall gain for the conditioning and maintenance of precurrent behavior to occur? Exploring these questions in the present paradigm could represent a free-operant approach to self-control, an alternative to paradigms based on "choice" (e.g., Rachlin, 1978; cf. Skinner, 1986, pp. 231–232).

Acquisition of precurrent left-key responding by S4 was successful when the reinforcement probability in the normal state was reduced to zero for one session. Then, when the regular precurrent contingency was reintroduced, precurrent left-key responding was maintained for as long as the contingency was in effect. These data (along with our pilot research; see Footnote 2) suggest that although initial exposure to the precurrent contingency may be insufficient to condition precurrent behavior, maintenance can be obtained under the contingency once a higher rate of precurrent behavior has been induced by some other

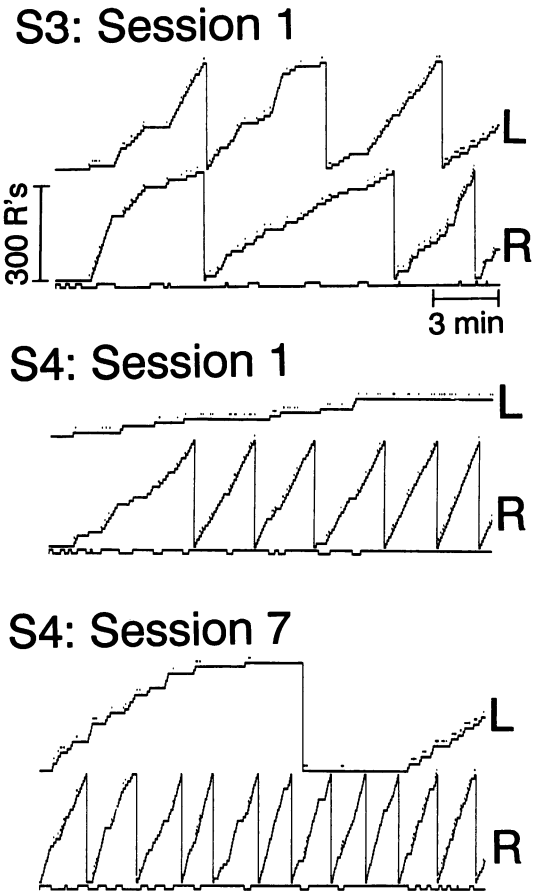

Fig. 5. Cumulative records of left-key (L) and right-key (R) responding for S3 and S4 during Session 1 when the precurrent contingency was present, and for S4 during Session 7 when a special conditioning procedure was employed. Other details as in Figure 3.

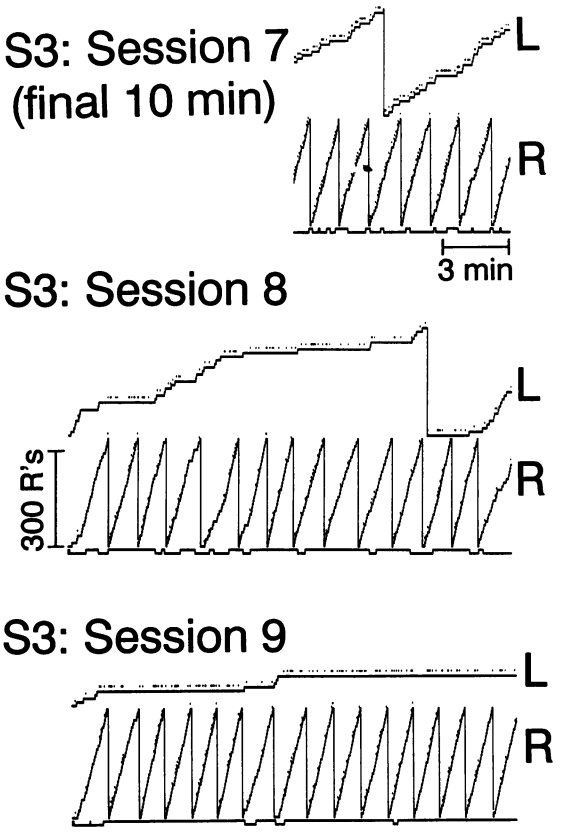

Fig. 6. Cumulative records of left-key (L) and right-key (R) responding for S4 during the latter half of Session 7 and all of Sessions 8 and 9. The precurrent contingency was present up to and including Session 7, but was removed for the next three sessions. Other details as in Figure 3.

means. Future research might explore the impact of factors such as the operant level of precurrent behavior, instructions (cf. Torgrud & Holborn, 1989, pp. 188–190), and establishing operations (Michael, 1982) on the sensitivity of precurrent behavior to precurrent contingencies.

Reconditioning precurrent left-key responding by removing and later reintroducing the precurrent contingency was demonstrated once for S4 and twice for S3. It is interesting to note that reconditioning was successful for S4, even though initial exposure to the standard precurrent contingency did not induce elevated levels of precurrent left-key responding. In fact, reconditioning was rapid, as with S3 in Phases B2 (see Session 11 in Figure 7) and B3. The apparent relative ease of reestablishing precurrent behavior is consistent with findings elsewhere. For example, quick recovery of precurrent behavior has been reported following its prevention (Laties et al., 1969; Parsons, 1976; Torgrud & Holborn, 1989) and during recovery of extinguished current behavior (Laties et al., 1965; Parsons, 1976). Noteworthy from S3's data was the finding that the displacement of the precurrent contingency a second time produced a more immediate reduction in left-key responding than the first time it was removed. This result awaits replication but is consistent with reports of more rapid extinction with successive extinction periods using a directly reinforced operant (e.g., Bullock & Smith, 1953).

Research into precurrent contingencies in which one response enhances reinforcement for another response might proceed in many

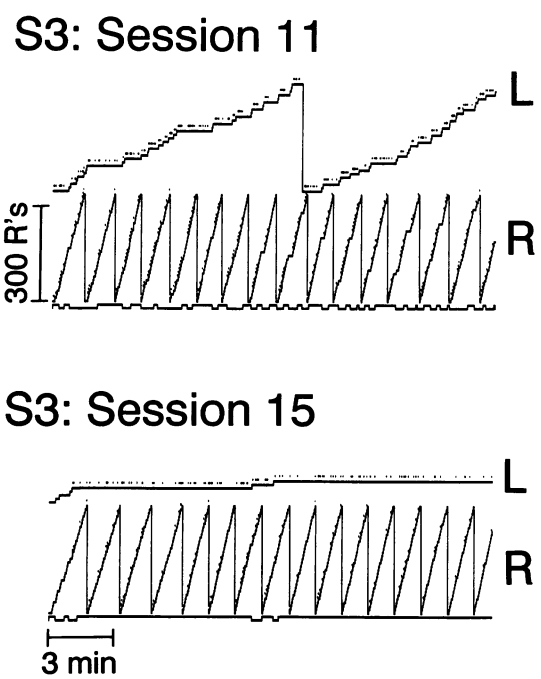

Fig. 7. Cumulative records of left-key (L) and right-key (R) responding for S4 during Sessions 11 and 15. The precurrent contingency was introduced a second time in Session 11 and was removed a second time in Session 15. Other details as in Figure 3.

directions. First, our preliminary research was limited to one restricted set of parameters. Subsequent research might examine how precurrent responding is a function of how much it changes the reinforcement probability for current responding, the duration of the change, and whether or not the change is explicitly signaled. The present paradigm might also be used to study the effects of other reinforcement-enhancement parameters, such as the degree to which precurrent behavior increases reinforcement magnitude for current behavior or reduces its delay to reinforcement. Finally, subsequent studies might explore alternatives to the standard "human button pressing for points" preparation, which is open to criticism. For example, Case, Ploog, and Fantino (1990) suggested that this setup may unduly compromise external validity for internal validity, and they questioned the functional equivalence of consequences such as points backed by money versus consequences of intrinsic value in context. Their alternative approach involved the modification of a popular computer game in which "reinforcers were an integral part of a task designed to be a realistic and entertaining simulation of naturally occurring behavior" (p. 185). A similar strategy might better advance continued investigations into precurrent contingencies with human subjects.

In sum, Skinner's (1953, 1957, 1968, 1969) speculative discussions of complex human behavior have often included the notion of precurrent contingencies. Surprisingly, little research has been generated on this topic. It is clear that one activity can affect the conditions that control other activities such that the second activity is more likely to occur (e.g., Guevremont et al., 1988; Ziegler, 1987) or is more likely to be reinforced (Skinner, 1957); that is, many responses serve a precurrent function. It is less clear what role, if any, precurrent contingencies play in the development and maintenance of precurrent operants in the absence of direct reinforcement by the verbal community. Continued research may suggest a common approach to studying such seemingly diverse actions as stepping on the accelerator pedal before starting the car, qualifying statements with "I think," flattery, repeating a telephone number given by the operator, tying a string on one's finger, looking at someone when you speak, highlighting a school textbook, and stating a rule.

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