

EFFECTS OF THE CHANGEOVER DELAY ON INTERCHANGEOVER
RESPONDING IN CONCURRENT SCHEDULES OF
REINFORCEMENT

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Maria D. Bosch
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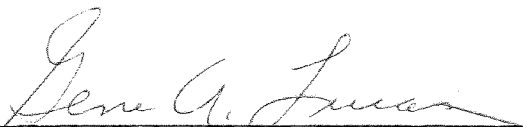
by
Maria D. Bosch

Approved by Committee:




Dr. Larry A. Alferink, Chair

Dr. Phillip K. Duncan



Dr. Gene Lucas



Dr. Earle L. Canfield
Dean of the School of Graduate Studies

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An abstract of a Thesis by
Maria D. Bosch
September 1983
Drake University
Advisor: Larry A. Alferink

The problem. In concurrent schedules of reinforcement, the use of a changeover delay has been assumed to be necessary in order to reduce superstitious alternation, separate the components in time, and thus insure independence between components. The purpose of this study was to look at responding between changeovers and to see whether superstitious alternation does indeed occur.

Procedure. During daily sessions, four male rats were exposed to a concurrent variable-interval schedule on which changeover delays of different values were superimposed. Food-lever responses intervening between changeovers and changeover responses were measured and recorded.

Findings. When a changeover delay was used, total changeover responses decreased, and number of interchangeover responses and overall responding increased. This effect was found to be more pronounced with higher changeover delay values. A high percentage of changeover responses occurring without an intervening food-lever response was observed, especially when a changeover delay was introduced.

Conclusions. No evidence of superstitious alternation was found. Therefore, it was concluded that the use of a changeover delay to eliminate such a pattern was not justified. The increase in interchangeover responses and percentage of changeover responding was argued to be due to the possible discriminative stimulus and conditioned reinforcing function of the changeover delay.

Recommendations. It was suggested that further attention be paid to the role and effect of the changeover delay, especially in terms of simple alternation, a pattern that seems to be more dominant than superstitious alternation.

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CHAPTER I

INTRODUCTION AND REVIEW OF THE LITERATURE

In continuous choice procedures (called concurrent schedules) two or more alternative schedules of reinforcement are simultaneously available and the animal continually chooses between responding to one alternative or the other. Two different methods of programming concurrent variable-interval schedules (conc VI VI) have generally been used. One of these uses two operanda each associated with a different schedule and exteroceptive stimulus. The schedules are independently programmed such that responses on one operandum have no effect on reinforcers programmed for the second operandum (Catania, 1962). The switching from one lever to the other by the organism is called a changeover (CO) response. Another method of programming concurrent schedules uses a single operandum, whereby only a single schedule is assigned to it at one time, and a second operandum, or CO lever, determines which schedule and stimulus associated with it is in effect at the time. In both cases, the schedules operate simultaneously, and assign reinforcers independently. The two methods for arranging concurrent schedules are assumed to be functionally equivalent (Pliskoff, 1971).

Responding on these schedules may be characterized by a high rate of switching or alternating from one

schedule to the other. Catania (1962) has argued that this alternation may be due to the fact that in concurrent schedules, a response on one schedule is sometimes followed by a reinforced response on the second schedule. This strengthens not only the response on the second schedule, but also the preceding response on the first schedule, and the behavior of switching from schedule to schedule. Another effect of concurrent schedules seems to be that matching, or correspondence between relative rate of responding and relative rate of reinforcement for each component, does not usually occur under these conditions (Herrnstein, 1961). To make the behavior of one schedule independent of reinforcers delivered on a second schedule, changeover delays (COD) are often used. The COD specifies the minimum time interval that must elapse between a CO and a reinforced response. The introduction of a changeover delay assures independence between the schedules, reduces the number of alternations between the schedules and produces matching (Herrnstein, 1961).

In the last twenty years, the COD and its effects on concurrent performance have been widely investigated. Catania (1962) found that when a COD was introduced, concurrent interval performance in pigeons was more similar to that which is observed when interval schedules are programmed separately than when a COD was not used. Catania and Cutts (1963) extended these results to

concurrent performance in humans, finding that concurrent superstitions were reduced or eliminated when a COD was used. Silberberg and Fantino (1970), using COD values of 0.875 sec, 1.75 sec and 3.5 sec, showed that Herrnstein's (1961) conclusion that matching is only obtained when a COD is used, was found to be true with several COD values. They also found that response rates during the COD were higher than post COD rates, and that the matching relation holds despite the fact that neither responding during the COD nor after the COD, taken in isolation, matched the relative rate of reinforcement. Pliskoff (1971) examined the dependence of changeover responses on an immediate consequence, the COD. He found that as the COD increased, not only did CO responses decrease, but food responses per CO increased, thus suggesting that the COD functionally punishes CO responding. Allison and Lloyd (1971) looked at the effects of gradual and abrupt changes in COD value on the degree of correspondence between relative reinforcement rate and relative performance measures in pigeons. Their results suggest that a more gradual increase in COD value does help maintain a greater degree of correspondence between the scheduled and actual relative rate of reinforcement. However the effectiveness of a gradual increase in COD duration is limited by the interaction of the COD with the concurrent schedules of reinforcement.

Using symmetrical (i.e., same COR value for each component) and asymmetrical (i.e., different COR value for each component) changeover ratio (COR) requirements instead of a COD, White (1979) found that an increase in one or both COR requirements produces a decrease in CO rate and an increase in local response rates, an effect analogous to that of the COD (Pliskoff, 1971). However, if only one COR is increased, the extra time and responses are allocated more to the schedule with the larger switching-into COR. White argued that this is not the result of changes in local reinforcement rate but due to the COR acting as an aversive stimulus affecting the behavior which precedes the CO response. Pliskoff and Fetterman (1981) investigated a one, two and four fixed ratio (FR) CO requirement on concurrent variable two and six-minute schedules, and its effects on both time and response data. It was found that the time data overmatched (i.e., behavior measure is more extreme than relative reinforcement rate) when a FR-4 CO was used, and undermatched (i.e., behavior measure is less extreme) when either a FR-2 CO or a FR-1 CO was used. Response rates overmatched with a FR-4 CO and a FR-2 CO and undermatched when a FR-1 CO was required. It was concluded that matching is basically a function of experimental variables.

Using COD values of fixed or varied duration,

van Haaren (1981) found that response rates during COD's of fixed duration were higher than post-COD rates, confirming Silberberg and Fantino's (1970) results, but that differences in COD and post-COD rates were greatly reduced when a variable COD was used. He argued that a COD of fixed duration could best be described as a:

subject controlled stimulus change
superimposed on a conc VI VI baseline
schedule of reinforcement having a
conditioned reinforcing effect for the
behavior preceding it and a discrimina-
tive stimulus function for responding
in the presence of and following the
stimulus change. (p. 430)

The following study attempted to analyze the need for and function of the COD in concurrent schedules. The COD has been assumed to be needed in order to reduce rapid or superstitious alternation and increase sensitivity to schedule changes. However, this alternation has not been systematically documented. Thus, number of responses between COs was measured in a concurrent schedule with equal variable-interval components to: (1) see whether superstitious alternation actually does occur, and (2) investigate the effects of a COD on the pattern of responding between changeovers.

CHAPTER II

METHOD

Subjects

Four male albino rats approximately three months old were maintained at 80% of their free-feeding weight throughout the duration of this study. Housing was in individual cages with free access to water.

Apparatus

The experimental chamber measured 27.5 cm by 30 cm by 26 cm (h x l x w). Two 5 cm-long bars, a food-lever and a CO-lever, 8.5 cm apart, were located on one panel 7 cm from the grid floor and protruded 2.5 cm into the chamber. A food magazine into which 45 mg Noyes pellets could be deposited by a pellet dispenser (Davis model PD-104), was situated directly below and between the two levers. One 7.5 W houselight was on the opposite side of the chamber. An 8 ohm speaker was mounted on one of the walls of the sound-attenuated shell enclosing the chamber, with an exhaust fan on the opposite wall. Control of the experiment and recording of the data was done by means of solid state equipment (BRS-LVE).

Procedure

Preliminary Training. During this stage, each subject was hand-shaped to press the food lever, then exposed

to a schedule of continuous reinforcement for seven 30-min sessions. Next, the subjects were shaped to lever-press only during the time a two-frequency random tone was on, and then trained to press the second, or CO-lever, to activate the tone which made reinforcement available by means of a food-lever press. This response alternation training continued for three 30-min sessions after acquisition. Following this the animals were exposed to the following sequence: conc VI 10 sec VI 10 sec, conc VI 15" VI 15", conc VI 30" VI 30", and conc VI 60" VI 60". In all cases, the two schedules were differentiated by a two-frequency tone, with each frequency associated with a particular schedule or component. A single CO response was required for switching between schedules and altering the tone frequency. Each schedule was maintained until an approximately equal number of reinforcers (± 5) were obtained in each component for at least seven consecutive sessions. Each session lasted until sixty reinforcers were delivered.

During preliminary training the dependent measures were: total number of reinforcers obtained per component; total number of responses per component; total CO responses; and for one of the schedule components, a frequency distribution of the number of food-lever responses intervening between changeovers.

Experimental Phases. Following preliminary training, the animals were exposed to a conc VI 60" VI 60" during the first experimental condition. No changeover delay was in effect during this condition. In the second condition, a two-second COD was introduced such that every CO response started the COD timer and food-lever responses had no consequence until that time period was over. In the third condition the COD was eliminated; thus, this phase was functionally equivalent to the first. In the fourth condition, a one-second COD was introduced. During the fifth and last condition, the COD was again removed. For all experimental phases, a conc VI 60" VI 60" was in effect. Sessions lasted until sixty reinforcers were delivered, and each condition was maintained for at least ten consecutive sessions (days).

The dependent measures during the experimental phases were the same as those in preliminary training except for the frequency distribution of food-lever responses, which was now recorded for both schedule components.

Criteria for changing experimental phases were: in terms of matching, a difference between relative response rate and reinforcement rate no greater than ± 0.05 or a range of 10%; and in terms of the food-lever distribution, no apparent changes in the relative value of each individual bin. Decisions were based on the last five days' total.

CHAPTER III

RESULTS

Figures 1, 2, 3 and 4 show the percentage of interchangeover responses and their distribution as a function of total changeover responses for each schedule component and each of the experimental subjects. The variability indicators show the variability for each component and within each bin for the last five days of each condition. For experimental purposes, interchangeover responses were defined as the number of food-lever responses occurring between changeovers, with each bin representing the number of intervening food-lever responses. Tables 1, 2, 3 and 4 show the total number of interchangeover and changeover responses from which the percentages in Figures 1, 2, 3 and 4 were derived for each of the subjects. All of the data presented are totals derived from performance during the last five days of each condition.

In general, during the first experimental condition or baseline, where no COD was used, subjects showed about the same percentage of responding in all bins with few intervening food-lever responses and frequent changeovers (Figures 2-A, 3-A and 4-A). This is less evident for subject five (Figure 1-A) where slightly over 60% of responding was observed in bin #25, in both schedule components.

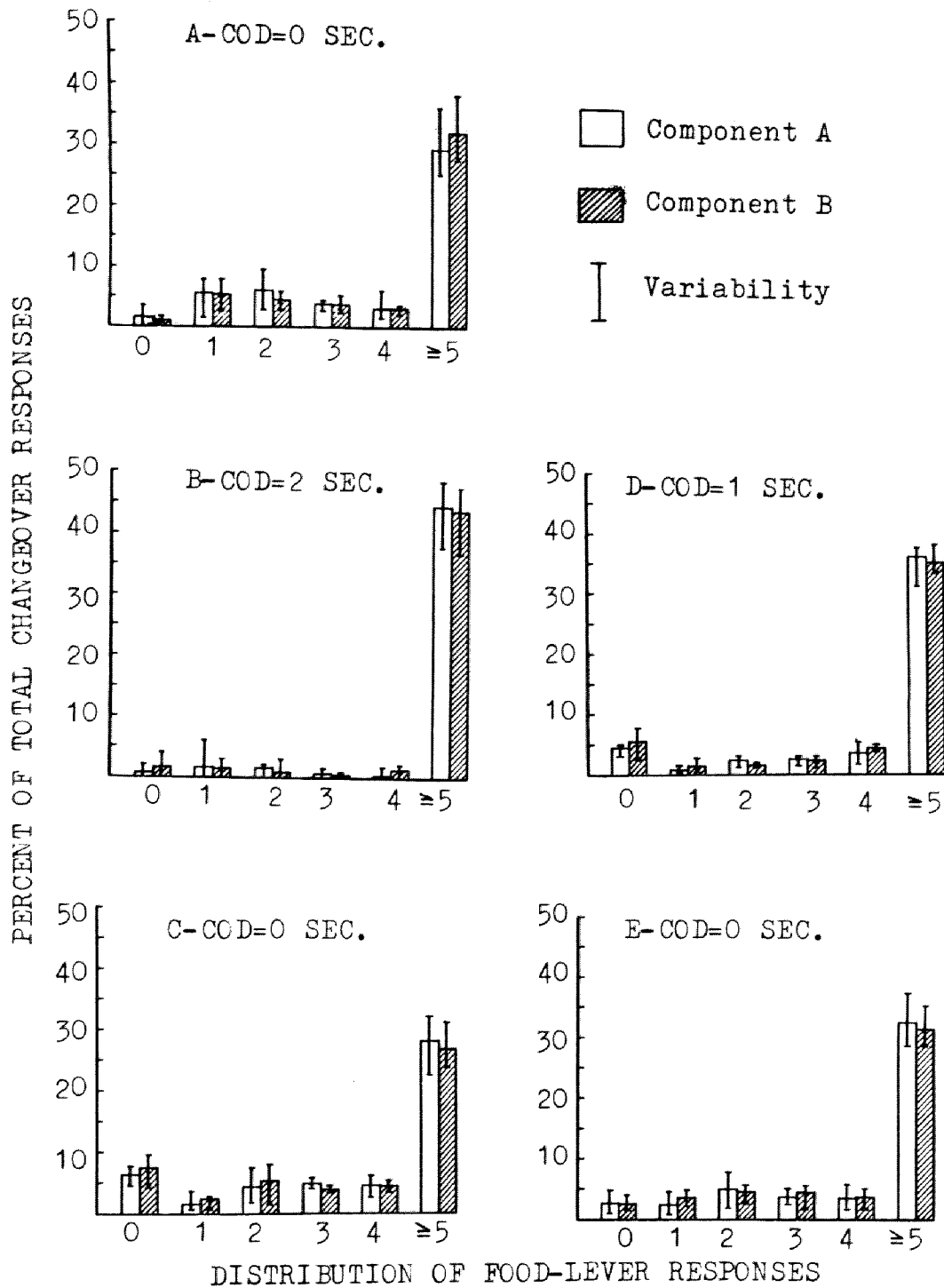


Figure 1. Distribution of food-lever responses for both VI 60" VI 60" components as a percentage of total changeover responses, during all experimental conditions for subject number five.

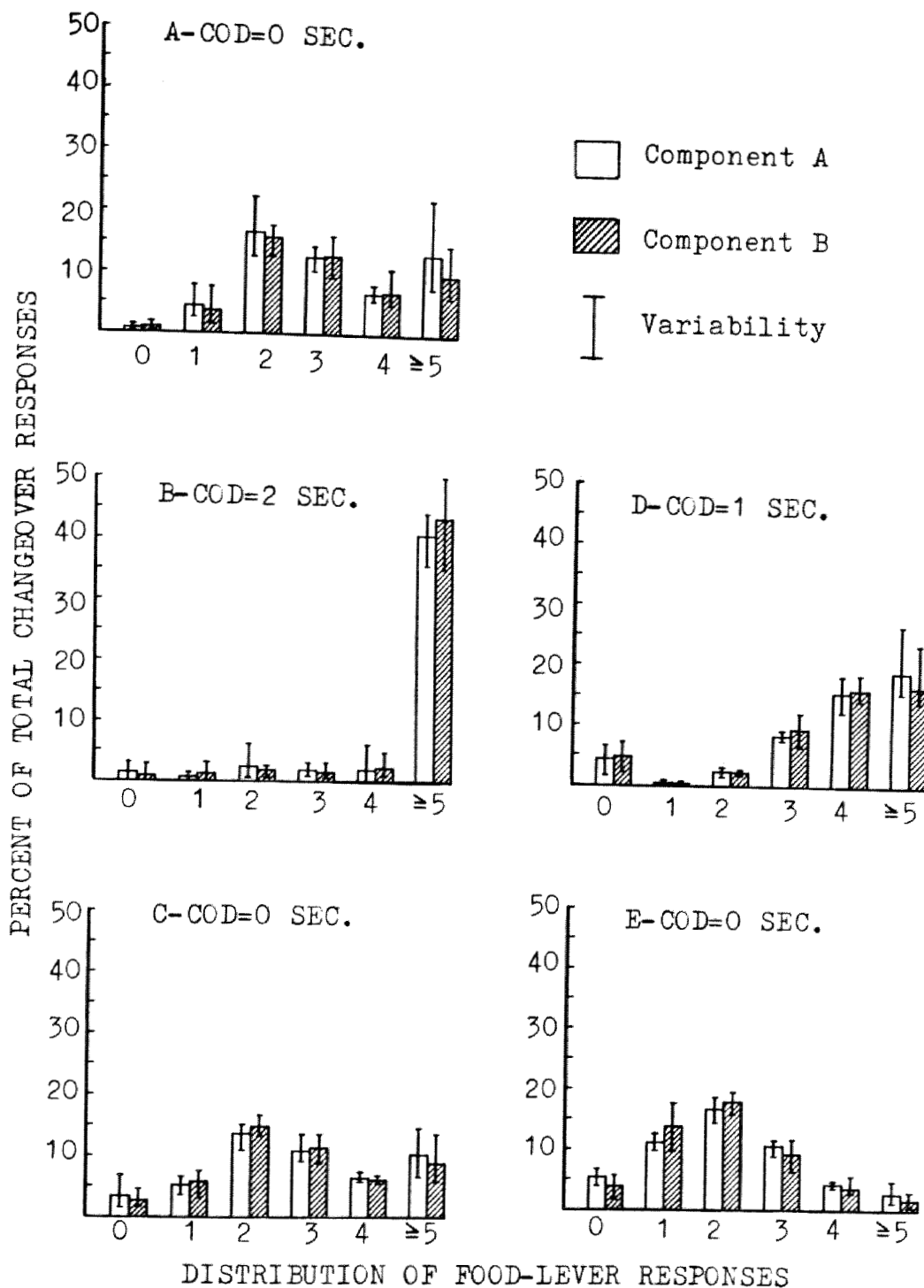


Figure 2. Distribution of food-lever responses for both VI 60" VI 60" components as a percentage of total changeover responses, during all experimental conditions for subject number six.

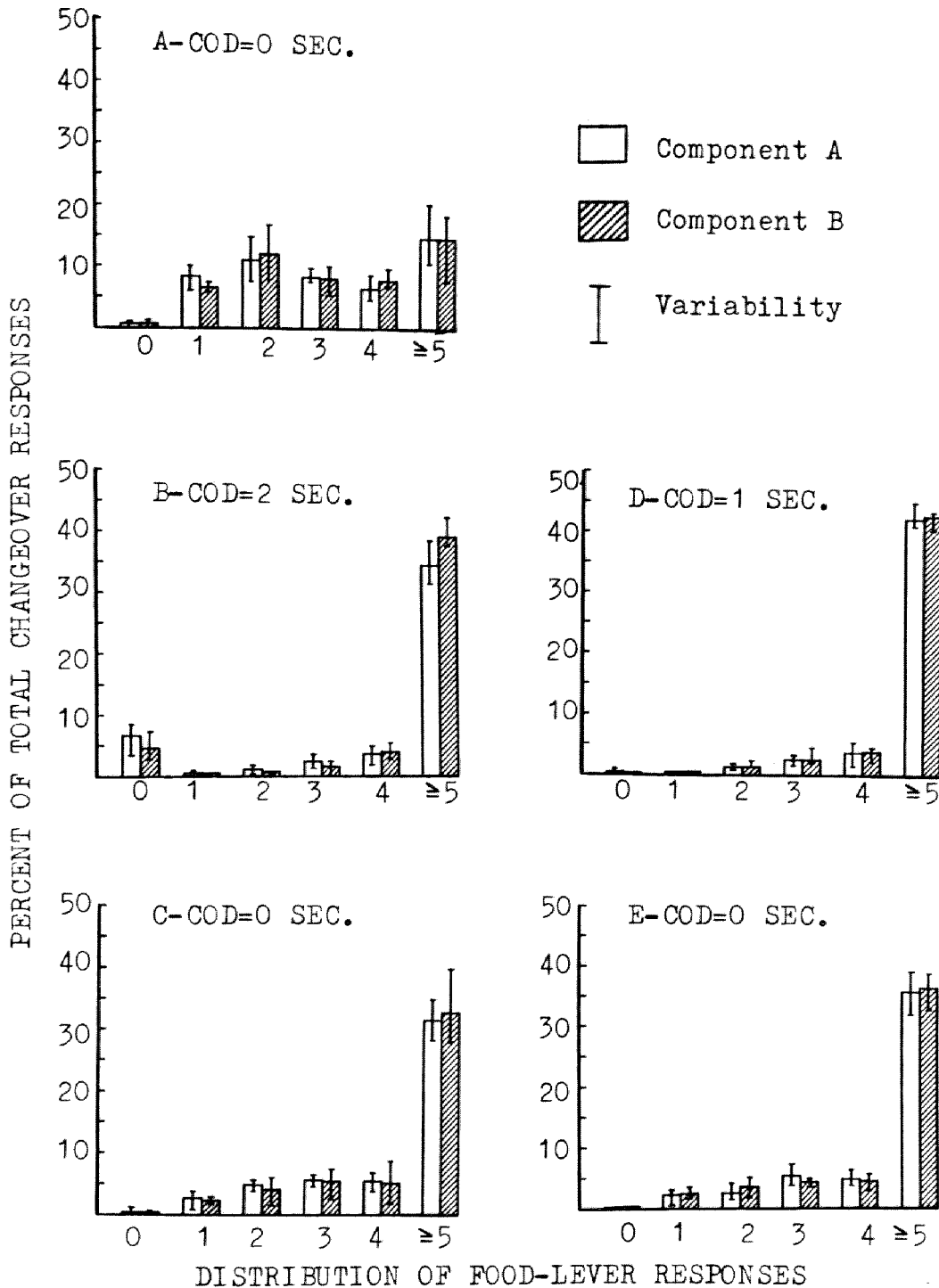


Figure 3. Distribution of food-lever responses for both VI 60" VI 60" components as a percentage of total changeover responses, during all experimental conditions for subject number seven.

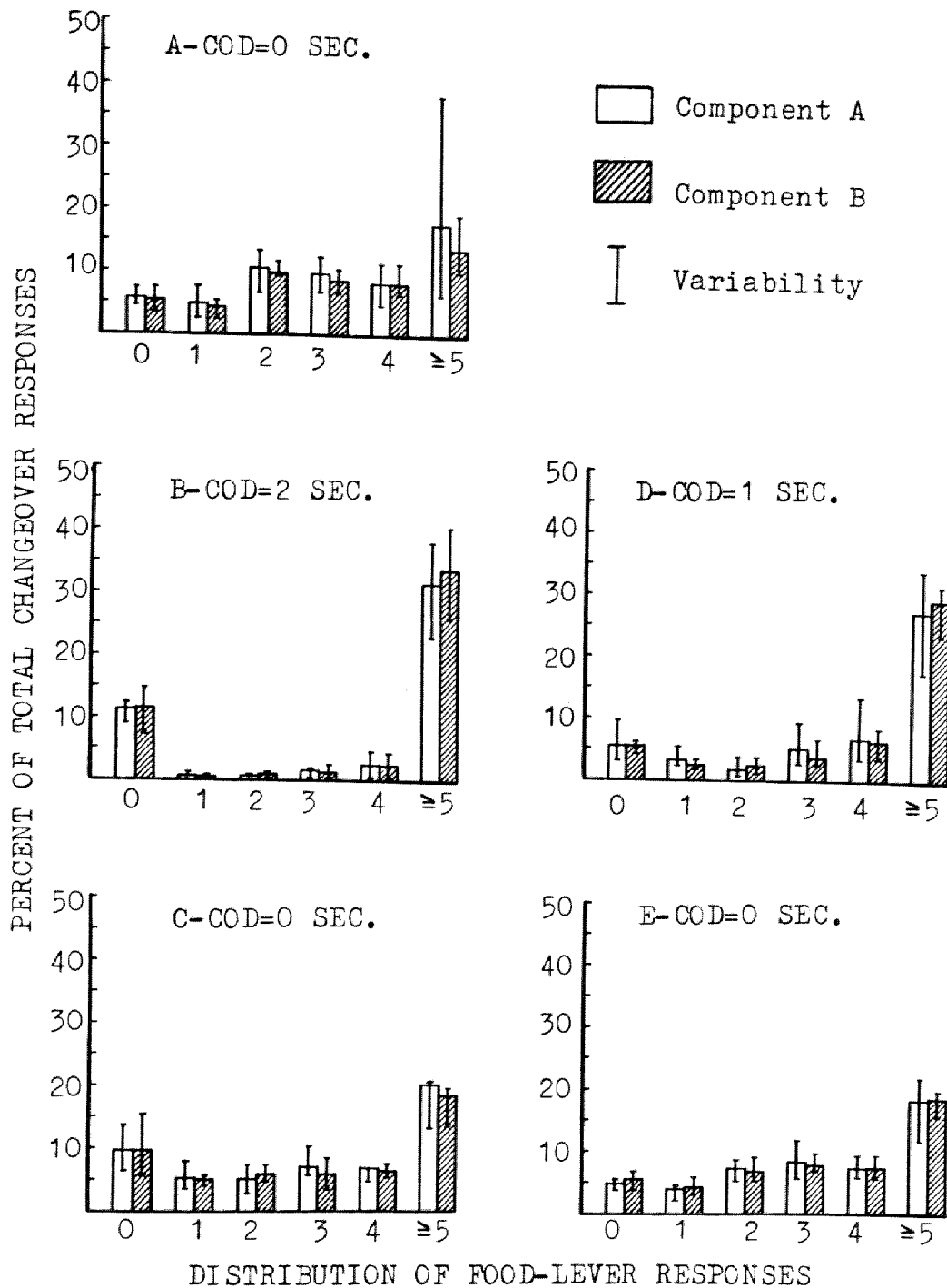


Figure 4. Distribution of food-lever responses for both VI 60" VI 60" components as a percentage of total changeover responses, during all experimental conditions for subject number eight.

Table 1

Summary data for subject number five. Columns two through thirteen show the total number of interchangeover responses in each bin for both VI 60" components, and for each experimental condition. Column fourteen shows the total number of changeover responses made in each experimental condition. All data are totals for the last five days of each condition.

EXPERIMENTAL CONDITION	COMPONENT A					COMPONENT B					TOTAL CO		
	0	1	2	3	4	Σ	0	1	2	3		4	Σ
	A COD=0"	14	72	79	52	39	399	13	70	56		49	36
B COD=2"	4	9	8	3	1	240	9	8	5	2	7	237	
C COD=0"	99	26	66	78	71	440	120	37	81	62	67	416	
D COD=1"	64	13	34	38	50	522	79	19	22	34	62	506	
E COD=0"	38	31	67	49	45	441	37	48	60	57	48	423	

Table 2

Summary data for subject number six. Columns two through thirteen show the total number of interchangeover responses in each bin for both VI 60" components, and for each experimental condition. Column fourteen shows the total number of changeover responses made in each experimental condition. All data are totals for the last five days of each condition.

EXPERIMENTAL CONDITION	COMPONENT A						COMPONENT B						TOTAL CO
	0	1	2	3	4	Σ	0	1	2	3	4	Σ	
	A COD=0"	13	91	345	259	140	273	19	77	329	266	145	
B COD=2"	13	5	19	15	16	342	8	10	15	13	18	364	842
C COD=0"	82	116	303	244	142	225	66	130	334	251	136	197	2230
D COD=1"	95	7	51	181	339	413	103	4	46	207	348	361	2172
E COD=0"	106	222	335	212	82	53	77	278	361	185	74	32	2017

Table 3

Summary data for subject number seven. Columns two through thirteen show the total number of interchangeover responses in each bin for both VI 60" components, and for each experimental condition. Column fourteen shows the total number of changeover responses made in each experimental condition. All data are totals for the last five days of each condition.

EXPERIMENTAL CONDITION	COMPONENT A					COMPONENT B					TOTAL CO		
	0	1	2	3	4	Σ5	0	1	2	3		4	Σ5
	A COD=0"	14	174	232	172	132	313	14	137	254		170	165
B COD=2"	118	7	18	40	61	587	80	6	10	25	65	667	1708
C COD=0"	4	42	73	85	81	490	2	36	63	83	79	509	1547
D COD=1"	2	1	16	30	47	519	0	2	17	31	48	514	1226
E COD=0"	2	31	37	77	70	519	1	35	53	62	65	515	1466

Table 4

Summary data for subject number eight. Columns two through thirteen show the total number of interchangeover responses in each bin for both VI 60" components, and for each experimental condition. Column fourteen shows the total number of changeover responses made in each experimental condition. All data are totals for the last five days of each condition.

EXPERIMENTAL CONDITION	COMPONENT A					COMPONENT B					TOTAL CO		
	0	1	2	3	4	Σ5	0	1	2	3		4	Σ5
A COD=0"	129	111	234	219	185	402	118	95	219	195	182	311	2242
B COD=2"	183	7	8	25	38	512	183	4	6	21	36	550	1626
C COD=0"	223	119	114	161	140	373	226	114	134	134	141	385	2267
D COD=1"	116	68	38	105	140	559	114	50	48	78	134	600	2050
E COD=0"	109	84	157	184	160	402	118	89	149	178	162	410	2196

During the second experimental condition, when a two-second COD was introduced, this pattern changed to show a higher percentage of responses being allocated to the higher bins. In fact, subjects five and six showed almost no responding in bins #0 through #4, allocating about 90% of all food-lever responses to bin #25, for both components (Figures 1-B and 2-B). In other words, subjects increased the number of responses during either VI 60" component before emitting a changeover response. For subjects seven and eight (Figures 3-B and 4-B) this pattern was also evident but with a slight difference, the percentage of responding in bin #0 increased. Thus, the animals also increased the number of times they changed schedules without an intervening food-lever response. This increase was from about 2% to 10% for subject seven in both components, and from 10% to 20% for subject eight in both components.

In the third experimental phase, when the COD was removed, subjects seemed to return to the pattern of responding which was observed during baseline (Figures 1-C, 2-C, 3-C and 4-C). However, subject seven allocated a high percentage of responding to bin #25, about 60% in both components (Figure 3-C). This is more similar to the results obtained with a two-second COD than to baseline.

When a one-second COD was introduced, all subjects showed a tendency to emit several food-lever responses in one component before changing over to the other component.

Subject five (Figure 1-D) allocated a slightly higher percentage of responding to the lower bins than in the two-second COD, and slightly less in bin #25. Subject six (Figure 2-D) also shifted to the higher bins, and although the effect was not as pronounced as with a two-second COD, it was markedly different from the pattern observed during the baseline condition. For subject seven (Figure 3-D), the effect of a one-second COD was more pronounced than that of a two-second COD. Moreover, responding in bin #0 was almost eliminated, and that in bins #1 through #4 decreased to 10% or less in each bin for both components. Subject eight (Figure 4-D) also shifted responding to the higher bins, and again this effect was less pronounced than that observed with a two-second COD.

During the last experimental condition when the COD was again removed, subjects again returned to the pattern of responding observed during the first experimental phase, or baseline (Figures 1-E, 2-E and 4-E). An exception to this was subject seven which again, did not show the pattern observed during baseline, but something closer to that seen during the COD and second baseline conditions (Figure 3-E). In other words, the subject seemed to allocate a high percentage of responding to bin #25. This is less than in the conditions where a COD was used, but not similar to the subject's original baseline pattern.

In terms of total number of changeovers, all subjects showed a decrease when a COD was introduced, and a subsequent increase when the COD was removed (Tables 1, 2, 3, and 4). This decrease in number of total changeovers was more evident the higher the COD value. Subject seven showed some differences in terms of the general pattern. There was a decrease in total changeovers with a two-second COD, which was followed by a subsequent decrease when the COD was removed (Table 3). When a one-second COD was introduced the number of changeovers again decreased, but relatively less than that observed with the first COD.

As can be seen from the data, all subjects were sensitive to the changes in experimental conditions. In general, the introduction of a COD had the same effect for all the subjects, an increase in the number of interchangeover responses and a decrease in the total number of changeovers. Further, with the exception of subject seven, this shift seems to become more pronounced with a higher COD value.

The distribution of responses between the two schedule components was approximately equal to the distribution of reinforcers obtained for responding in each component. Thus, relative responding matched relative reinforcement for all subjects both with and without a COD.

CHAPTER IV

DISCUSSION

One of the purposes of this study was to see whether rapid or superstitious alternation actually does occur. For this reason, a concurrent schedule with equal VI components was chosen; if such a response pattern does indeed occur, it is more likely to do so when equal components are used. With equal components, superstitious alternation would seem to be the pattern of responding which would maximize the probability of reinforcement for the subject, provided a COD is not used (Herrnstein, 1961). This pattern has been reported in past literature (Ferster & Skinner, 1957; Herrnstein, 1961; Catania, 1962). This study specifically looked at responding between changeovers (i.e., interchangeover responding). Superstitious alternation would be observed as a high percentage of responding in bin #1. There was some responding in that bin, but except for the last condition in subject six's data, there is no evidence that suggests such alternation might be a dominant response pattern. While the introduction of a COD does reduce and in some cases eliminates responding in bin #1, its use for purposes of reducing low levels of alternation may not be justified. The occurrence of superstitious alternation as a dominant response pattern in concurrent schedules of reinforcement has been assumed

in past literature; under the conditions of this study, it was found that there may be little reason for concern. Such concern is expressed by Herrnstein (1961), who argues that superstitious alternation results in the relative frequency of responding not matching the relative frequency of reinforcement. With unequal schedule values, frequent alternation would result in a more equal frequency of responding in both schedules and thus prevent matching to the relative frequency of reinforcement. The use of a COD insures independence between the schedules, reduces alternation and results in matching. Catania and Cutts (1963) argued that superstitious alternation produces schedule insensitivity whereby the subject's behavior does not come under the control of the schedule contingencies. The use of a COD separates the schedules in time, reducing superstitious responding and ensuring sensitivity to schedule contingencies. However, the present study found that superstitious alternation does not occur. The COD may produce matching and schedule sensitivity, but it does not do so by eliminating superstitious alternation.

The data obtained in this study further emphasize some of the results previously documented in the literature. Pliskoff (1971), White (1979) and Pliskoff and Fetterman (1981) examined the dependence of changeover responses on their immediate consequence, the COD or COR. They found that as the COD increased, not only did CO

responses decrease but food-lever responses increased. These results were duplicated in this study. Pliskoff (1971) has argued that the COD functions as an aversive stimulus punishing CO responding. However, the fact that response rate during the COD increases suggests that such an explanation of the function of the COD might not be entirely correct. Van Haaren (1981) argued that a COD of fixed duration may have a discriminative stimulus function for responding in the presence of and following the stimulus change (i.e., the COD). Such an argument would explain why when a COD is introduced, response rates during the COD increase, instead of decrease, which might be the expected outcome if the COD was indeed an aversive stimulus. The present study found that not only do overall response rates increase as the COD increases, but that the number of interchangeover responses (i.e., the number of food-lever responses intervening between changeovers) also increase. Silberberg and Fantino (1970) found that response rates during the COD are higher than post-COD rates. They argued that such a burst reflects the increased probability of reinforcement which is in effect after the COD. Although this study was not designed to test such an assumption, it may be that the increase in interchangeover responding is a direct result of the increase in responding during the COD. If such is the case, both van Haaren's (1981) and Silberberg and Fantino's

(1970) data are in agreement and complement one another: the COD may have a discriminative stimulus function for behavior in the presence of and following the stimulus change, indicating or reflecting the increased probability of reinforcement in effect after the COD.

So far the overall decrease of changeover responding when a COD is used has been well documented in the literature (Pliskoff, 1971; Pliskoff & Patterman, 1981; White, 1979) and this study confirmed such findings. However, it was also observed that a high percentage of responding was allocated to bin #0. In other words, two or more CO responses occurred with no intervening food-lever responses. Such a pattern was most obvious in the data of subject eight (Figure 4), where for all conditions simple switching or alternating between the schedules seemed to be a more dominant response pattern than superstitious alternation. Simple alternation was at its highest level in the condition where a two-second COD was used, remained high in the third condition when the COD was removed, and was still observed in the last two conditions. The pattern is somewhat less evident in the other subjects' data; in subject five it showed up in conditions three and four (Figure 1-C and 1-D); in subject six it was observed in the last three conditions (Figure 2-C, 2-D and 2-E); and in subject seven the pattern was observed in the second condition (Figure 3-B). Simple alternation then, seems to be at a

high percentage in the conditions where a COD is in use, suggesting that the COD does not, in effect, punish CO responding. Again, van Haaren's (1981) explanation seems to be the most plausible: the COD is a subject controlled stimulus change superimposed on a concurrent baseline schedule which has a conditioned reinforcing effect for behavior in its presence and following it. In concurrent VI VI schedules, the mere passage of time increases the probability that the next response will be reinforced. Thus, while a CO response during the COD would reset the timer, initiating another COD, the probability of reinforcement at the end of the delay would increase.

In summary, although the effects of the COD have been investigated for over two decades, its effects on interchangeover responding had not yet been systematically documented. The present study suggests that first, superstitious alternation is not a dominant response pattern and the use of the COD to reduce or eliminate it and thus insure independence between schedule components is not necessary in this case. Second, further investigation of the pattern of simple alternation could bring new light to the issue of the effects of the COD in concurrent schedules of reinforcement.

REFERENCES

- Allison, T. S., & Lloyd, K. E. Concurrent schedules of reinforcement: Effect of gradual and abrupt increases in changeover delay. Journal of the Experimental Analysis of Behavior, 1971, 16, 67-73.
- Catania, A. C. Independence of concurrent responding maintained by interval schedules of reinforcement. Journal of the Experimental Analysis of Behavior, 1962, 5 (2), 175-184.
- Catania, A. C., & Cutts, D. Experimental control of superstitious responding in humans. Journal of the Experimental Analysis of Behavior, 1963, 6 (2), 203-208.
- Ferster, C. B., & Skinner, B. F. Schedules of Reinforcement. New York: Appleton-Century-Crofts, 1957.
- Herrnstein, R. J. Relative and absolute strength of response as a function of frequency of reinforcement. Journal of the Experimental Analysis of Behavior, 1961, 4, 267-272.
- Pliskoff, S. S. Effects of symmetrical and asymmetrical changeover delays on concurrent performances. Journal of the Experimental Analysis of Behavior, 1971, 16, 249-256.
- Pliskoff, S. S., & Fetterman, J. G. Undermatching and overmatching: The fixed-ratio changeover requirement.

Journal of the Experimental Analysis of Behavior,
1981, 36, 21-27.

Silberberg, A., & Fantino, E. Choice, rate of reinforcement, and the changeover delay. Journal of the Experimental Analysis of Behavior, 1970, 13, 187-197.

Van Haaren, F. The effects of changeover delays of fixed or variable duration on concurrent variable-interval performance in pigeons. Animal Learning & Behavior, 1981, 9 (3), 425-431.

White, J. M. Changeover ratio effects on concurrent variable-interval performance. Journal of the Experimental Analysis of Behavior, 1979, 31, 239-252.