CONCURRENT PERFORMANCES: RATE CONSTANCIES WITHOUT CHANGEOVER DELAYS¹

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Pigeons' pecks on two keys were maintained, without changeover delays, by independent variable-interval schedules of food reinforcement. Four regularly cycling 2-min components scheduled reinforcement respectively for both keys, left key only, both keys, and right key only. Initially, reinforcement scheduled for one key alone produced more responding on that key than reinforcement scheduled concurrently for both keys. Continued sessions reduced this difference; response rate on a given key approached constancy, or invariance with respect to the performance on and schedule for the other key. When extinction replaced the reinforcement schedule on either key, responding on that key decreased more during components that scheduled reinforcement for the other key than during those that did not. This demonstration that responses on one key were not supported by reinforcers on the other key suggested that the alternation of concurrent responding and either-key-alone responding prevented concurrent superstitions from developing.

Key words: concurrent schedules, multiple schedules, variable-interval schedules, changeover delays, rate constancy, concurrent superstition, response independence, key peck, pigeon

The obvious criterion for independence of concurrent responses is that the rate of each response is unaffected by changes in either the rate of the other response or the reinforcers produced by the other response. But concurrent schedules may generate contingencies that operate against such independence. For example, when a pigeon's pecks on two keys are reinforced concurrently according to independent variable-interval (VI) schedules, the probability that a peck on one key will be reinforced increases with time spent in pecking the other key. For this reason, reinforced pecks on one key may often follow closely on changeovers from the other key. But the reinforcer may then act on the sequence of pecks on the two keys. Once this happens, the concurrent performances cannot be independent, because each response is partially under the control of the reinforcers scheduled for the other (*cf.*

Catania and Cutts, 1963; see also Hawkes and Shimp, 1975, on the treatment of response sequences as higher-order behavioral units).

Concurrent schedules often include changeover contingencies (*e.g.*, Findley, 1958; Todorov, 1971), to circumvent or at least reduce the magnitude of this problem. For example, the changeover delay or COD (Herrnstein, 1961) arranges a time interval after each changeover from one response to the other, during which no response can be reinforced. But although a COD may reduce the likelihood that either response is maintained by reinforcers scheduled for the other, it also affects the rate and pattern of responding immediately after the changeover (Catania, 1972; Guilkey, Shull, and Brownstein, 1975; Pliskoff, 1971; Silberberg and Fantino, 1970). Thus, the properties of concurrent performances may depend critically on whether and at what delay value a COD operates (Catania, 1962, 1963; Shull and Pliskoff, 1967).

Prior research on the independence of concurrent performances has used CODs to demonstrate rate constancies, invariance in the rate of one response during the alternation between reinforced high and unreinforced low rates of a second response (Catania, 1962; see also Catania, 1966, pp. 249-253, for a distinction between *rate constancy* and *response independence*). For example, when pigeons'

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pecks on one key were maintained by a continuously operating VI schedule and pecks on a second key were maintained by alternating VI and extinction (EXT) schedules correlated with different stimuli, approximately the same response rate was maintained on the first key during the second key's VI component as during the second key's EXT component. With removal of the COD, however, rate on the first key during the second key's VI component became lower than that during the second key's EXT component.

Following on the finding that rate constancies occurred with but not without a COD, later research suggested that the COD had its effect not because it separated responses on one key from reinforcers scheduled for the other, but rather because it generated locally high rates of responding immediately after changeovers from one key to the other (Catania, 1972). The rate constancies were presumably approximated because these high rates during concurrent responding made up for the time spent in responding on the other key: for a given key, the high local rate, in combination with the interruptions for other-key VI responding, produced an overall rate that roughly equalled the moderate but relatively uninterrupted rate during EXT on the other key. The role of the COD in maintaining independent concurrent responses by separating each response temporally from the other response's reinforcers therefore remains ambiguous. Thus, it is of interest to determine whether rate constancies can be obtained without a COD.

The present research examined the feasibility of substituting the frequent alternation of concurrent and single-key responding for the operation of a COD. The rationale was that stereotyped nonindependent sequences of concurrent responses might be less likely to develop if conditions under which the two responses were maintained concurrently alternated frequently with conditions under which either response was maintained alone. Pigeons' pecks on each of two keys were first brought under the control of stimuli correlated with VI reinforcement and stimuli correlated with nonreinforcement (extinction: EXT). The stimuli were then arranged in a cycle of four components: concurrent reinforcement of left-key and right-key pecks; reinforcement of left-key pecks only; concurrent reinforcement of

left-key and right-key pecks; and reinforcement of right-key pecks only. Under these circumstances, pecks on a given key sometimes occurred concurrently with pecks on the other key and sometimes occurred alone.

Because responses on one key can be affected either by the other key's responses or the other key's reinforcers, the respective contributions of concurrent responding and concurrent reinforcement were also examined, by replacing a given key's VI schedule either with EXT or with signalled VI reinforcement. These procedures allow the effects of concurrent responding and concurrent reinforcement to be separated: EXT reduces both reinforcement and responding, whereas a signalled VI schedule, which presents the VI stimulus only when it has scheduled a reinforcer for the next response (Catania, 1963, 1969; Rachlin and Baum, 1969), maintains reinforcement while reducing responding.

METHOD

Subjects

Three adult, male, White Carneaux pigeons, 1.5- to 2-yr old at the start of this research, were maintained at about 80% of free-feeding weights. Pigeon 277 was experimentally naive except for shaping of pecks to a red key; Pigeons 319 and 320 had brief experimental histories of responding on simple reinforcement schedules.

Apparatus

The standard two-key chamber, described in Catania (1969), included two Gerbrands keys 23 cm from the floor and spaced 6.4 cm apart, center-to-center. The keys operated at a threshold of 15 g (0.14 N). The left key could be lit amber or blue and the right key green or red by 6-V Christmas-tree lamps. Pecks on the left key during amber and on the right key during red produced clicks of a dc relay mounted behind the panel. During reinforcement, the 4-sec operation of a Gerbrands feeder centered below the keys, the keys were inoperative, both keylights and houselight were off, and timing of schedules and components was discontinued. During feeder operations produced by left-key pecks, the feeder was lit amber; during those produced by right-key pecks, the feeder was lit red.

Procedure

Table 1 summarizes the schedules arranged in each component during the various conditions. Concurrent 3-min variable-interval schedules each consisted of 15 intervals, constructed according to the specifications of Catania and Reynolds (1968, Appendix II) and timed from the end of the last reinforcer arranged for a given key. The irregular order of intervals for one key was the reverse of that for the other key, and scheduled reinforcers were cancelled if not produced by the end of each 2-min component. Daily sessions typically began with one of two concurrent-reinforcement components (components in first or third columns of Table 1). Through Session 80, sessions consisted of 12 cycles (96 min) of four regularly repeating 2-min components; after Session 80 they consisted of nine cycles (72 min).

After preliminary training, single-key schedules were introduced in which three 2-min components of VI reinforcement in the presence of one stimulus alternated with one 2-min component of EXT in the presence of another stimulus; the right-key stimuli were respec-

tively red and green, and the left-key stimuli were amber and blue. In the basic concurrent procedure, these two schedules were combined so that the 2-min EXT component for either key occurred during the second of the three 2-min VI components for the other key. Thus, 2-min periods of concurrent responding (VI VI) alternated with 2-min periods of single-key responding (VI EXT or EXT VI). This procedure was arranged for a total of 184 non-consecutive sessions. At various points in this sequence of sessions, as indicated in Table 1, effects of the concurrent VI stimuli, VI reinforcers, and VI responses were examined by introducing the following additional conditions: one key's VI stimulus and schedule were eliminated (dark-key right and dark-key left); signalled VI reinforcement was substituted for one key's standard VI schedule (signalled right and signalled left); and, reinforcement was discontinued in the presence of one key's former VI stimulus (extinction right and extinction left). Exposure to the first two conditions was relatively brief, because these procedures produced their effects rapidly; exposure to the last condition lasted 19 (extinction right) or 20 (extinction left) sessions.

Table 1

Summary of procedures. Session numbers begin with preliminary training (12 sessions of VI 1-min reinforcement, red right key). Components recycled regularly in the order shown. Entries show schedules (VI—3-min variable-interval; SVI—signalled 3-min variable-interval; EXT—extinction) and the key-colors with which they were correlated (red; gr—green; amb—amber; bl—blue; dk—dark key); in SVI, the dark key changed to the appropriate color when reinforcement had been scheduled for the next peck on that key. Details in text.

Procedure	Key	Successive 2-min components				Sessions
Single-key	Right	VI red	VI red	VI red	EXT gr	13-36, 55-59
Single-key	Left	VI amb	EXT bl	VI amb	VI amb	37-53
Concurrent	Left	VI amb	EXT bl	VI amb	VI amb	60-316 ¹
	Right	VI red	VI red	VI red	EXT gr	
Dark-key right	Left	VI amb	EXT bl	VI amb	VI amb	144-145, 179-180, 214-215, 219-220
	Right	EXT dk	EXT dk	EXT dk	EXT gr	
Dark-key left	Left	EXT dk	EXT bl	EXT dk	EXT dk	149, 166-171, 193-197, 226-227, 232-234
	Right	VI red	VI red	VI red	EXT gr	
Signalled right	Left	VI amb	EXT bl	VI amb	VI amb	216-218
	Right	SVI dk → red	SVI dk → red	SVI dk → red	EXT gr	
Signalled left	Left	SVI dk → amb	EXT bl	SVI dk → amb	SVI dk → amb	228-231
	Right	VI red	VI red	VI red	EXT gr	
Extinction right	Left	VI amb	EXT bl	VI amb	VI amb	265-283
	Right	EXT red	EXT red	EXT red	EXT gr	
Extinction left	Left	EXT amb	EXT bl	EXT amb	EXT amb	291-310
	Right	VI red	VI red	VI red	EXT gr	

¹Sessions 60 to 143 were consecutive; subsequent sessions through Session 316 exclude those listed elsewhere in the table. In addition, Session 263 alternated only the two concurrent components shown in the first two columns and Sessions 264 alternated only those shown in the last two columns (*cf.* Figure 2).

RESULTS

The basic procedure and some properties of the concurrent performances it generated are illustrated by Pigeon 320's cumulative records in Figure 1. During left-key-only performance, VI responding (amber) alternated with a near-zero rate of EXT responding (blue). During right-key-only performance, VI responding (red) similarly alternated with near-zero EXT responding (green). In the first session with both keys concurrently available, most VI responding occurred on the left key; VI responding occurred on the right key mainly during the left-key EXT stimulus (blue). Within the segment shown, right-key VI responding during concurrent left-key VI reinforcement gradually increased. In subsequent concurrent performance, illustrated by the

lower-right segments, the records became similar to those obtained earlier when the keys were only available separately (except that absolute response rates were somewhat lower). Concurrent responding, when both VI schedules operated, alternated with single-key responding, when one key's VI schedule operated together with EXT on the other key. The rate of concurrent responding on a given key was roughly the same as the single-key rate, during the other key's EXT stimulus.² (The

²Strictly, concurrent responding may occur even when EXT is scheduled for one of the two keys, but for the present purposes it is convenient to distinguish response rates on one key on the basis of the schedule operating for the other key. Thus, rates will be referred to either as concurrent, maintained during reinforcement of pecks on both keys, or single-key, maintained during the other key's EXT schedule.

Fig. 1. Sample segments from cumulative records of Pigeon 320's performance during single-key schedules (LEFT ONLY, Session 54, and RIGHT ONLY, Session 59), the first opportunity for concurrent responding (Session 60), and concurrent responding after a substantial history (Session 200). For each key, the recorder pen was in its normal position during VI components and displaced downward during EXT components; each key's record shows only the reinforcers produced by pecks on that key. Note the crossover of the left-key and right-key records during the first concurrent session. Additional details in text.

middle of the right-key record also shows a brief period of high-rate responding immediately after the onset of the left-key EXT stimulus; although no quantified assessment of its frequency is available, this response pattern was not unusual, and it therefore may have contributed to some of the response-rate differences discussed below.)

The approximate constancy of one key's rates during the alternation of VI responding and near-zero rates on the other key is illustrated further in the more extended portion of a session in Figure 2. In this session (*cf.* Table 1 footnote), the left-key VI schedule (amber) operated continuously while the right-key schedule alternated between VI (red) and EXT (green). The record is similar to those obtained with analogous concurrent schedules that included a COD (*cf.* Catania, 1963, Figure 1), except for the absence of the steplike grain that is typically produced when a COD operates for concurrent responding. With the present procedure, the alternation on one

key of its responses and pauses during other-key responses occurred at too high a rate to be resolved by the cumulative recorder, so that such steplike grain was not produced by concurrent VI responding.

Figure 3 provides quantitative data from the performance of each pigeon. The first two columns of histograms show response rates in each 2-min component averaged over the last five sessions of left-key-only and right-key-only responding. Responding did not vary systematically across the three VI components on either key. The third column of histograms shows response rates averaged across the first five sessions of exposure to the concurrent procedure. The highest VI response rate on either key occurred during the other key's EXT stimulus; concurrent response rate on a key was typically about half the single-key rate. The concurrent procedure also reduced each pigeon's EXT responding on both keys. The last column shows response rates averaged across the last five of 84 consecutive sessions of

Fig. 2. Concurrent cumulative records from a portion of Session 264 for Pigeon 320 (*cf.* Table 1 footnote). On the left key, a VI schedule (amber) operated continuously; on the right key, a VI schedule (red) alternated with EXT (green). Both recorder pens reset to baseline simultaneously; details as in Figure 1 (see also Catania, 1961, Figure 1).

the concurrent procedure. During these sessions, rates of changeover during concurrent responding (one direction) were 27 per minute for Pigeon 277, 22 per minute for Pigeon 319, and 46 per minute for Pigeon 320. The difference between single-key and concurrent VI response rates had diminished, although single-key rates tended to remain somewhat higher than concurrent rates (except for Pigeon 319, right key). In all cases, this change came about through reductions in single-key response rates, rather than through increases in concurrent response rates (*cf.* third and fourth columns). Variable-interval response rates on both keys were lower in the concurrent procedure than in the procedures with either key alone.

Over the course of the concurrent sessions illustrated in Figure 3, responding on a given key approached rate constancy, but it was at-

tained in only one case (Pigeon 319, right key). Over later sessions of the concurrent procedure, each pigeon's responding on one or both keys continued to approach rate constancy more or less closely, but increased deviations from constancy occurred from time to time. Such deviations usually continued for several sessions, and were typically in the direction of higher single-key than concurrent VI rates (an exception was Pigeon 277's right-key responding, for which single-key rates were once lower than concurrent rates for 16 consecutive sessions; at one point, the most extreme observed during the experiment, single-key responding occurred at two-thirds the rate of concurrent responding.)

The approach to rate constancy can be represented conveniently in terms of the ratio between single-key and concurrent response rates; when these two rates are equal, this sta-

Fig. 3. Histograms of left-key and right-key response rates during successive 2-min components. Each row shows data from a single pigeon, averaged across the blocks of sessions indicated along the top; procedures are summarized along the bottom. The two left histograms show response rates during the last five sessions each of left-key-alone and right-key-alone procedures. The two right histograms respectively show rates during the first and the last five of 84 consecutive sessions of the concurrent procedure. Shaded areas show response rates maintained on a key during its EXT stimulus. Note the displacement of the left-key and right-key histograms (respective scales at left and right). Table 1 provides schedule and key-color details.

tistic equals 1.00. Table 2 presents frequency distributions of this statistic for each key and each pigeon within blocks of 10 sessions at various stages of the experiment. During initial exposure to the concurrent schedule (Sessions 60 to 69), most single-key response rates were considerably higher than concurrent response rates (ratios greater than 1.40 in Table 2). After about 40 sessions (Sessions 97 to 106), this difference decreased (shift of distributions to the left in Table 2); for Pigeon 277, single-key rate on the right key was within 10% of concurrent rate in eight of 10 sessions. After about 40 additional sessions (Sessions 134 to 143), the difference decreased still more, except for Pigeon 320's right-key responding. Other procedures interrupted subsequent additional sessions (Sessions 183 to 192, 204 to 213, 253 to 262; *cf.* Table 1); rate constancies were only variably approximated during these sessions. Pigeon 277's single-key rates tended to remain more than 10% greater than concurrent rates on the left key; on the right key, rate constancies were closely approximated except during the last block of sessions. Pigeon 319's left-key responding continued to approach constancy, except during the next-to-

last block of sessions, when all single-key rates were more than 40% greater than concurrent rates; on the right key, the rate constancies that had occurred in earlier sessions were not maintained. For Pigeon 320, left-key performance began to deviate from rate constancy during these later sessions and right-key performance closely approximated constancy in the last block of sessions.

For each pigeon, rate constancies were obtained on one or the other key for at least some blocks of sessions, though they tended not to occur on both keys at the same time. The present data do not allow the effects of continued exposure to the basic concurrent procedure to be distinguished from those of the other procedures that were interpolated. The data that follow show the results of those procedures.

Figure 4 illustrates the effects of discontinuing VI reinforcement of right-key pecks. Right-key responding decreased more concurrent with the left-key VI stimulus than concurrent with the left-key EXT stimulus. Thus, it appears unlikely that right-key responding was incidentally maintained by left-key reinforcers.

Table 2

Frequency distributions of the ratio between single-key and concurrent response rates within 10-session blocks. Numbers in parentheses show cumulative sessions of the basic concurrent procedure. Through Session 143, sessions of this procedure were consecutive; thereafter, other procedures intervened between successive blocks of sessions (*cf.* Table 1). Details in text.

$\frac{\text{Single-key rate}}{\text{Concurrent rate}}$ (class intervals)		Left key					Right key				
		<1.11	1.11-1.40	1.41-1.70	1.71-2.00	>2.00	<1.11	1.11-1.40	1.41-1.70	1.71-2.00	>2.00
Pigeon	Sessions										
277	60-69 (1-10)	0	0	2	5	3	0	0	4	3	3
	97-106 (38-47)	0	0	8	2	0	8	2	0	0	0
	134-143 (75-84)	1	5	4	0	0	7	3	0	0	0
	183-192 (113-122)	2	8	0	0	0	10	0	0	0	0
	204-213 (129-138)	1	4	5	0	0	10	0	0	0	0
	253-262 (162-171)	3	7	0	0	0	0	5	5	0	0
319	60-69 (1-10)	0	0	5	4	1	0	6	1	3	0
	97-106 (38-47)	0	1	3	6	0	3	4	3	0	0
	134-143 (75-84)	0	8	2	0	0	6	3	1	0	0
	183-192 (113-122)	1	9	0	0	0	0	5	5	0	0
	204-213 (129-138)	0	0	6	2	2	1	9	0	0	0
	253-262 (162-171)	5	5	0	0	0	0	0	1	6	3
320	60-69 (1-10)	0	0	3	4	3	0	2	5	3	0
	97-106 (38-47)	0	1	5	4	0	2	7	1	0	0
	134-143 (75-84)	4	6	0	0	0	1	8	1	0	0
	183-192 (113-122)	5	5	0	0	0	0	8	2	0	0
	204-213 (129-138)	2	8	0	0	0	0	5	5	0	0
	253-262 (162-171)	0	8	2	0	0	10	0	0	0	0

Fig. 4. Concurrent cumulative records from a portion of Session 271 for Pigeon 319 (seventh session of EXT in the presence of red, the former right-key VI stimulus). On the left key, VI reinforcement (amber) alternated with EXT (blue); the pen was displaced downward during blue. On the right key, EXT in the presence of red alternated with EXT in the presence of green; the pen was displaced downward during green. Details as in Figures 1 and 2.

Figure 5 illustrates the effects of substituting either a dark key correlated with EXT or signalled VI reinforcement for the right-key VI stimulus. The first pair of records shows concurrent performance during the original procedure. The second pair of records shows that left-key VI responding was not appreciably affected when EXT correlated with a dark key replaced the right-key VI stimulus; left-key EXT responding, however, increased substantially. The third pair of records shows that subsequent introduction of signalled VI reinforcement on the right key reduced left-key VI responding, but did not reduce the increased rate of left-key EXT responding. Thus, lower left-key EXT rates occurred during right-key responding than during its absence, but the presence or absence of right-key reinforcers was without any obvious effect.

The histograms in Figure 6 summarize these results. When VI reinforcement was discontinued during either key's VI stimulus, response rate on this key was typically lower during VI responding on the other key than during EXT on the other key (first two columns of histograms). Right-key EXT for Pi-

geon 277 (first column) provided an exception; for this pigeon, the higher right-key rate during left-key VI responding than during left-key EXT might argue that right-key responding had come under the control of left-key reinforcers. When dark-key EXT or signalled VI reinforcement was substituted for either key's VI reinforcement schedule (last two columns of histograms), other-key EXT responding typically increased (for Pigeon 320, this effect cannot be seen in Figure 6 because EXT response rates were too low in these conditions to be plotted in the histograms). Relative to effects of dark-key EXT, signalled VI reinforcement had no consistent effect on other-key EXT responding but consistently reduced the rate of other-key VI responding (dashed *versus* solid histograms in third and fourth columns of Figure 6).

DISCUSSION

Rate constancies were maintained only some of the time on one or the other key for each pigeon. Nevertheless, to the extent that some close approximations to rate constancy were

Fig. 5. Segments of cumulative records from Sessions 213, 215, and 217 for Pigeon 277. The left pair of records shows concurrent performance under the basic procedure (*cf.* Figure 1). The middle pair shows the effect of substituting a dark key correlated with EXT for red, the right-key VI stimulus. (Because right-key responding was infrequent under this condition, a portion of the right-key record is omitted). The right pair shows the effect of introducing signalled VI reinforcement into the right dark-key condition; whenever a reinforcer was scheduled for the next right-key peck, that key changed from dark to red. This procedure provided right-key reinforcers at least as often as the basic procedure (left), but, like the EXT procedure (middle), maintained insubstantial rates of right-key responding. The left-key record was displaced downward during blue (EXT), and the right-key record during green (EXT); additional details as in Figures 1, 2, and 4.

obtained, the present research demonstrated the feasibility of producing rate constancies in concurrent performances without CODs. Rate constancies, however, are not the only criterion, or even a necessary one, for the independence of concurrent performances. For example, time is spent in responding on each of two keys during concurrent responding, whereas time is spent almost exclusively in responding on one key during single-key responding. If a failure to obtain rate constancies simply depends on the time available for responding on one or two keys, and not on the control of one response by the other response's reinforcers, responses would be independent with respect to their reinforcement schedules, but not independent with respect to their competition for the available time. It may therefore be relevant that closer approximations to rate constancy were obtained concurrent with other-key signalled VI reinforcement in the near absence of other-key responding (third and fourth columns of Figure 6) than concurrent with both other-key VI

reinforcement and other-key VI responding (fourth column of Figure 3).

It is also important to show that neither response is under the control of the other response's reinforcer. In the present experiment, this was demonstrated by substituting EXT for either key's VI schedule. In Figure 6 (second column only for Pigeon 277, and first two columns for Pigeons 319 and 320), the higher response rates during other-key EXT than during other-key VI reinforcement not only indicated that the reinforcers on one key were not maintaining responses on the other key, but also suggested that these reinforcers contributed to reducing responses on the other key during EXT. The effects may be summarized as follows: EXT responding on one key was reduced by other-key responding but was not reduced by other-key reinforcement, whereas reinforced responding on one key was reduced by other-key reinforcement but was not reduced by other-key responding (see also Catania, 1963, 1966, p. 259; 1969; *cf.* Herrnstein, 1970, on r_o).

Fig. 6. Histograms of left-key and right-key response rates during successive 2-min components for each pigeon. The histograms in the left half of the figure show the effect of extinguishing responding in the presence of one key's former VI stimulus. The histograms in the right half show the effect of substituting a dark key for one key's VI stimulus (solid histograms) or of substituting signalled VI reinforcement superimposed on a dark key (dashed histograms: the key changed from dark to the VI color whenever a reinforcer had been scheduled for the next peck on that key). Details as in Figure 3.

Responding is said to be superstitiously maintained when it can be shown that it depends on accidental correlations between responses and reinforcers (Skinner, 1948). In the simplest case, the response happens to be followed by an independently presented reinforcer, but other types of accidental correlations can also occur (e.g., Catania and Cutts, 1963; Herrnstein, 1966; Morse and Skinner, 1957). Accidental correlations, and therefore the opportunity for the development of superstitions, are almost inevitable in any behavioral procedure, and yet the phenomenon of superstition is not ubiquitous (Staddon and Simmelhag, 1971). As suggested by Herrnstein (1966, pp. 42-43), this may be because accidental correlations are likely to be more variable than those that are explicitly scheduled; it is reasonable to assume that organisms can be sensitive to the difference between situations in which their responses have consequences and situations in which their responses just happen to be followed by particular environmental events. The present

procedure, by alternating concurrent and single-key reinforcement, presumably prevented the development of concurrent superstitions by increasing the variability with which reinforcers followed particular sequences of responses on one or both keys. If this is correct, varying durations or orders of the concurrent components might have been even more effective. A corollary of the finding that superstition can be circumvented even when one response can be closely followed by another response's reinforcer (i.e., without a COD) is that the close temporal proximity of responses and reinforcers is not a sufficient condition for invoking the concept of superstition as an explanation for responding.

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