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EFFECTS OF RESPONSE VARIABILITY ON THE SENSITIVITY OF RULE-GOVERNED BEHAVIOR

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Two experiments examined the relation between response variability and sensitivity to changes in reinforcement contingencies. In Experiment 1, two groups of college students were provided complete instructions regarding a button-pressing task; the instructions stated "press the button 40 times for each point" (exchangeable for money). Two additional groups received incomplete instructions that omitted the pattern of responding required for reinforcement under the same schedule. Sensitivity was tested in one completely instructed and one incompletely instructed group after responding had met a stability criterion, and for the remaining two groups after a short exposure to the original schedule. The three groups of subjects whose responding was completely instructed or who had met the stability criterion showed little variability at the moment of change in the reinforcement schedule. The responding of these three groups also was insensitive to the contingency change. Incompletely instructed short-exposure responding was more variable at the moment of schedule change and was sensitive to the new contingency in four of six cases. In Experiment 2, completely and incompletely instructed responding first met a stability criterion. This was followed by a test that showed no sensitivity to a contingency change. A strategic instruction was then presented that stated variable responding would work best. Five of 6 subjects showed increased variability after this instruction, and all 6 showed sensitivity to contingency change. The findings are discussed from a selectionist perspective that describes response acquisition as a process of variation, selection, and maintenance. From this perspective, sensitivity to contingency changes is described as a function of variables that produce response variability.

Key words: rule-governed behavior, contingency-shaped behavior, response variability, selectionism, button press, college students

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Skinner (1969) distinguished behavior acquired through direct exposure to environmental consequences, or contingency-shaped behavior, from behavior acquired through verbal descriptions of contingencies, or rule-governed behavior. Contingency-shaped behavior is controlled by contingencies of reinforcement for the particular response. Rule-governed behavior may be topographically identical to behavior controlled directly by environmental reinforcement contingencies, but because the rule-governed response is in part maintained by the social contingencies for rule following (Hayes, Brownstein, Haas, & Greenway, 1986), the two responses are controlled by different variables. This is the basis for the distinction between rule-governed and contingency-shaped behavior.

One feature that rules and contingencies have in common is that they often restrict the variability of behavior (Andronis, in press). For example, if a college student is given a rule that states, "rapid button pressing will earn money," a high rate of button pressing will likely follow. If that high rate of responding is then reinforced, it will persist and alternative response patterns will be less likely to occur. In the same situation, but without a rule, button pressing may occur in a variety of ways and eventually contact reinforcement. Continued contact with reinforcement may restrict variability of the response, thereby selecting a particular behavior pattern.

The example above suggests that rules and contingencies may differ in how they restrict response variability. For example, the rapid acquisition of a rule-governed response relative to responses acquired through exposure to contingencies (Ayllon & Azrin, 1964; Baron & Kaufman, 1966) indicates that subjects' preexperimental histories of reinforced rule following are responsible for behavior similar

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to that called for by the instruction. Instructions combine elementary discriminative stimuli that can produce complex novel responses without prior exposure to direct contingencies of the instructed response (Cerutti, 1989). Therefore, following an instruction allows a previously established repertoire to contact reinforcement quickly without extensive exposure to the reinforcement contingency. In contrast, behavior shaped directly by contingencies may initially show a high level of variability, and a relatively long exposure to contingencies may be required before an effective response pattern is selected.

Another difference identified between rule-governed and contingency-shaped behavior is that rule-governed behavior is less likely than contingency-shaped behavior to change when the prevailing environmental contingencies for the behavior change (Galizio, 1979; Kaufman, Baron, & Kopp, 1966; Matthews, Shimoff, Catania, & Sagvolden, 1977; Shimoff, Catania, & Matthews, 1981). Much research from human operant laboratories has focused on identifying the variables that produce this "insensitivity" to contingencies (Galizio, 1979; Hayes, Brownstein, Zettle, Rosenfarb, & Korn, 1986; LeFrancois, Chase, & Joyce, 1988; Shimoff et al., 1981; Shimoff, Matthews, & Catania, 1986; Weiner, 1964, 1969). None of these studies, however, has investigated the possibility that insensitivity to changing contingencies is due to the lack of variability produced by the rules that have been manipulated. These rules or instructions can be characterized as describing the complete form of the response; both the topography (e.g., button pressing) and the pattern of responding (e.g., rapid button pressing) are specified. Perhaps rules that allow for variability, particularly at the moment of contingency change, are more likely to produce responding that is sensitive to the changing contingencies.

The following experiments addressed this possibility by seeking answers to the following questions: First, will responding that is stable (i.e., meets a stability criterion) be relatively less sensitive to contingency changes than is variable responding? Second, will this sensitivity occur regardless of whether the instruction completely specifies the form of responding included in the contingency? Third, can instructions about responding variably function to increase the sensitivity of stable responding to contingency changes?

EXPERIMENT 1

METHOD

Subjects

Nineteen undergraduate students, 9 females and 7 males ranging in age from 18 to 24, served as subjects. All subjects were enrolled in introductory psychology classes.

Apparatus

An Apple II Plus® computer placed on a table in a windowless room that measured 2.39 m by 2.58 m was used to arrange contingencies, provide instructions to subjects, count responses and reinforcers earned, and time the length of schedules. Schedules were programmed by software that enabled presentation of different instructions and schedule parameters. The software also enabled recording of the number of responses emitted per second and the time of each response in milliseconds. Two buttons served as operanda, one for earning points (marked "Earn") and one for registering points (marked "Register"). The buttons operated with a force of 3.08 N. When a point was earned, a computer "beep" occurred, after which a press on the register button incremented a number on the screen, signifying the total number of reinforcers earned during that session. A cumulative recorder, placed in an adjacent room, recorded the earn responses. Extraneous noises and the sound of the cumulative recorder were masked by two ceiling fans.

Procedure

Subjects in Experiment 1 were randomly assigned to one of four experimental groups: complete instructions with a stability criterion (CI-stable), complete instructions without a stability criterion (CI-short exposure), incomplete instructions with a stability criterion (II-stable), and incomplete instructions without a stability criterion (II-short exposure). The term *complete* was used because, in addition to describing the stimuli and the contingencies, the specific form of the response was described; subjects in these groups were instructed to "Press the earn button 40 times for each point."

Table 1

General instructions presented to all subjects.

Introductory instructions:

Welcome to the human behavior lab!!! Get comfortable and when you are ready to read the general instructions, press the space bar.

In order to earn points, you must press the "earn" button. You will hear a beep when you have earned a point. In order to have the point register, press the "register" button. So, as soon as you have earned a point, register it! Press the space bar to continue. Now you are ready to begin the session. Your job is to earn and register as many points with the least effort possible. You will be paid 1 cent for each registered point. Press the space bar to continue.

Here is an instruction for you to follow: [either complete or incomplete instruction, depending on condition]

Final instruction after test phase:

Good job! This portion of the session is over. You earned *x* cents. Please wait here until Jim or one of the assistants comes for you. . . . Thanks!

Table 2

Experimental design for Experiment 1.

Group	Training	Test
Incomplete instruction (II)		
Stable ($n = 4$)	FR 40 to stability	4 sessions
Short exposure ($n = 6$)	No training condition	4 sessions
Complete instruction (CI)		
Stable ($n = 4$)	FR 40 to stability	4 sessions
Short exposure ($n = 5$)	No training condition	4 sessions

Note. For 3 subjects in each group the four test sessions consisted of exposure to the FR 40 schedule until six reinforcers had been earned, followed by 15 min of responding under an FI 10-s schedule. One subject in each group participated in one test session as described above, followed by three test sessions consisting only of 15 min of exposure to the FI 10 s schedule. Three subjects (2 II-short exposure and 1 CI-short exposure) were exposed to the FR 40 schedule until two reinforcers had been earned.

In contrast, the incomplete instructions did not specify the pattern of responding that would produce reinforcers. This feature of responding was allowed to be produced by the contingencies. Therefore, fixed-ratio 40 (FR 40) responding was established either by instructions or by differential reinforcement, and responding either met a stability requirement or not prior to the contingency change. Table 1 presents the instructions given to all subjects.

In all conditions, reinforcement consisted of points exchangeable for money with each point earned entitling the subject to $0.01. Subjects also received a bonus of $0.50 for each day of attendance, which was paid at the end of the experiment. The total amount earned approximated the minimum hourly wage of $3.35. At the beginning of each session, all subjects were given general instructions regarding the computer and operanda. The general instructions are presented in Table 1. Sessions lasted approximately 20 min, and no more than three sessions were conducted in one day.

Training condition. Table 2 presents the experimental conditions for each group. Only the two stable responding groups participated in the training condition. In this condition, a button-press response first was established under an FR 40 schedule of reinforcement. Sessions of responding under the FR 40 schedule were conducted until the following stability criterion was met; response rates during the last 2 min of three consecutive sessions could not differ by more than 10% of the mean of those three sessions, and there was no trend (either increasing or decreasing) in response rates across the last 2 min of the three sessions.

Tests of sensitivity. All four groups participated in four sessions in which sensitivity to a fixed-interval (FI) 10-s schedule was tested. The two stability groups began this condition in the session after responding had met the stability criterion. The two nonstability groups received this as their initial condition. The two incomplete instruction groups were given the minimal instruction: "It is up to you to figure out how best to earn points." The two complete instruction groups were given the instruction: "Press the earn button 40 times for each point." Subjects were then exposed to the FR 40 schedule until six reinforcers had been earned, followed by 15 min of exposure to the FI 10-s schedule. No stimulus change accompanied the change in the reinforcement contingency. For 3 subjects in each group, four sessions were conducted with this unsignaled switch from FR 40 to FI 10-s. In order to test for any possible effects of switching from FR 40 to FI 10 s many times, 1 subject in each group had the unsignaled switch during the first session and then the FI 10-s schedule was continued

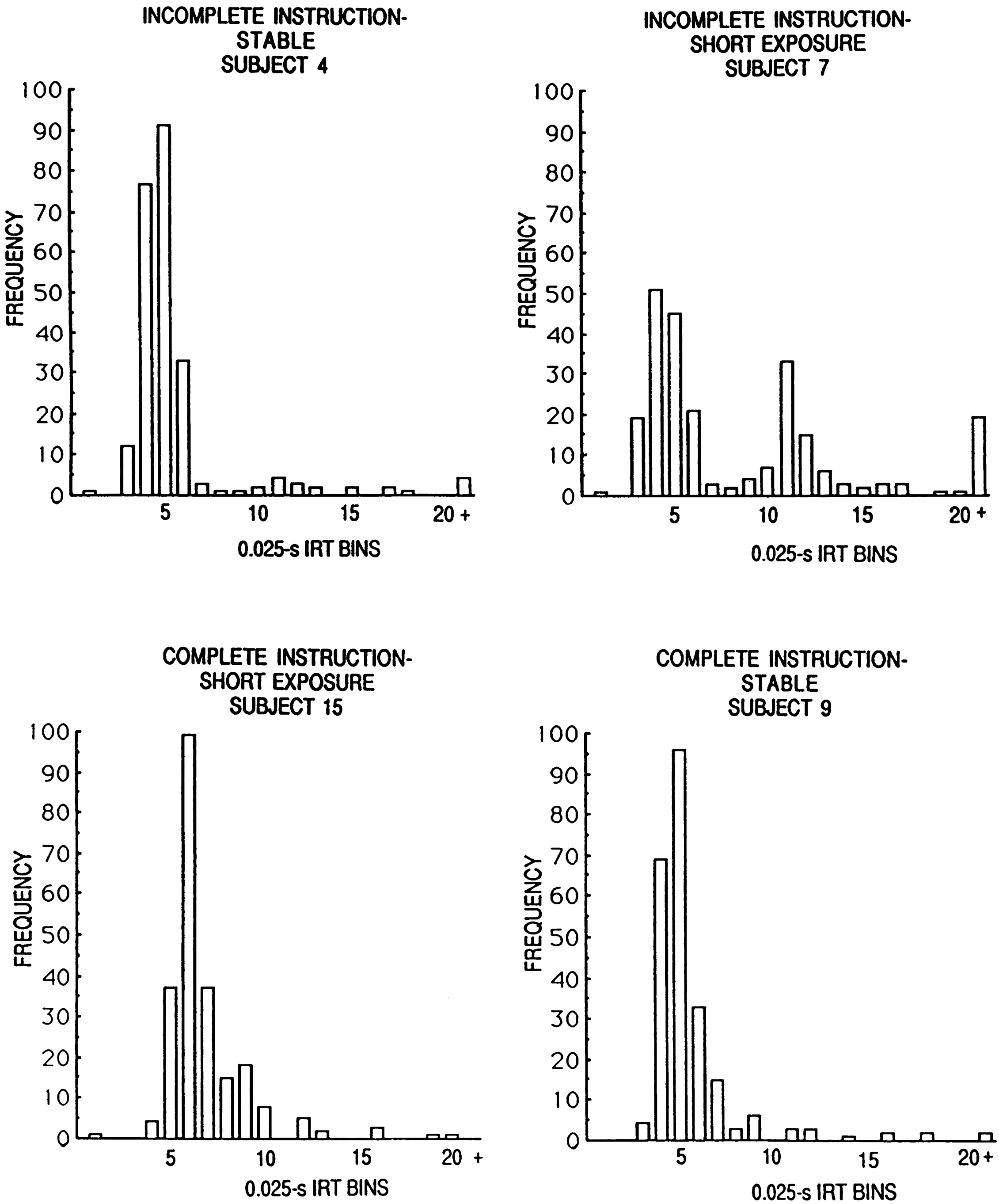

Fig. 1. Representative IRT distributions of first sensitivity test sessions for S4 (II-stable), S7 (II-short exposure), S9 (CI-stable), and S15 (CI-short exposure). IRTs were measured during the FR 40 component of the session. Bin 1 represents IRTs 0.075 s or smaller. Bin 20 represents IRTs 0.525 s to 0.55 s. The bin labeled "+" shows the frequency of IRTs longer than 0.55 s.

for three additional complete sessions. To provide an even shorter exposure to reinforcement and, therefore, increase the likelihood that behavior was variable, 3 subjects (2 in the incomplete instruction group and 1 in the complete instruction group) were exposed to the FR 40 until only two reinforcers were earned and then were switched to the FI 10-s schedule for 15 min.

Measures of efficiency and variability. A measure of the efficiency of responding under the FI 10-s schedule was determined for each test session. This was calculated by dividing the number of responses in the last 5 min of the FI 10-s schedule by the total number of reinforcers available during that 5-min period (30). Under an FI schedule, perfectly efficient responding is one response per available reinforcer. Therefore, ratios higher than one indicate responding at higher rates than necessary to earn maximum reinforcement and ratios lower than one indicate responding too slow to earn maximum reinforcement.

The variability of responding in test sessions was assessed by calculating the distribution of interresponse times (IRTs) for responding in the FR 40 reinforcement schedule and plotting a continuum of IRT bins that graphically show the distribution of IRT lengths.

Table 3

Efficiency ratios for each session of Experiment 1.

Group		Session 1	2	3	4
II-stable	S1	46.43	45.40	46.17	40.70
	S2	46.80	42.23	48.60	42.90
	S3	53.67	48.67	48.33	45.30
	S4	50.17	51.07	51.70	47.23
	M	49.27	46.84	48.70	44.03
II-short exposure	S5	20.30	2.80	12.80	17.33
	S6	55.97	50.30	24.20	54.37
	S7	1.20	6.93	18.53	5.30
	S8	45.43	44.90	4.63	42.87
	S23[a]	22.60	1.13	.90	1.10
	S24[a]	14.96	12.17	2.27	2.87
	M	26.74	19.71	17.22	20.64
CI-stable	S9	49.27	47.00	52.20	50.53
	S10	35.43	36.40	38.33	39.47
	S11	54.67	55.43	42.23	52.80
	S12	51.67	57.80	55.70	56.77
	M	47.76	49.16	47.12	49.89
CI-short exposure	S13	39.53	44.33	45.07	47.47
	S14	35.57	40.77	38.67	27.97
	S15	32.00	36.53	39.63	41.90
	S16	34.57	40.17	40.47	40.47
	S25[a]	26.83	34.23	37.77	37.97
	M	33.70	39.21	40.32	39.15

Note. Group abbreviations as in Table 2.

[a] These subjects were exposed to the FR 40 for two reinforcers. All others were exposed to the FR 40 for six reinforcers during the test.

RESULTS

Variability

Measures of response variability prior to the contingency change, represented by the IRT distributions presented in Figure 1, show differences in variability between S7 and the other subjects. The responding of S7 was selected for illustration because it was the least variable of subjects in the II-short exposure group with a standard deviation of IRTs of 0.27 s. Standard deviations of IRTs of the other subjects in this group were 5.31 s for S5, 1.91 s for S6, and 0.79 s for S8. The IRT distributions for the other groups were similar, and those selected were typical for that group. Rather than a peaked gradient, the distribution of IRTs for S7 is flatter and somewhat bimodal with a higher frequency of long IRTs.

Efficiency

Ratios of responses per available reinforcer are presented in Table 3. No subject in the two stability trained groups or the CI-short exposure group responded efficiently under the FI 10-s schedule in the first or subsequent test sessions. Instead, the high response rates exhibited under the FR 40 schedule persisted for the remainder of the session. In contrast, the responding of 4 II-short exposure subjects (S5, S7, S23 and S24) showed more efficient patterns throughout the test sessions.

Two subjects in the II-short exposure group did not respond efficiently under the FI 10-s schedule. In both cases, however, response variability rapidly decreased after reinforcement was initially contacted. The standard deviation of IRTs measured over the last four FR reinforcers was 0.10 and 0.09 for these 2 subjects, showing stability of responding at the point of the contingency change comparable to responding of subjects that had met the stability criterion.

DISCUSSION

Experiment 1 demonstrated that, once an effective pattern of responding had become stable, either by sufficient exposure to the contingencies or by instructions, it was insensitive to changes in contingencies. In addition, 4 of 6 subjects who received incomplete instructions and only a brief exposure to the FR contingencies did change their responding under the FI 10-s schedule, and each of these subjects had more variable performances before the change than subjects who continued to respond at high rates. This finding suggested that sufficient variability of responding that allows different patterns of behavior to contact reinforcement may be involved in the sensitivity of instructed behavior to changes in contingencies.

One question that this experiment did not answer was whether completely instructed responding could be sensitive to changing contingencies if responding was variable at the time of the contingency change. This question was not answered because of an inability to produce variable responding through short exposures to the reinforcement schedule when the instruction described the complete response topography. Andronis (in press) has suggested that true instruction following may only occur during the period of responding prior to the first reinforcer. Once the instruction-following behavior is reinforced, the reinforcement contingency itself may control subsequent responding. The complete instructions provided to subjects in the present experiment enabled the first contact with reinforcement under the FR 40 schedule, which then produced high response rates. These high rates were also reinforced under the FI schedule, and, therefore, high-rate responding was maintained. This conceptualization of rules as enabling the first contact with reinforcement also describes the findings of Kaufman et al. (1966), who found that responding as instructed, which was reinforced, persisted despite the fact that the instructions did not accurately describe the prevailing reinforcement contingency.

A second problem with this experiment was that short exposure to the training contingencies was confounded with variability; thus, the relation between variability and sensitivity could not be assessed.

EXPERIMENT 2

Experiment 2 was designed to examine the relation between variability and sensitivity using conditions that did not confound length of exposure with variability and that produced variable performance under both kinds of instructions. Experiment 2 assessed whether responding that had met a stability criterion could then be made to increase in variability by providing an instruction to respond variably, and whether this responding would subsequently show increased sensitivity to a contingency change.

METHOD

Subjects

Six subjects, 3 males and 3 females ranging in age from 19 to 24 years old, served in Experiment 2. They were selected from introductory psychology classes and were randomly assigned to one of two experimental groups.

Apparatus and Procedure

The apparatus was the same as used in Experiment 1.

Training conditions. Responding of one half of the subjects (CI) was established with the explicit instruction for responding on the FR 40 schedule used in Experiment 1. The other subjects (II) received only the instruction indicated in Table 1. The pattern of responding was established under an FR 40 schedule of reinforcement. Sessions with FR 40 schedules continued for both groups until responding became stable. The stability criterion was the same as that used in Experiment 1.

Baseline sensitivity. After each subject's responding had met the stability criterion, a session was conducted to determine the baseline for sensitivity to changes in the reinforcement schedule. This test began with the FR 40 schedule until six reinforcers had been earned. Then the reinforcement contingency changed to an FI 10-s schedule that continued for 15 min.

Strategic instruction. After the test to assess sensitivity to the novel FI 10-s schedule, a session was conducted that began by presenting subjects with a strategy for determining whether they were "earning the most points with the least effort" and examples of both a ratio contingency and an interval contingency. The instruction stated:

> Your task is to earn the most points with the least effort. Sometimes the points will be delivered on the basis of how many button presses

Table 4
Experimental design for Experiment 2.

Group	Experimental conditions		
	Training condition	Baseline sensitivity	Instructed variability
II (3 subjects)	FR 40 to stability	FR 40, FI 10 s	Variability instruction, FR 40, FI 10 s
CI (3 subjects)	FR 40 to stability	FR 40, FI 10 s	Variability instruction, FR 40, FI 10 s

Note. The training condition lasted until stability of responding was achieved. The baseline sensitivity and instructed variability conditions lasted one session each. Each experimental condition was conducted twice. Group abbreviations as in Table 2.

> you make, for example, every 20 button presses may earn a point. At other times, points will be delivered on the basis of a passage of time, for example, if you respond once every 20 seconds, you may earn a point. The best way to figure out which system of point delivery is in effect is to vary your speed of responding until you reliably earn points with the least effort.

After this instruction was presented, subjects' responding was reinforced under the FR 40 reinforcement schedule until six reinforcers had been earned; this was followed by 15 min of responding under the FI 10-s schedule.

This test session was followed by a reversal to the training condition the subject had already received, in which no strategic instruction was presented. Responding was reinforced under an FR 40 schedule until responding was again stable. Stability during the reversal was achieved if responding in the first reversal session varied by less than 10% from the mean response rate from the baseline training condition. Following the reversal, a session was conducted to reassess baseline sensitivity to a novel schedule; this session was followed by another session in which the strategic instruction was presented. Table 4 presents the experimental conditions for both groups.

Results

Providing the strategic instruction effectively increased response variability in both groups of subjects. Prior to the strategic instruction session, IRT distributions for all 6 subjects peaked at approximately 0.125 s to 0.225 s during the first session; there were few IRTs longer than 0.55 s. when the strategic instruction was presented, the IRT distributions changed in five of six cases. Except for Subject 17, the peaked gradients typical of the baseline session were replaced by flatter or bimodal gradients and an increase in IRTs longer than 0.55 s.

The reduced variability in the second baseline sensitivity session was again evident in the sharp gradients of the IRT distributions. The gradients for most subjects peaked at approximately 0.125 s to 0.275 s, and the number of IRTs longer than 0.55 s decreased to baseline levels. Subject 17 continued to respond more variably than other subjects, with a larger number of long IRTs than in the previous strategic instruction session. The second presentation of the strategic instruction again produced flatter gradients and increased numbers of long IRTs, indicating more variable responding than in the baseline sessions.

Cumulative records showed differences in response variability during the baseline sensitivity and strategic instruction sessions. The cumulative records of Subject 22, presented in Figure 2, show the typical performances (all subjects except Subject 17) under these two conditions. High rates of responding persisted throughout the two baseline sensitivity sessions. However, in both sessions in which the strategic instruction was presented, response patterns were initially variable, characterized by alternating high and lower rates. In each case, efficient patterns under the FI schedule developed as the sessions progressed.

Efficiency

The efficiency ratios for the two baseline sensitivity and strategic instruction sessions are presented in Table 5. No subject in either group responded efficiently in the FI component of the initial baseline sensitivity session. This inefficiency was reflected in the high response to reinforcer ratios, which ranged from 31.91 to 57.29 in that session. However, in the first strategic instruction session, all 6 subjects' response rates decreased sharply under the FI

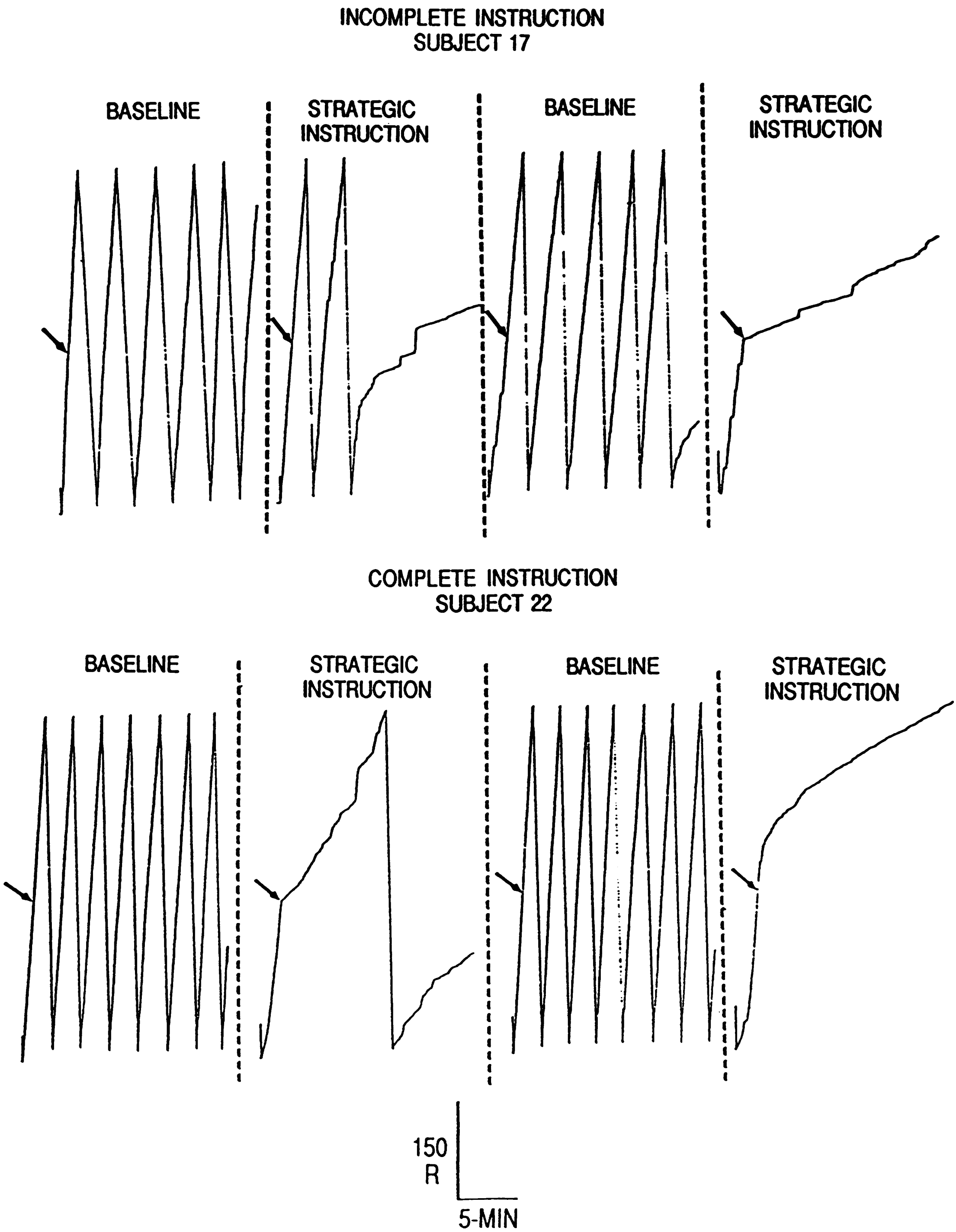

Fig. 2. Cumulative records showing representative performances in the baseline sensitivity and strategic instruction sessions. Records were obtained from sessions of Subject 22 (CI) and Subject 17 (II). Arrows mark the point of the contingency change from FR 40 to FI 10 s.

10-s schedule, and the efficiency ratios decreased to a range of 3.71 to 12.50 responses per reinforcer. The second presentation of the baseline sensitivity test produced a reversal in the efficiency of responding in all 6 subjects. Response-per-reinforcer ratios ranged from 27.97 to 63.81 in this session. The second presentation of the strategic instruction again produced responding that was efficient under the FI 10-s schedule.

Changes in the efficiency of responding in the two conditions were also reflected in cumulative records (see Figure 2). In the initial baseline sensitivity session, cumulative records showed persistent high response rates with no changes in patterns or rates that would indicate sensitivity to the FI 10-s schedule. However, after presentation of the strategic instruction, efficient response patterns developed. During the second baseline sensitivity session, efficiency was reversed in 4 of the 6 subjects (e.g., see Subject 22 in Figure 2). During the second strategic instruction session, efficient patterns under the FI schedule again developed.

Two subjects' cumulative records showed only a partial reversal of sensitivity during the second baseline sensitivity session. Cumulative records for Subject 17, presented in Figure 2, showed that this subject responded at high rates for approximately 14 min; responding then gradually decreased in the last 2 min of the session. Subject 18 also showed a partial reversal in the second baseline sensitivity session. This subject responded at a high rate for approximately 10 min and then suddenly shifted to a more efficient response rate.

Correlation between Variability and Efficiency

Significant negative correlations were found between variability and efficiency across all test sessions, $r = -.468$, $p < .01$; in the last two sessions, $r = -.684$, $p < .007$; and in the final strategic instruction session, $r = -.87$, $p = .012$. (The correlations are negative because a lower efficiency number implies greater sensitivity.) Correlations between variability and efficiency in the initial baseline sensitivity and strategic instruction sessions were not significant.

Table 5

Efficiency ratios for each test session of Experiment 2.

Group		Condition: Baseline	Strategic instruction	Baseline	Strategic instruction
II	S17	31.91	12.50	27.97	1.70
	S18	56.81	7.92	35.82	6.91
	S19	46.30	4.79	52.32	2.11
	M	45.01	8.40	38.70	3.57
CI	S20	57.29	3.71	63.81	7.59
	S21	40.91	6.99	41.97	3.39
	S22	35.99	4.88	40.00	3.27
	M	44.73	5.19	48.59	4.75

Note. Response-per-reinforcer ratios were measured over the full 15 min of the FI 10-s component of the sessions. Group abbreviations as in Table 2.

Discussion

This experiment replicated the finding of Experiment 1 that stable instructed responding was insensitive to a contingency change regardless of whether the topography of the response was completely instructed or not. However, the major finding of this experiment was that variability could be increased by the use of a strategic instruction; subsequently, increased sensitivity to a change in a reinforcement contingency developed. After each of the 12 presentations of the strategic instruction, responding became efficient in the FI component of the session. Further, in 11 of those presentations, the increased variability was immediately evident (within the six-reinforcer FR 40 component). Although this experiment did not determine that the increased variability caused the increased sensitivity to the novel schedule, it did present evidence that response variability had a strong relation to sensitivity to changes in contingencies. When this evidence is combined with data from the first experiment, it appears that the relation between sensitivity and variability occurred whether variability was produced by short exposure to the initial training conditions or by instructions.

GENERAL DISCUSSION

The findings of these studies can be summarized as follows. First, when instructed responding was allowed to become stable, it was insensitive to changes in a reinforcement schedule; however, when responding was variable at the moment of contingency change, the responding was sensitive to the contingency change. Second, providing a strategic instruction increased response variability. Finally, both the increased variability and increased efficiency were reversed when conditions present in the initial sensitivity baseline were reinstated. These findings indicated that response variability plays an important role in contingency sensitivity and may account for some of the reported insensitivity of rule-governed behavior. We will discuss the significance of these findings in light of a selectionist perspective of rule governance.

A Selectionist Perspective of Rules

Donahoe (in press) describes a selectionist view of the development of behavior as a three-component process of variation, selection, and retention (see also Skinner, 1981). In this conceptualization, behavioral variation, or variability, is a result of an interaction among the organism's genetic history, environment, and reinforcement history. Given this variability, contingencies select particular responses from alternatives in accordance with the principles of reinforcement, and behavior is maintained in accordance with the principles of stimulus control. These three components provide a framework for analyzing discrepancies in research on rule governance and for integrating this research with studies of other behavioral phenomena.

Variability

Many factors influencing behavioral variability have been described. These include the morphological characteristics of the organism, establishing operations such as deprivation, behavior–consequence relations such as punishment, extinction (Layng, in press), and reinforcement contingent upon variability (Neuringer, 1986).

The present study demonstrated that instructions can produce variability. In Experiment 1, an instruction that did not specify the exact topography that leads to reinforcement produced variable responding (see also LeFrancois et al., 1988). Experiment 2 demonstrated that explicit rules to respond variably also can produce variable responding. Therefore, rules or instructions, as well as other environmental changes, can produce variability in behavior.

Selection

Selection by exposure to contingencies is characterized by a gradual shaping of a response from alternatives through interaction with the contingencies. Usually, rules do not select behavior in any pure sense. In order for rules to affect a response class, rule following itself first must be selected by reinforcement contingencies. This process results in a rule-following repertoire that enables responding to complex arrangements of discriminative stimuli in novel circumstances (Cerutti, 1989). Therefore, college-aged verbal subjects are likely to enter experiments with long histories of reinforcement for following rules in many different environmental contexts. If the experimental environment is similar to others in which rule following has been reinforced, the response occurs without direct contact with the experimental contingencies. The behavior may then be strengthened by subsequent consequences.

This was demonstrated consistently in the present experiments in the responding of subjects given the explicit FR 40 instruction. Responding at high rates began immediately, often before the initial reinforcer had been earned. This effect of rules was similar to other studies of rule-governed behavior (Hayes, Brownstein, Zettle, Rosenfarb, & Korn, 1986; Hayes, Brownstein, Haas, & Greenway, 1986; Kaufman et al., 1966; LeFrancois et al., 1988) and may be better described by maintenance processes.

Maintenance

Behavior analysts' current interest in the insensitivity of rule-governed behavior appears to be an interest in maintenance processes. The defining feature of insensitivity to contingencies is the maintenance of behavior after a contingency change. Rules have been targeted as a likely variable in producing responding that is maintained even when such changes have occurred. However, many other variables have been demonstrated to interact with rules to produce behavior that is insensitive to changes in contingencies (Galizio, 1979; Hayes, Brownstein, Zettle, Rosenfarb, & Korn, 1986; LeFrancois et al., 1988; Shimoff et al., 1981). For example, Galizio (1979) demonstrated that if responding did not come into contact with the change in contingencies then it would be maintained. When a loss contingency was suspended, responding as instructed continued, even though it was no longer necessary to avoid point loss.

Another variable that has been shown to affect the maintenance of responding after a contingency change is a history of alternative responses (LeFrancois et al., 1988). This was demonstrated by the maintenance of insensitive responding in subjects who had only reinforcement histories for high rates of responding and changes to sensitive responding in subjects having a history of response alternatives. Finally, the present study suggests that maintenance of behavior insensitivity is due to the stability of responding.

The maintenance of environment–behavior relations in the presence of environmental changes is not unique to human behavior. There are a number of examples in the nonhuman learning literature that have shown the maintenance of behavior even when the environment changes to make the response unnecessary. One example is found in the literature on operant blocking (e.g., vom Saal & Jenkins, 1970; Williams, 1975). When behavior previously has been reinforced in the presence of a stimulus, that stimulus may block a second stimulus from gaining control of responding. More recently, Wanchisen, Tatham, and Mooney (1989) showed that a history of variable-ratio responding interfered with sensitivity to FI responding in pigeons.

Summary

In summary, many variables have been cited for producing insensitivity to contingency changes. However, insensitivity is simply the maintenance of previously shaped or instructed behavior. To produce behavior that is sensitive to changes in contingencies, variation must occur. Variation occurs if the behavior is still in transition or if one of the variables that produce variation has occurred. If this variation produces an alternative response that makes contact with the current reinforcement contingencies, the contingencies will select the alternative and responding will be sensitive. The selectionist view, therefore, allows both rule-governed and contingency-shaped behavior to be described in terms of variation, selection, and maintenance.

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