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LOCAL TEMPORAL PATTERNING OF OPERANT BEHAVIOR IN HUMANS

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Button pressing by 44 college students intermittently produced points and the words "GOOD" or "POOR" on a computer screen. The events were arranged according to a paced random-interval 10-s schedule in which the target interresponse-time categories were 1 to 3, 3 to 5, or 6 to 12 s. The degree to which instructions specified certain aspects of the contingency (e.g., whether response spacing was critical) was also varied, and in some conditions the experimenter prompted specifically paced responses during the first 2 min of the session. The procedures shaped the local patterning of behavior of some subjects in less than 30 min of exposure to the contingencies. Most subjects who, in a postexperimental questionnaire, accurately identified the schedule contingencies also responded more accurately than those whose verbal descriptions were inaccurate or imprecise.

Key words: interresponse times, paced random-interval schedule, instructional control, button pressing, human adults

A sizable body of empirical and theoretical literature has developed on local temporal patterning in operant behavior of animals (Gibbon, 1977; Platt, 1979; Shimp, 1976, 1984). Research with human subjects on corresponding issues, however, lags behind, particularly so with interresponse-time (IRT) contingencies. A few studies have examined human behavior under differential-reinforcement-of-low-rate contingencies, under which each IRT longer than some criterion value produces some event of consequence (Lowe, Harzem, & Bagshaw, 1978; Shimoff, Catania, & Matthews, 1981). We know of only one study that has examined human performance under IRT contingencies in which responses terminating IRTs in some target class are subject to an intermittent schedule, such as variable-interval (VI) schedules (Wearden & Quinn, 1982). In that study, only IRTs either greater than or less than some value could produce reinforcers (points exchangeable for money) under a VI schedule. Behavior of 2 of the 3 subjects adapted to the contingencies in the rather crude sense that the effect of an IRT $> t$ rule was generally to slow responding, and an IRT $< t$ rule was to accelerate it. Little evidence of precise adjustment to the schedule parameter was found.

The present study examined human performance under contingencies that defined a target class of IRTs (e.g., between 3 and 5 s) within which an IRT had to fall if it was to fulfill the schedule requirement. Instead of conditioned reinforcers such as points exchangeable for money (e.g., Bradshaw, Szabadi, & Bevan, 1976) or for food (Buskist & Miller, 1981), the words "GOOD" or "POOR," presented on a computer screen, were contingent on the value of the emitted IRT.

A postexperiment questionnaire was used to assess whether adaptation to an IRT contingency, as defined by measures of IRT differentiation, was correlated with accurate verbal responses regarding the contingency. There is evidence that there can be close relations between verbal and nonverbal behavior in operant tasks with human subjects (e.g., Catania, Matthews, & Shimoff, 1982; Harzem, Lowe, & Bagshaw, 1978).

GENERAL METHOD

Subjects

All subjects were University of Utah students enrolled in an introductory psychology course; their participation in the study earned course credit, which was not, however, contingent on performance. Subjects were not known to either of the experimenters and had been assigned arbitrarily to different experimental groups before their arrival. Data from 5 subjects had to be discarded because of apparatus failure or experimenter error. The data from all remaining 44 subjects tested are presented here.

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Apparatus

Subjects sat at a table in a small room facing the screen of a PDP-12® computer. This screen displayed the response-contingent events (the words "GOOD" and "POOR," which appeared in capital letters 3 mm high and remained on the screen for 1 s). The PDP-12® arranged all experimental contingencies and recorded all responses. Subjects responded on the center button of a three-button apparatus. The left and right buttons were inoperative. The center button was 28 mm by 20 mm and was mounted above the table surface; it required a force of 0.85 N or greater for operation. Above each button was a standard electromechanical cumulative counter that incremented by one every time a "GOOD" appeared on the computer screen.

Instructions

Details of the instructions were varied over the several experiments, but the basic type of instructions (referred to as "neutral" in the text) were as follows:

> In this experiment you can obtain points, which will be shown on this counter [experimenter indicates the counter]. Every time you get a point, the number on this counter will increase by one. The aim of the experiment is for you to obtain as many points as you can. To get points you have to press this key [experimenter indicates]. When you press the key, just tap it and release it; do not hold it down. Please do not press either the left or right key; they're inoperative, as are their counters. When you press the key, one of three things will happen. This screen [experimenter indicates] will either show "GOOD" (in which case you'll obtain a point), or it will show "POOR" (in which case you will not get a point). A third possibility is that the screen will not show anything after you press. We would like for you to obtain as many points as you can in 30 minutes. The maximum possible number is about 180, but most pepole do not get anywhere near that. *It is up to you to work out what you have to do and* you can use the information that the computer gives you in any way you want. Are there any questions? [If so, the experimenter reads the relevant part of the instructions again.]
>
> If you are clear as to the procedure, I'll leave you and come back in 30 minutes when the experiment is over. Please do not touch any of the switches or knobs on the computer.

The italicized words were replaced by other instructions in later experiments.

Procedure

The procedures of the different experiments all followed the same basic format. Subjects were seated in front of the computer screen, and the instructions were read to them. Each subject received a single experimental session lasting 30 min (Matthews, Shimoff, Catania, & Sagvolden, 1977, found clear evidence of sensitivity to contingencies within single sessions). A questionnaire (details of which are given below) and debriefing were administered immediately afterwards. The specified consequences were contingent on a particular class of IRTs, which was varied as described below for each of the different experiments. IRTs within this class were said to fall into the "target class" (e.g., between 3 and 5 s). A random-interval (RI) 10-s schedule arranged consequent events with probability .1 every 1 s. When a consequent event was arranged, it was produced by the next button press. If the IRT terminated by this button press was in the target class, the computer screen displayed "GOOD," and the subject received a point. If the IRT was outside the target category, a "POOR" was displayed and the counter was not incremented. If no press occurred within 21 s of the scheduling of consequent events, the events were canceled.

Questionnaire

Immediately after completion of the experimental conditions, a subject received the following questionnaire:

> QUESTIONNAIRE
>
> This questionnaire is designed to give us some information about what you thought the experiment was about, and your opinions of various aspects of the procedure. Please answer all questions.
>
> 1. What did you have to do to get a "GOOD"? Was it
>   (a) space your presses in time by a certain amount? If so, how long did they have to be spaced apart?
>   (b) make a certain number of presses? If so, how many?
>   (c) press with a certain force on the key?
>   (d) none of the above? Please then specify what you did.

2. What did you have to do to get a "POOR"? Please specify.
3. Feedback events (e.g., getting "GOOD" or "POOR") came about every
   (a) 10 seconds
   (b) 20 seconds
   (c) 30 seconds
   (d) none of the above. Please specify about how often you thought they came.
4. What was your strategy for getting a "GOOD" on the screen? Please don't write more than five lines.
5. How sure were you that this strategy was correct? Were you
   (a) certain
   (b) very sure but not certain
   (c) quite sure
   (d) not really sure, but you did what you thought was right
   (e) unsure
   (f) very unsure
6. Did the number of "GOOD" indications you got increase or decrease as the experiment went on?
7. Was the experiment
   (a) too short
   (b) too long
   (c) interesting
   (d) boring
   Please indicate which you thought.

EXPERIMENT 1

This experiment was designed to obtain information about human performance under an IRT contingency with the instructions described earlier as "neutral," which did not specify spacing of response as important.

METHOD AND RESULTS

Twelve subjects were arbitrarily allocated to two groups of 6 subjects each. For one group (Group 1–3), the target IRT class was from 1 to 3 s; for the other (Group 3–5), it was from 3 to 5 s. All other details are as described in General Method.

A measure of behavioral adaptation often used in animal studies employing temporal contingencies similar to the ones used here is the proportion of all IRTs falling into the target class. These are shown in Figure 1 for successive 5-min periods. Consider first the results from Group 1–3. Only 1 subject (413) showed a substantial or systematic increase in the proportion of IRTs in the target class over the course of the session. Other subjects performed variably, having a more or less constant proportion of IRTs in the class (213 and 513), or having very few (113, 313, and 613). Subjects in this group responded at markedly different absolute rates.

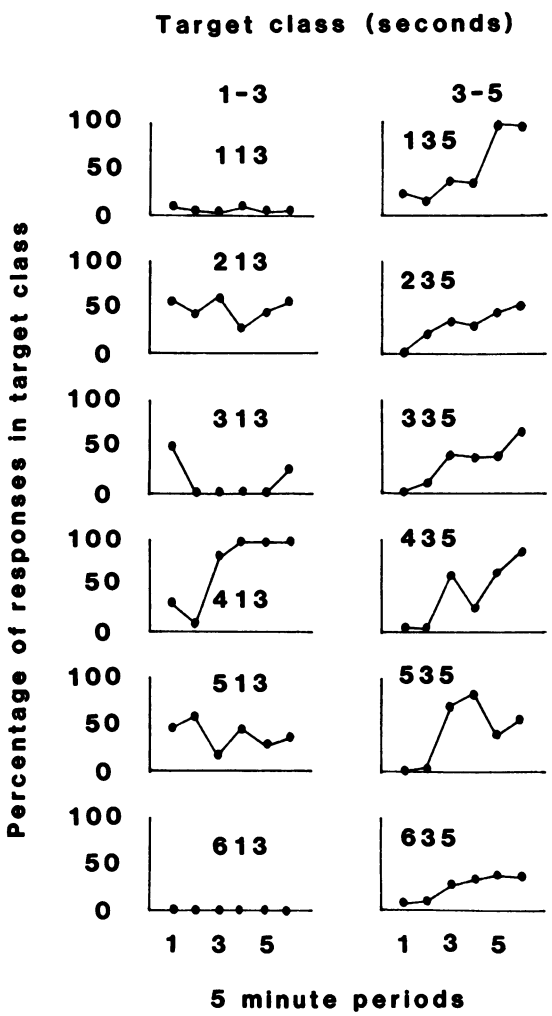

Fig. 1. Percentage of total responses falling in the target class during each 5-min period of Experiment 1. The left column shows data from subjects for whom the target class of interresponse times was 1 to 3 s. The right column shows data from subjects for whom the target class was 3 to 5 s.

In contrast, all subjects in Group 3–5 showed systematic increases of IRTs in the target class over the session, and two subjects (135 and 435) achieved terminal 5-min periods in which more than 75% of the IRTs were in the target class. The relative frequency distributions of IRTs for Group 3–5 are displayed in Figure 2 and confirm the indications of Figure 1. For all of these subjects,

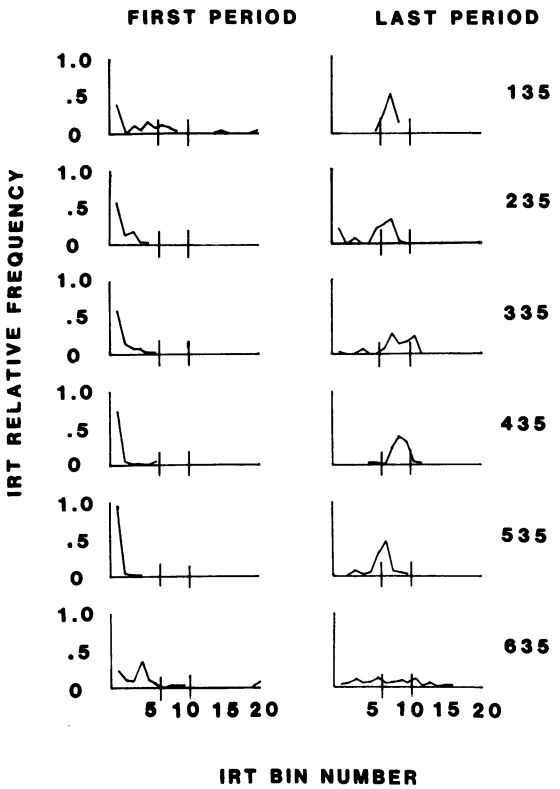

Fig. 2. Relative frequency distributions of IRTs from the first and last 5-min periods of Experiment 1, for subjects in the group for which the target class was 3 to 5 s. Vertical lines show the boundaries of the target class, and each IRT bin has a width of 0.5 s.

there were marked shifts in the relative frequency distributions over the course of the session. In general, they initially responded at high rates, with the modal IRT class being the 0 to 0.5-s bin for all subjects except 635. During the final 5-min period, however, all subjects except 635 exhibited a modal IRT class within the target class, and for 4 subjects (135, 335, 435, and 535), almost all IRTs were either within the target class or in classes adjacent to it. Subject 235 was exceptional in continuing to emit a substantially larger number of very short IRTs than did the other subjects in the final period, but nevertheless showed clear differentiation of IRTs during the course of the experiment.

In response to the questionnaire, 4 subjects for whom the target class was 1 to 3 s indicated that spacing responses in time was critical. Subject 513 was vague about the duration required and 213 described the critical band as 6 to 10 s. Subjects 613 and 413 identified the critical spacing as 1 s, but 613 was "very unsure" about this. Four subjects estimated that consequent events came every 10 to 20 s, and Subjects 413 and 313 indicated that feedback events came at none of the specific intervals indicated on the questionnaire.

All subjects in Group 3–5 identified response spacing as critical, and 5 of 6 reported various counting or timing strategies. Subjects 135 and 235 reported spacing responses regularly after 5 and 8 "counts," respectively; 435 described a spacing of 5 s as being necessary, whereas other subjects said spacing varied; 635 did not specify spacing value. Most subjects in this group indicated greater confidence about their answers than did subjects in the 1 to 3-s group, with none indicating "very unsure" that the strategy was correct, 1 indicating "very sure," and 2 indicating "quite sure." Subjects differed in their estimates of the spacing of feedback events: 1 correctly reported the value, 1 underestimated, 2 overestimated, and 2 reported the value as variable but unspecified.

Discussion

These results suggest the following tentative conclusions: First, the procedure of Experiment 1, although it exposed subjects to the schedule contingencies for a very brief duration relative to animal studies, appears adequate to initiate orderly IRT differentiation from some human subjects. All subjects for whom the target class was 3 to 5 s showed development of IRT differentiation. Second, the value of the IRT target class was critical in producing IRT differentiation within 30 min, as only 1 subject whose target class was 1 to 3 s showed good IRT differentiation, whereas all subjects in Group 3–5 did so. Third, the replies to the questionnaire suggested a positive relation between a correct verbal description of the contingency and degree of IRT differentiation. All subjects in Group 3–5 identified response spacing as important, and several were able to state approximately the actual requirement. On the other hand, most subjects in Group 1–3 did not accurately and confidently identify the contingency; only 413, the subject whose performance was best in Group 1–3, did so.

The next experiment explored the possibility that instructions explicitly identifying re-

sponse spacing as important would substantially improve sensitivity to the 1 to 3-s contingency. Except for the additional instructions, the procedure was identical to that of Experiment 1.

EXPERIMENT 2

Method

Ten subjects were allocated to two groups of 5 subjects each. As before, one group was exposed to a contingency with a target IRT class of 1 to 3 s; the target class for the other group was 3 to 5 s. All experimental arrangements were identical to those of Experiment 1 except for a change in instructions; the material italicized in the General Method section was omitted and was replaced by the following:

> To get a point, you have to space your presses in time by a certain amount. It is up to you to work out exactly what the spacing is, and ....

Results

The proportions of responses occurring in the target IRT class are shown in Figure 3 for the six 5-min periods. Four of 5 subjects for whom the target class was 1 to 3 s showed some IRT differentiation, as measured by an increase in the proportion of responses in the target class during the experiment. Subject 2131 showed at best a marginal increase in proportion of IRTs in the target class. In contrast, the performances of subjects for whom the target class was 3 to 5 s were not orderly: Only 1 subject (1351) showed a systematic increase in the proportion of IRTs in the target class.

In the questionnaire replies, most subjects in Group 1–3 correctly identified the reinforcement contingency, with 4 of 5 correctly naming a spacing interval that was within the target class. Subject 2131, on the other hand, suggested that response force was important, with harder presses on the key more likely to produce "GOOD." Similarly, 2 subjects in Group 3–5 (2351 and 4351) reported that their strategy was not based on response spacing.

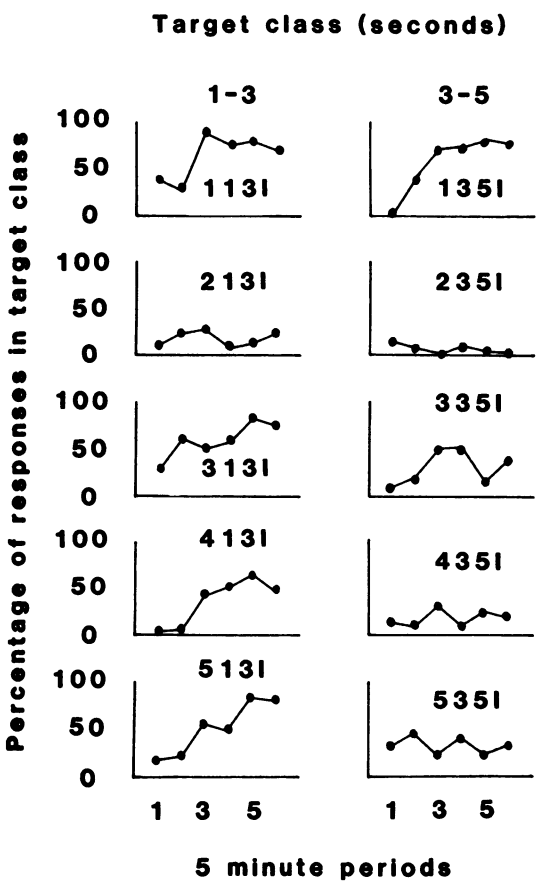

Fig. 3. Percentage of total responses falling in the target class for subjects in Experiment 2 during each 5-min period in Experiment 2. The left column shows data from subjects for whom the target class of IRTs was 1 to 3 s; the right column shows data from subjects for whom the target class was 3 to 5 s.

DISCUSSION

The results of Experiment 2 suggest that explicitly instructing subjects that the experimental contingencies involve temporal spacing of responses only sometimes improves performance on IRT differentiation schedules. Although subjects for whom the target class of IRTs was 1 to 3 s performed substantially better in this condition than in the neutral-instruction condition of Experiment 1, the instructions not only failed to improve performance of those whose target class was 3 to 5 s relative to the corresponding group in Experiment 1, but actually seemed to make performance worse. The 1 to 3-s group showed a positive relation between accurate identification of the contingency and accurate performance. Only 1 subject (2131) did not clearly and accurately identify the spacing requirement, and this subject showed the least IRT differentiation. The effect of the spacing in-

structions appears ambiguous in the context of the 3 to 5-s groups in Experiments 1 and 2.

Although some aspects of the subjects' reactions to the experimental instructions may be difficult to identify, their initial behavior under the contingency may be more easily assessed. A wide range of response rates occurred during the first 5 min of the contingency (from 0.4 to 137 presses per minute), and such a range of response rates may produce substantially different consequences. Subjects who persistently responded too quickly or too slowly may not have been given sufficient exposure to the schedule contingency to permit it to have had much control over behavior.

This initial tendency for subjects to respond at widely differing rates may have a number of causes, such as some extra-experimental experience, some particular interpretation of the experimental instructions, or some nonverbal characteristic of the experimental situation. Whatever its source, perhaps initial responding under a schedule contingency could be controlled by the imposition of an initial pacing requirement. In Experiments 3 and 4, subjects were exposed to contingencies identical or similar to those used above, with the exception that their responding in an initial 2-min period of the experiment was under the control of prompts supplied by the experimenter; through this control, all subjects in a particular condition initially emitted an identical sequence of IRTs. This procedure equated subjects, on average, in their initial exposure to the schedule contingency. This pacing contingency may be seen as analogous to manual shaping of an animal's lever pressing or key pecking, which is sometimes required to prevent extinction when a temporal schedule parameter is newly imposed or importantly changed (e.g., when a rather short time requirement is changed suddenly to a long one).

EXPERIMENT 3

Method

The method was identical in most respects to that of Experiment 2. Ten subjects were arbitrarily allocated to one or the other of two groups for which the target IRT class was either 1 to 3 s or 3 to 5 s. All experimental events and instructions were identical to those used in Experiment 2 (i.e., the instructions included an explicit statement about response spacing). The only difference from Experiment 2 came when subjects were told, after receiving instructions identical to those of Experiment 2:

> For the first 2 minutes or so of the experiment, I want you to press the key every time I say "press." Then I will say "continue," and you can then press the key whenever you want.

For Experiment 3, the IRT sequences prescribed by the experimenter's prompts consisted of IRTs of values 1, 2, 3, 4, 5, and 6 s. These were grouped in an arbitrary sequence such that each occurred once, then the six IRTs were presented in a different order, and so on, until six such sequences were completed, taking a total of about 2 min. Subjects responded almost exactly as instructed by the experimenter, and not at any other time. When the 2-min pacing period was completed, the experimenter left the experimental room.

Results

The proportions of responses falling into the target IRT class during the six 5-min periods of each subject's session are shown in Figure 4. The short horizontal dashed lines represent the percentages of responses that would have fallen in the target class during the first 5 min due simply to the experimenter's pacing prompts, during the first 2 min, if a subject had responded instantly to the instruction to press the button. Sometimes the latencies were a second or so in duration and produced lower percentages than those indicated by the dashed lines. Three (213P, 313P, and 513P) of 5 subjects with a target class of 1 to 3 s showed development of IRT differentiation, as evidenced by an increase in the proportion of responses in the target class. Of the other 2 subjects, 1 (113P) showed little systematic change in accuracy of performance over periods and for the other (413P), the proportion of responses in the target class actually decreased after the second 5-min period. Subjects exposed to the 3 to 5-s target class exhibited a similar picture, with 3 (135P, 235P, and 435P) of 5 subjects developing IRT differentiation, 1 (335P) showing little change throughout the experimental session, and 1 (535P) for whom the proportion in the target class seemed to decrease.

Results from the questionnaires suggested

a reasonably good correspondence between verbal and nonverbal behavior. Subjects 213P, 313P, and 513P all described a timing strategy involving spacing of responses 2 s apart. Subjects 135P and 435P described more complex timing strategies involving counting to various numbers between responses, with the numbers varying from one response to the next. Subject 235P, the other who appeared to develop IRT differentiation over the course of the experiment, described a slightly different counting strategy involving pauses separating brief bursts of responses. In accordance with this, 235P exhibited more short IRT responses than did the other subjects in the 3 to 5-s group who produced a substantial proportion of reinforcers. The 2 subjects (113P and 335P) whose behavior appeared to show little shift over the course of the experiment described the contingency as involving variable or random spacing, which they were unable to describe precisely. Subjects 535P and 413P, on the other hand, tended to characterize the contingency in terms of a complicated sequence of behavior, involving both time between responses and response numbers (i.e., a complex response pattern).

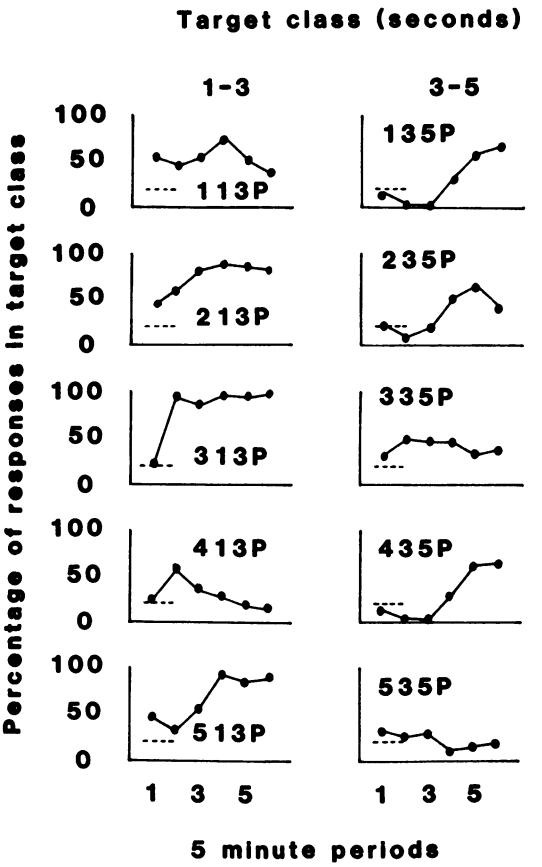

Fig. 4. Percentage of total responses falling in the target class of IRTs during each 5-min period of Experiment 3. Dotted horizontal lines indicate performance that would have been consistent with perfect adherence to the initial pacing contingency. The left column shows data from subjects for whom the target class of IRTs was 1 to 3 s; the right column shows data from subjects for whom the target class was 3 to 5 s.

Discussion

The experimental procedures used in Experiments 1, 2, and 3 increasingly constrained subjects' performances, first by introducing explicit instructions about timing, then by keeping the timing instruction and adding an initial pacing requirement. With the combined constraints of Experiment 3, behavioral control was sufficiently powerful that 3 of 5 subjects in each group adapted to the contingencies.

The behavioral control achieved in Experiments 1, 2, and 3 raised further questions about effects of the schedule contingency. In Experiment 4, two such questions were addressed. First, might different versions of the experimenter-prompted paced responding in the first few minutes of the session affect behavior differently over the entire 30 min of responding? Second, can the present procedure apply to a class of target IRTs longer than those used earlier? Both of these questions were addressed by employing, with different groups, two different pacing requirements during the initial few minutes of a session, and by employing a target class of from 6 to 12 s.

EXPERIMENT 4

Method

Twelve subjects were arbitrarily allocated to two groups of 6 subjects each, with the contingency for both groups having a target class that included IRTs between 6 and 12 s. Consequent events were arranged as in the previous experiments. Both groups received instructions identical to those of Experiment 3, with the exception that the initial pacing requirement differed. For one group ("Fast"), the prompted IRT distribution in the first 2

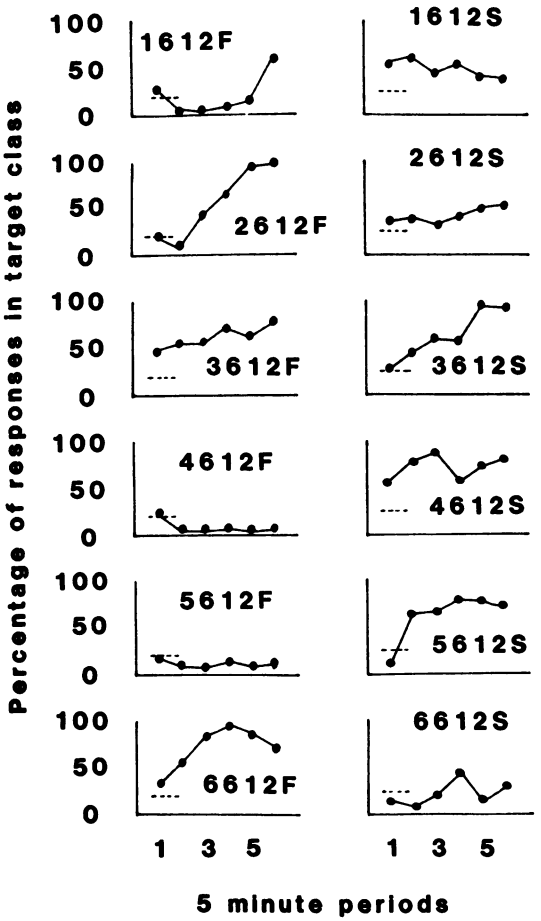

Fig. 5. Percentage of responses falling in the target class (in all cases, 6 to 12 s) for each 5-min period of Experiment 4. Horizontal dotted lines indicate performance consistent with continued adherence to the initial pacing contingency, which included a range of shorter IRTs for subjects represented in the left column (the group exposed to the "Fast" paced condition) than for those represented in the right column (those exposed to the "Slow" paced condition).

min of the experiment was a rectangular distribution of intervals ranging from 1 to 12 s; for the other group ("Slow"), the IRT requirement was the same, but with the 1-, 2-, and 3-s intervals replaced by 14-, 15-, and 16-s intervals. All other experimental details were as in Experiment 3.

Results

The proportion of responses falling into the target class for the six 5-min periods of each subject's session are shown in Figure 5. For 4 of the 6 subjects in the Fast group (1612F, 2612F, 3612F, and 6612F), there was some limited evidence of IRT differentiation. Two other subjects (4612F and 5612F) responded at a low level of accuracy throughout the experiment. Two subjects in the Slow group (3612S and 5612S) showed clear IRT differentiation. Two subjects (4612S and 6612S) showed no clear trend in the proportion of IRTs in the target class, and for another subject (1612S), the proportion of IRTs in the target class decreased.

In response to the questionnaire, the subjects in the Fast group who showed IRT differentiation (1612F, 2612F, 3612F, and 6612F) reported their response strategy as involving response spacing from 8 s to 10 to 15 s apart. Subject 4612F reported a strategy involving variations in response number, spacing, and force; 5612F reported a complex strategy involving a few responses of arbitrary spacing, followed by a 10-s pause. The 2 subjects in the Slow group who showed IRT differentiation (3612S and 5612S) verbally described a strategy involving spacing of responses about 10-s apart.

Discussion

The results of Experiment 4 resemble those of Experiment 3 in several ways. Performances of about half of the 12 subjects showed IRT differentation. These subjects also verbally described the contingencies in ways that were approximately accurate. Other subjects who adapted less well to the contingency tended to report nonspacing response rules or complex or vague timing strategies. All the above findings suggest that these aspects of the results of Experiments 1, 2, and 3 were not restricted to the use of the particular IRT classes that were used as target classes, inasmuch as similar results were obtained when a 6 to 12-s target class was used.

GENERAL DISCUSSION

Over the course of the four experiments, certain trends emerged that were most clearly evident when considering questionnaire data taken from all four experiments from subjects who adapted to the contingency versus those who did not. Our criterion for "adaptation" was that the subjects should show higher proportions of responses in the target class at the end than at the beginning of the experiment,

Table 1

Numbers of adapting and other subjects giving various confidence ratings of response strategy.

	Certain	Very sure but not certain	Quite sure	Not really sure	Unsure	Very unsure
Adapting subjects	0	4	6	10	3	0
Others	0	0	2	8	6	5

Table 2

Numbers of adapting and other subjects who rated the experiment as interesting or as other than interesting.

	Adapting subjects		Others	
Experiment	Interesting	Other	Interesting	Other
1	5	2	2	3
2	5	0	4	1
3	5	1	2	2
4	3	2	3	4
Total	18	5	11	10

when viewed against the pattern of responding over the course of the experiment. Overall, there were approximately equal numbers of adapting and nonadapting subjects. However, the level of adaptation displayed here is not necessarily similar to a level that would be obtained if subjects encountered the schedule contingencies for many hours. We make no claim that the behavior obtained in these experiments approximated "steady-state" levels.

The results obtained from postexperimental questionnaires revealed several differences between adapting subjects and the others. First, there was a tendency for adapting subjects to indicate greater confidence in the correctness of their response strategies. These results are shown in Table 1. Although the modal confidence rating for both groups was "d" ("not really sure"), the adapting subjects appeared to give higher confidence ratings to their strategies (e.g., categories "b" and "c") than did the other subjects (who frequently rated their strategy as "e" or "f"—"unsure" or "very unsure"). Note that no adapting subject gave a rating of "very unsure," whereas 5 others did; 4 adapting subjects gave a rating of "very sure but not certain," whereas no other subjects did.

Another difference that emerged from examination of the questionnaire data overall was that the adapting subjects tended more often to rate the experiment as interesting (as opposed to any other rating) than did the nonadapting or marginal subjects. Eighteen of the 23 adapting subjects, for example, rated the experiment as interesting, whereas only 11 of the other 21 subjects did so (as shown in Table 2).

There were no obvious differences between adapting and other subjects in their estimates of how frequently feedback stimuli were delivered. Most subjects estimated the time (which varied about a mean of 10 s) as from 5 to 20 s, with a mode of around 10 s.

The responses to the questionnaire administered to each subject after the experiment provided a kind of verbal self-report by each subject of his or her own performance. The relation between performance during the experiment and the subsequent verbal self-reports was somewhat similar to that which has been obtained previously (Catania et al., 1982; Wearden & Quinn, 1982), in the sense that accurate adaptation of the temporal patterning of behavior to the schedule contingency tended to be accompanied by subsequent verbal reports that corresponded approximately to both the schedule contingency and the subject's own behavior. Furthermore, several types of maladaptive temporal patterning were accompanied by corresponding forms of inaccurate verbal descriptions of the contingencies.

These results are similar to others that have found correlations between behavior and report of behavior, or statements about contingencies assessed by postexperimental questionnaires (see review by Lowe, 1979). Such correlations, of course, leave open the question of whether the verbal behavior changes before or after nonverbal behavior. Catania et al. (1982) addressed this question by employing concurrent monitoring of verbal and nonverbal actions, and found that verbal changes usually occurred prior to nonverbal ones. However, this was not invariably the case. Postexperimental questionnaires are clearly inadequate by themselves to give closure on these issues. Perhaps questionnaire "probes" during performance, similar to those employed with animals by Shimp (1981, 1982) might throw some light on the question. In

any event, the present results are broadly consistent with conclusions such as that of Harzem et al. (1978, p. 405), that performance "depended on a subject's verbal formulation of the experiment."

REFERENCES

Bradshaw, C. M., Szabadi, E., & Bevan, P. (1976). Behavior of humans in variable-interval schedules of reinforcement. *Journal of the Experimental Analysis of Behavior,* **26,** 135–141.

Buskist, W. F., & Miller, H. L., Jr. (1981). Concurrent operant performance in humans: Matching when food is the reinforcer. *Psychological Record,* **31,** 95–100.

Catania, A. C., Matthews, B. A., & Shimoff, E. (1982). Instructed versus shaped human verbal behavior: Interactions with nonverbal responding. *Journal of the Experimental Analysis of Behavior,* **38,** 233–248.

Gibbon, J. (1977). Scalar expectancy theory and Weber's law in animal timing. *Psychological Review,* **84,** 279–325.

Harzem, P., Lowe, C. F., & Bagshaw, M. (1978). Verbal control in human operant behavior. *Psychological Record,* **28,** 405–423.

Lowe, C. F. (1979). Determinants of human operant behaviour. In M. D. Zeiler & P. Harzem (Eds.), *Advances in analysis of behaviour: Vol. 1. Reinforcement and the organization of behaviour* (pp. 159–192). Chichester, England: Wiley.

Lowe, C. F., Harzem, P., & Bagshaw, M. (1978). Species differences in temporal control of behavior. II: Human performance. *Journal of the Experimental Analysis of Behavior,* **29,** 351–361.

Matthews, B. A., Shimoff, E., Catania, A. C., & Sagvolden, T. (1977). Uninstructed human responding: Sensitivity to ratio and interval contingencies. *Journal of the Experimental Analysis of Behavior,* **27,** 453–467.

Platt, J. R. (1979). Temporal differentiation and the psychophysics of time. In M. D. Zeiler & P. Harzem (Eds.), *Advances in analysis of behaviour: Vol. 1. Reinforcement and the organization of behaviour* (pp. 1–29). Chichester, England: Wiley.

Shimoff, E., Catania, A. C., & Matthews, B. A. (1981). Uninstructed human responding: Sensitivity of low-rate performance to schedule contingencies. *Journal of the Experimental Analysis of Behavior,* **36,** 207–220.

Shimp, C. P. (1976). Organization in memory and behavior. *Journal of the Experimental Analysis of Behavior,* **26,** 113–130.

Shimp, C. P. (1981). The local organization of behavior: Discrimination of and memory for simple behavioral patterns. *Journal of the Experimental Analysis of Behavior,* **36,** 303–315.

Shimp, C. P. (1982). On metaknowledge in the pigeon: An organism's knowledge about its own behavior. *Animal Learning & Behavior,* **10,** 358–364.

Shimp, C. P. (1984). Timing, learning, and forgetting. In J. Gibbon & L. Allan (Eds.), *Timing and time perception* (pp. 346–360). New York: New York Academy of Sciences.

Wearden, J. H., & Quinn, M. (1982). Human performance under inter-response time contingencies. *Behaviour Analysis Letters,* **2,** 309–319.

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