

*CONCURRENT ACTIVITIES AND INSTRUCTED HUMAN  
FIXED-INTERVAL PERFORMANCE*

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Two experiments explored the effects of two types of concurrent activity on human fixed-interval performance. Eight adult subjects were given access to either reading material or a working television set across three fixed-interval values (60 s, 300 s, and 600 s). During Experiment 1, 2 subjects produced "scalloped" patterns and reported no verbal regulation (e.g., counting) in the presence of the reading material, but shifted to low-rate patterns and reported verbal regulation when the reading material was withdrawn. The 2 other subjects in Experiment 1 produced consistent low-rate performances and reported verbal regulation during access to reading material. However, when these subjects were given access to a working television set, they produced scalloped patterns and reported no verbal regulation. During Experiment 2, 4 experimentally naive subjects showed consistent scalloped patterning and no verbal regulation across fixed-interval values when they were allowed to watch television. When access to the television was denied, subjects reliably reported verbal regulation, and low-rate patterns emerged. These behavioral effects focus our attention on the contingencies that control human performance on fixed-interval schedules.

*Key words:* fixed-interval schedule, concurrent activities, verbal regulation, scallop, break and run, low rate, humans

Many human subjects produce low-rate patterns of operant responding and report some form of verbal regulation (e.g., counting) when exposed to fixed-interval (FI) schedules of reinforcement (e.g., Laties & Weiss, 1963; Lowe, 1979; Wearden, 1988). This behavior-behavior relation between verbal regulation and the low-rate pattern has usually been examined by providing instructions as to the interval-based nature of the contingencies and subsequently attenuating the subjects' verbal regulation through the employment of either concurrent verbal tasks (Laties & Weiss, 1963; Lowe, Harzem, & Hughes, 1978) or the provision of a response-produced clock (Lowe, Harzem, & Bagshaw, 1978; Lowe, Harzem, & Hughes, 1978). The decreased postreinforcement pauses (PRPs) and higher response rates usually emitted on FI schedules under these conditions differ from the extended PRP

low-rate patterns normally observed with FI-instructed subjects.

These studies have demonstrated a strong relationship between verbal regulation and the low-rate pattern on the FI schedule, but the environmental variables that support this behavior-behavior relation have received little explicit attention (see Barnes, 1989). More informally, it remains open to speculation as to why human subjects often attempt to count out the interreinforcer interval when they have not been explicitly asked to do so. A satisfactory exploration of this behavioral effect, from a behavior-analytic viewpoint, must involve identification and demonstration of the historical and current contexts responsible for the behavior-behavior relation (see Barnes, 1989; Hayes & Brownstein, 1986).

It was in this spirit that Barnes and Keenan (1989) set out to investigate the effects of the experimental setting on human FI performance. Their study departed in two fundamental ways from the traditional operant conditioning experiment. First, subjects were required to move away from the manipulanda during exposure to the schedule of reinforcement. The required operant response involved typing the word "FEED" on a computer keyboard in one room and then walking to a second room to see if the computer monitor was

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displaying a message saying that a point had been delivered (note that each message remained on the screen for 15 s after typing FEED). At the end of a session, the subject's record of point deliveries was compared with the computer's record. If the subject's tally was lower, he or she was awarded the lesser amount (i.e., only observed point deliveries were reinforced). If the tally was higher, the subject lost all points for that session (i.e., recording point deliveries that had not been observed was punished). The second way in which the Barnes and Keenan study differed from standard procedures was in the availability of another room. This room was set aside as a relaxation area in which subjects could engage in a range of concurrent activities, such as eating, drinking, and reading. The results from this study indicated that the low-rate FI pattern, and the accompanying verbal regulation, were to some extent a function of the availability of the relaxation room. That is, subjects tended to produce pause-respond patterns and reported no verbal regulation when the relaxation room was open, but they emitted low-rate patterns and verbal regulation when access to the relaxation room was restricted. It is important to note that the experimental procedures employed by Barnes and Keenan did not involve explicit interference with verbal regulation; subjects were "free to count" during any of the conditions. It appears, therefore, that counting was made more or less likely by the experimental manipulation even though it was not actively prevented.

There are, however, a number of criticisms of the Barnes and Keenan (1989) study that should be considered. For instance, schedule-controlled performance was never examined in the more conventional experimental arrangement in which the subject remains seated in one place for the entire session (the operant response always involved walking between two rooms). It follows, therefore, that the findings did not show conclusively that the availability of the concurrent activities *on their own* crucially affected subjects' schedule-controlled performance. This interpretative problem is compounded by the fact that the relaxation room was restricted for only one condition. In view of these criticisms, both experiments reported here will focus directly on the effects of concurrent activities in the standard experimental arrangement (i.e., subjects remain

seated in one room for the entire session), and, furthermore, the effects of the concurrent activities will be examined across *two* condition reversals.

Another criticism is that the relaxation room in the Barnes and Keenan (1989) study permitted a range of concurrent activities (i.e., eating, drinking, reading, and smoking). This type of setting makes it impossible to determine whether one or some combination of the activities is affecting schedule-controlled performance. For the present studies, therefore, all subjects were allowed access to only one type of concurrent activity material, if any, during a given session. Specifically, during the first experiment a range of reading materials was made available to the subject (within reaching distance from a seated position in front of the operant equipment). If access to the reading material did not affect a subject's schedule-controlled performance, then during the second reversal of conditions, the subject was allowed access to a working television set (i.e., during Condition B, magazines [available as Condition A] were replaced by a television). For the second experiment, naive subjects were allowed access to a television set across two ABA reversals. In this way, it was possible to examine whether television watching had a more powerful influence on human schedule-controlled performance than did magazine reading.

The three FI values from the Barnes and Keenan (1989) experiment were used (i.e., 60 s, 300 s, and 600 s). However, because the limited-hold contingency (which was used by Barnes and Keenan) may help to produce the pause-respond pattern (cf. Lowe, Harzem, & Hughes, 1978, p. 359), limited holds were not employed during the current experiments.

## EXPERIMENT 1

### METHOD

#### *Subjects*

Four undergraduates, 2 female and 2 male, were recruited through faculty notice board advertisements. The recruitment advertisement stated that a small amount of money and a mystery prize could be earned as part of the study, and that each subject would also be paid £30.00 (about \$50.00) if he or she completed the entire experiment. Subjects were aged be-

tween 18 and 19 years. They were asked not to tell anyone about their participation in the study until the experiment was over. Subjects had no previous experience with psychology experiments and were not psychology majors. The researchers had no previous contact with any of the subjects before they volunteered for the study.

#### *Apparatus and Setting*

All sessions were conducted in an experimental room that had a floor area measuring 345 cm by 675 cm. Placed on a table against a wall was an Acorn Computer Limited, British Broadcasting Corporation (BBC), Model B microcomputer and a Kaga Denshi Model KG-12NB-N computer monitor with a 30.5-cm screen. Subjects were seated at the table, facing the computer keyboard and the monitor. Positioned beside the monitor was a plastic catering cup with 40 metal counters. A small table was positioned to the right (within easy reach) of the subject. During conditions when subjects were not allowed any concurrent activities, this table remained empty. When reading was allowed, a variety of recently published magazines was placed on the table. If watching television was allowed, a Mitsubishi Model BB-1406 portable (30-cm screen) monochrome television was placed on the table with the screen facing the subject. The set was plugged into the main electricity supply. The set itself was never operating when the subject entered the experimental room; subjects were allowed to switch the set on and off whenever they wished. The television could receive the four national stations of the United Kingdom. During experimentation at least three of these channels were always broadcasting typical daytime programs (e.g., popular soap operas, documentaries, chat shows, news items, cartoons, etc.). Subjects were never given access to both the magazines and the television during the same session. The experimental room contained only the materials or equipment outlined above. The FI schedules and data collection were controlled by the computer, which was programmed in BBC BASIC.

#### *Response Measurement*

A response was defined as typing D after having previously typed the three letters F, E, and E, in that order (i.e., a total of four discrete key strokes). A single response duration was

defined as the elapsed time between pressing F and D when typing FEED. There was no explicit restriction imposed on response duration (i.e., subjects could take as long as they wished to complete the four key strokes). If a subject made a typographical error (e.g., typed FEEED, EED, FFED, etc.), neither a response nor a response duration was recorded. The mean response duration for each subject, calculated across all sessions for all conditions, was as follows (standard deviations are in parentheses): MT = 0.71 s (0.12 s), PM = 0.92 s (0.22 s), CW = 0.83 s (0.19 s), and TD = 0.67 s (0.16 s).

#### *Procedure*

Experimental sessions were conducted daily, Monday through Friday. To minimize contact between the experimenter and the subjects, a weekly timetable was attached to the door of the experimental room, and after each session subjects used the timetable to indicate the next time they could attend. The experimenter made all the necessary preparations 30 min before a subject arrived for the next session. A note was then left on the door of the experimental room informing the subject that the experimental equipment had been suitably prepared for today's session. When conditions changed, the appropriate information was also included on the note; otherwise, no further information was provided.

At the beginning of the first session, each subject was shown and read the following general instructions:

For approximately the next half hour you will be required to remain in this room. During your stay, however, you can earn some money. Every so often, after a fixed period of time has elapsed, by typing the word "FEED" on the keyboard a message will come up on the monitor screen telling you that you have earned a point.

Whenever you see this message take one metal counter from the plastic cup beside the monitor and keep it beside you on the table. Each counter is worth 10 pence.

Only take a counter when you see the message on the screen; counters will be tallied with a computer record of the results at the end of each session!

The fixed period of time between the availability of points from the computer remains the same for the whole session.

The time interval will be exactly the same

Table 1

Sequence of conditions, number of sessions per condition, and standard deviations of mean postreinforcement pauses calculated across the final three sessions in each condition for each subject.

Subject	Condition	FI value (s)	Ses-sions	Standard deviation (s)
MT	1. Magazines	300	7	47.7
	2. No magazines	300	5	27.4
	3. Magazines	300	4	55.3
	4. Magazines	60	6	7.9
	5. Magazines	600	5	73.0
	6. Magazines	300	4	42.7
	7. No magazines	300	5	25.8
	8. Magazines	300	4	48.3
PM	1. Magazines	300	8	30.3
	2. No magazines	300	5	23.1
	3. Magazines	300	3	25.0
	4. Magazines	60	4	5.2
	5. Magazines	600	5	49.1
	6. Magazines	300	6	27.0
	7. Television	300	5	62.4
	8. Magazines	300	4	27.5
CW	1. Magazines	300	8	64.4
	2. No magazines	300	6	19.6
	3. Magazines	300	5	46.7
	4. Magazines	600	5	63.5
	5. Magazines	60	4	8.4
	6. Magazines	300	4	32.4
	7. No magazines	300	5	18.8
	8. Magazines	300	6	39.2
TD	1. Magazines	300	11	32.9
	2. No magazines	300	6	25.3
	3. Magazines	300	4	22.5
	4. Magazines	600	5	64.1
	5. Magazines	60	5	8.2
	6. Magazines	300	4	26.9
	7. Television	300	5	55.8
	8. Magazines	300	5	25.5

every day unless you receive instructions telling you otherwise.

The magazines on the small table beside you are available for your use. So, feel free to read or browse through them when you wish.

Once the session has started please do not touch any other keys on the keyboard except for the letters making the word "FEED."

Please do not leave the room until a message appears on the monitor screen telling you that the session is over.

To make the following few weeks more interesting for you, you will be assigned a number for every point you earn. At the end of the experiment I will draw a number out of a bag

and the subject who was assigned that number will win a mystery prize.

You must never bring anything into the experiment with you, such as books, personal hi fi's, wrist watches or other time pieces.

You start the session by pressing the space bar at the bottom of the keyboard.

A typed copy of the above instructions was pinned on the wall where it could be read by the subject while seated at the computer; if the subjects asked any questions they were referred to this copy. The experimenter arranged for a confederate, who was unaware of the nature of the study, to randomly check (across 75% of all sessions) that subjects were not taking watches or other materials into the experiment. On only one occasion was a subject found wearing a watch when entering the experimental room, and the subject readily gave it to the confederate, stating, "Oh! I forgot; I wasn't going to use it."

Whenever the subject typed the word "FEED" on the computer keyboard after the fixed interval had elapsed, the following message was presented on the monitor screen:

You have earned a point. Please take one metal counter from the cup and keep it beside you on the table.

After 3 s, the monitor screen cleared and the next interval began immediately.

Subjects were exposed to eight conditions. The first three conditions were identical for all 4 subjects, and consisted of an ABA reversal on FI 300 s, where Condition B was the withdrawal of reading material. Subjects MT and PM were then exposed to FI 60 s and FI 600 s with reading material (Conditions 4 and 5, respectively). Subjects CW and TD were exposed to these conditions in reverse order (i.e., FI 600 s followed by FI 60 s). Conditions 6, 7, and 8 represented the second reversal on FI 300 s. For Subjects MT and CW the reading material was withdrawn during Condition 7, but for Subjects PM and TD the reading material was replaced by the television set. Conditions were changed when the standard deviation of the mean postreinforcement pause (PRP), calculated across three consecutive 30-min sessions, was less than one quarter the length of the FI (see Table 1).

Before FI values were changed, subjects were informed that the programmed reinforcement interval would be different for the forthcoming

session. Subjects were not told the exact length of the interval, but were informed that it would be a certain ratio of the interval from the previous session. For example, when transferring from FI 300 s to FI 60 s, the following instructions were included on the note that was pinned to the door of the experimental room:

Starting today, the time interval between the availability of points will be one fifth the length of the interval from the previous sessions.

For the first session in those conditions in which the reading material was withdrawn, the following instructions were included on the note:

The time intervals operating during this session are exactly the same as yesterday. However, starting today there are no magazines in the room for you.

For the first session in which the magazines were reintroduced, the instructions included on the note read:

The time intervals operating during this session are exactly the same as yesterday. However, starting today there are magazines in the room for you.

For the first session in which the television was made available, the following instructions appeared on the note:

The time intervals operating during this session are exactly the same as yesterday. However, starting today there are no magazines in the room for you. Instead, a portable black and white television is being made available for your use. The television will be off when you go into the experimental room, but you can turn it on whenever you wish (in fact, you can turn it off and on whenever you feel like it during the session). Also feel free to change channels. All the buttons on the control panel are clearly marked.

For the first session in which the television was withdrawn, the following instructions were included on the note:

The time intervals operating during this session are exactly the same as yesterday. However, starting today the television is being replaced by magazines.

At the end of each session, Subjects MT and TD wrote down their responses to the following two questions (hereafter referred to as the

“describe” question and the “explain” question, respectively):

Describe, as fully as possible, what you did during the intervals between point deliveries for this session.

Explain, as fully as possible, exactly why you did what you did during the intervals between point deliveries.

The experimenter pinned these questions to the weekly timetable while the subject was in the experimental room. Only 2 subjects were required to give verbal reports after each session, so that the possible effects of providing these reports might be examined by comparing their performances with those of the 2 subjects who were not required to provide reports (see Hayes, 1986).

At the end of the experiment all 4 subjects were asked to write down their responses to the following queries:

As best you can, please write down the various things you did during the intervals between point deliveries, throughout the course of the experiment.

As best you can, please write down exactly why you did the things you did during the intervals between point deliveries.

Subjects could earn a maximum of £3.00 per session (about \$5.00). When the entire study was over, all 4 subjects were paid their accumulated earnings and the £30.00 for completing the experiment. Finally, the “mystery prize” raffle was held, and the winner was offered a choice between a book token or a bottle of Irish whiskey.

#### *Analysis of Verbal Reports*

The session-by-session written reports provided by Subjects MT and TD were typed onto individual sheets of paper by two secretaries who were both blind to the nature of the study. Both secretaries cross-checked each other's transcriptions of the written reports before returning them to the first author, who then rechecked them for accuracy. No discrepancies between written and typed reports were identified by the author. Concealed information was included on each sheet, indicating the subject, the experimental condition, the session number, and whether the verbal response was an answer to either the describe or the explain question.

To categorize subjects' reports, the authors

inspected the reports and derived five formal categories of verbal responses to the describe question and six formal categories of responses to the explain question. The five categories for the describe question were as follows:

1. *Verbal regulation by counting*, including references to simple numerical counting (e.g., "I counted to 100 and then typed FEED"), counting based on physiological responses (e.g., "I counted 500 heart beats before typing FEED"), and counting based on complex verbal responding (e.g., "I recited a poem I know by heart 10 times before typing FEED").

2. *Verbal regulation by reading*, which referred to using the reading material (when available) to regulate typing responses (e.g., "I read about half a page before typing FEED").

3. *Reading only*, which referred to reading the magazines for most of the session and either (a) explicitly denying verbal regulation (e.g., "I didn't count this time, I just read until I thought the interval was nearly over and started to type FEED"), or (b) failing to report any form of verbal regulation (e.g., "I just read for a while and then started to type FEED occasionally").

4. *Television only*, which referred to watching television for most of the session and either (a) explicitly denying verbal regulation (e.g., "I stopped reciting poetry today and just watched television and typed FEED whenever I felt the interval was nearly over"), or (b) failing to report any form of verbal regulation (e.g., "I watched television and typed FEED whenever it felt like the interval was almost up").

5. *Other*, including responses not previously classified (e.g., "I did so many things, I can't remember all of them," "Dozed and felt sick most of the time") or simply not writing a response to the question.

The six categories for the explain question were as follows:

1. *General experimental demands*, which referred to general statements about conforming to the "implicit demands" of the experiment without mentioning the discriminative effects of the reading material or the television (e.g., "The experiment involved time intervals, so I presumed that I should try to estimate the intervals as accurately as possible. Did I do the right thing?").

2. *Reading helps regulation*, which referred

to the reading material as discriminative for using reading as a form of verbal regulation (e.g., "You wouldn't leave the magazines in the room if you did not want me to use them to help time the intervals").

3. *No reading means regulation*, which referred to the absence of the reading material as discriminative for verbal regulation (e.g., "There were no magazines today, so I decided that you wanted me to find another way of timing the intervals, such as counting").

4. *Reading means no regulation*, which referred to the reading material as discriminative for not engaging in verbal regulation (e.g., "I thought you might want me to try to time the intervals by counting, but you wouldn't give me magazines if this was the case").

5. *Television means no regulation*, which referred to the television as discriminative for not engaging in verbal regulation (e.g., "I couldn't think of any way that I could use the television to help time the intervals, so I assumed that you wanted me to stop counting").

6. *Other*, including responses not previously classified (e.g., "Can't explain why," "Feel too ill to explain"), or not writing a response to the question.

Two final-year undergraduate students, who were unfamiliar with this experiment, agreed to spend approximately two 1-hr periods assigning the session-by-session verbal responses to one of their respective categories. For the first 1-hr period, each student was given a shuffled pile of photocopied responses to the describe question and the appropriate list of five categories. For the second 1-hr period, each student was given a shuffled pile of photocopied responses to the explain question and the appropriate list of six categories. To avoid overtiring the students (and potential rater drift), the two rating periods were arranged for separate days. For each rating period, the two students worked independently, inspecting each verbal response and writing down one of the categories that they thought applied. After they had finished a rating period, an arbiter (a postgraduate student who was unfamiliar with this study) compared the categories and identified any inconsistencies in their choices. The two raters then discussed, in the presence of the arbiter, why they had assigned those particular responses to those categories. On all but three occasions, across both rating periods, the two raters came to an agreement as a result

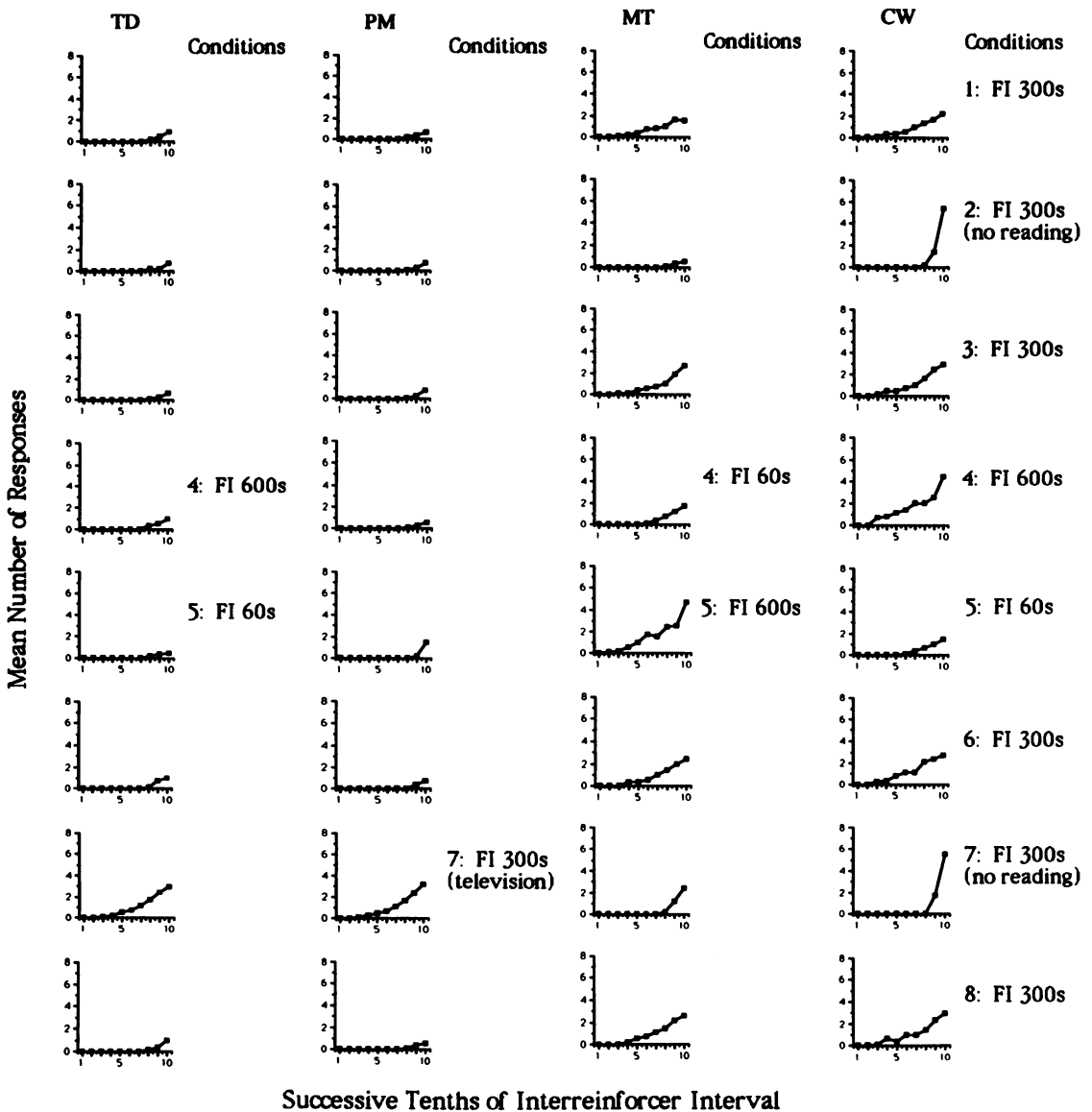


Fig. 1. The mean number of responses in successive 10ths of the fixed interval immediately after reinforcement for each subject in each condition. Data are from the final three sessions in each condition.

of this discussion. On those three occasions on which they failed to resolve the disagreement, the arbiter made the final decision as to which category was most appropriate.

Because Subjects PM and CW provided only one verbal report each at the end of the entire experiment, a summary statement of these reports will be provided in the Results section. The final verbal responses provided by MT and TD will also be reported in this format.

RESULTS

Figure 1 gives local response-rate data averaged over the last three sessions. Across all reading conditions, Subjects MT and CW showed a gradual increase in response rates up to reinforcement (hereafter referred to as "scalped"). This pattern was more accentuated on FI 600 s but was slightly suppressed on FI 60 s. When reading material was with-

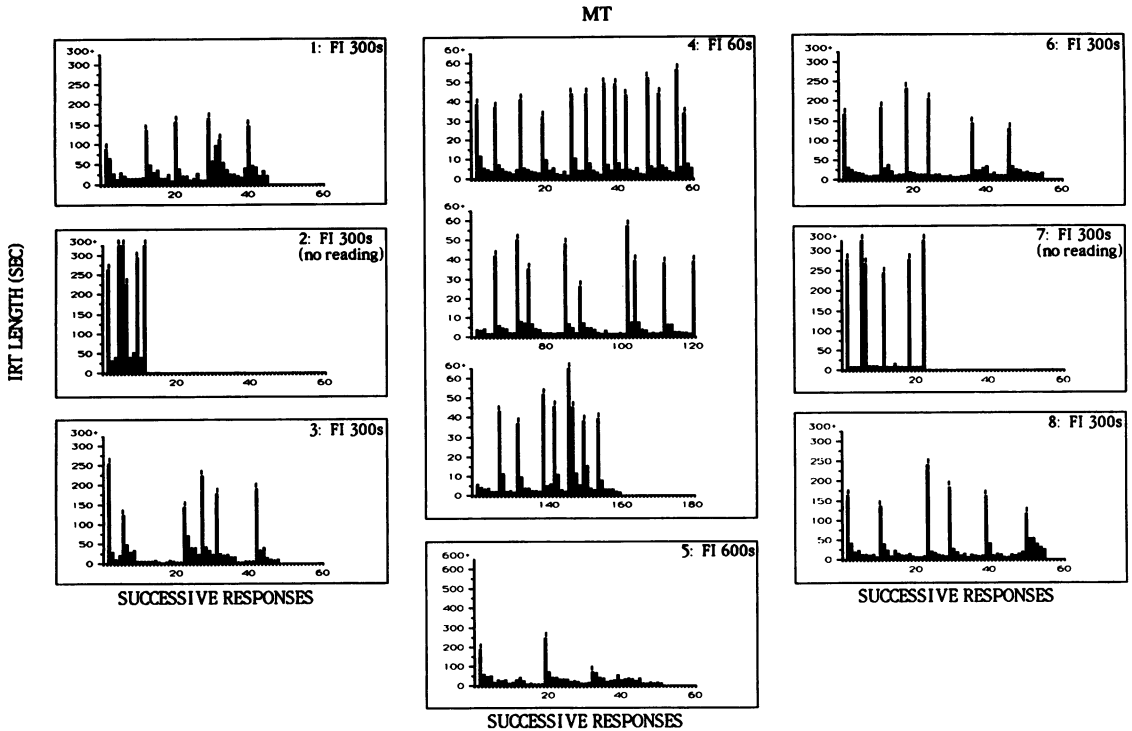


Fig. 2. Successive IRTs emitted by Subject MT during the final session of each condition. The data for each condition are framed. Each panel within a frame shows a maximum of 60 IRTs. Where there are more than 60 IRTs in one condition, they are distributed, from top to bottom, across each panel. Each vertical bar represents one IRT, and the height of the bar represents its duration. A small vertical line above a bar indicates a postreinforcement pause.

drawn for CW (across both ABA reversals), the scalloped pattern was replaced by a more abrupt transition to a higher response rate later in the interreinforcement interval (hereafter referred to as "break and run"). Across the first ABA reversal MT's scalloped pattern became quite suppressed during the no-reading phase, with only a very slight increase in response rate at the end of the interval (hereafter referred to as "low rate"). During the second ABA reversal, however, this subject shifted to a break-and-run pattern when reading material was absent.

Local response rates for TD and PM resembled low-rate patterns across all conditions except when the television was made available (Condition 7). During this condition both subjects produced scalloped patterns.

Figures 2 to 5 show interresponse-time (IRT) data from the final session in each condition for each subject (an IRT was defined as the time from typing D in one FEED to the next D in the following FEED). When

reading material was present for MT (Figure 2) and CW (Figure 3), PRPs were often followed by a gradual decrease in IRTs up to the next reinforcement (i.e., a scalloped pattern). This scalloped pattern was replaced when the reading material was withdrawn (Conditions 2 and 7). For both subjects there was an increase in PRPs, with some exceeding the duration of the FI value itself. During Condition 2, Subject MT produced only one, two, or three IRTs (ranging from 30 to 50 s) per interval. However, during Condition 7 he emitted a greater number of shorter IRTs (ranging from 15 to 20 s), the length of which remained relatively constant during the interval. This latter distribution of IRTs after a PRP is described as break-and-run performance. A more dramatic example of this break-and-run pattern was produced by CW during exposure to both Conditions 2 and 7. In contrast to MT and CW, Subjects TD (Figure 4) and PM (Figure 5) tended to produce extended PRPs and low-rate patterns (with an



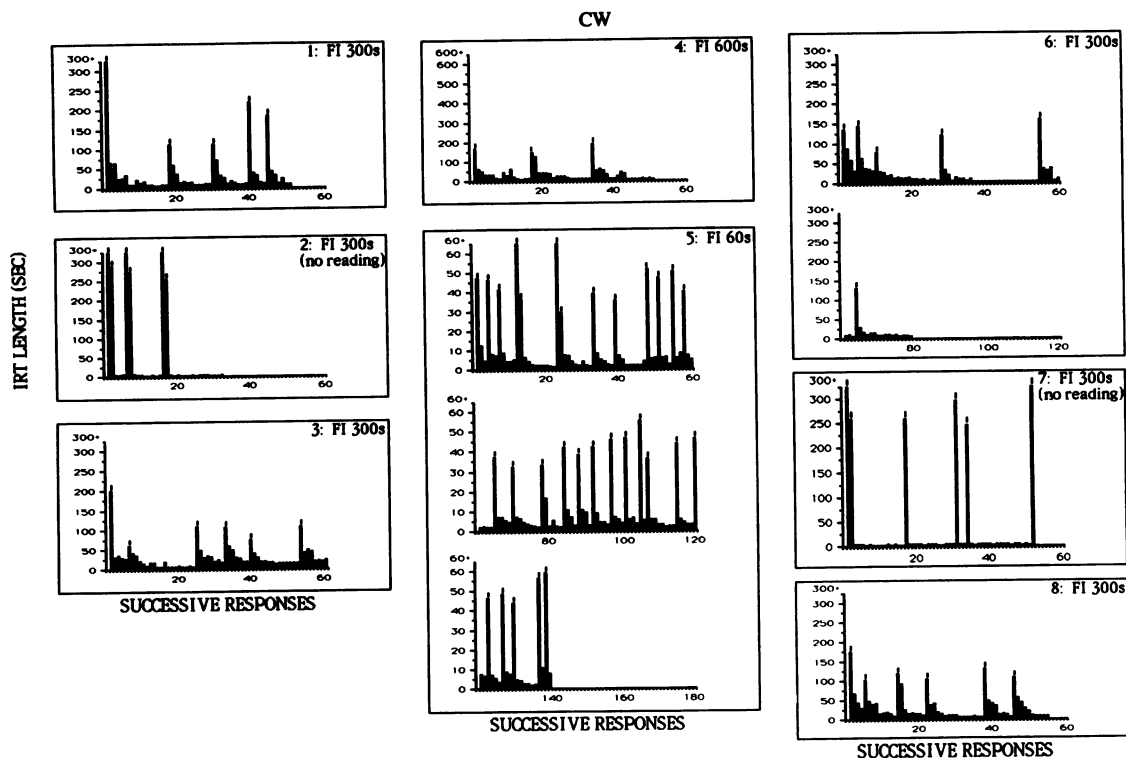


Fig. 3. Successive IRTs emitted by Subject CW during the final session of each condition (see caption to Figure 2 for details).

occasional break and run) across all reading conditions. When television was made available in Condition 7, both subjects emitted scalloped response patterns.

A comparison of the categorized, session-by-session verbal reports for Subjects MT and TD revealed that the performance differences on the different schedules were correlated with different types of written reports. The results of this analysis are summarized in Table 2. For Subject MT the availability of the reading material and the scalloped response patterns were reliably accompanied by reports that he had spent most of his time reading and had assumed that the provision of reading material indicated that he should not attempt to count out the fixed intervals. When the magazines were withdrawn and MT produced low-rate or break-and-run patterns, he reliably reported counting and indicated that the absence of magazines was taken as a sign that he should try to count out the intervals. For Subject TD, the presence and absence of the reading material, and her low-rate and break-and-run

patterns, were reliably correlated with reports of counting. During reading conditions, this subject usually reported that the magazines were provided to help time the intervals, and when the magazines were unavailable she reliably reported that their absence meant that another method of interval estimation should be used. When the television replaced the magazines and TD shifted to scalloped response patterns, she failed to report any form of verbal regulation and indicated that the television meant she should stop trying to time the intervals.

Two other points should be noted. First, after those sessions in which MT or TD produced scalloped patterns, their verbal reports sometimes included a reference to this response pattern. In the words of MT, "During reading, I typed FEED occasionally at first, and then typed more often as time went by." Second, both subjects reduced the amount of detail in their written reports during the course of the experiment. After the early sessions, their reports tended to be quite long (e.g., "I read

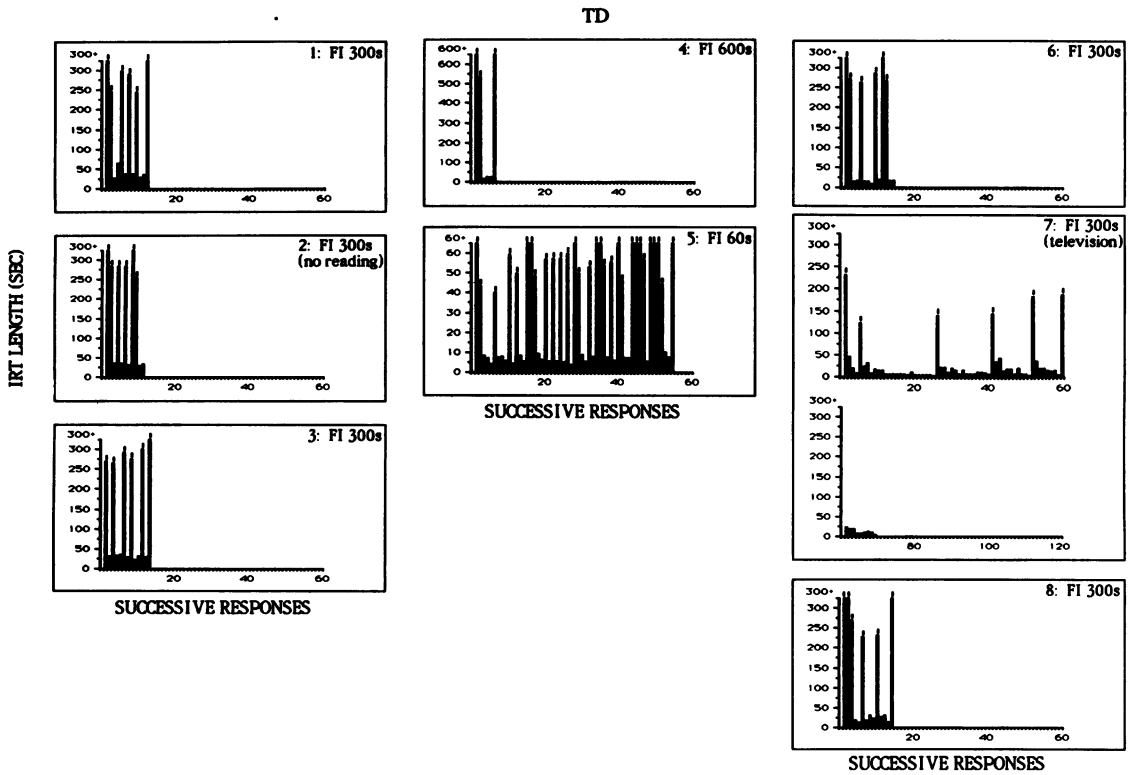


Fig. 4. Successive IRTs emitted by Subject TD during the final session of each condition (see caption to Figure 2 for details).

a problem page, an article on marriage breakdown, and part of a short story. All the time I was reading I kept stopping quite often and typing FEED on the computer. I think that I typed FEED more often when I felt a point was coming up, but I can't be sure because sometimes I got a point when I wasn't expecting it"). However, over multiple sessions of the same condition, both subjects gave very brief reports (e.g., "Same as yesterday; read magazines and typed FEED occasionally"). When a new condition was introduced, the amount of detail in the reports often increased for one or two sessions before becoming quite brief again.

The correlation between nonverbal performance and verbal behavior, as measured by the session-by-session verbal reports, was also apparent from the final written reports obtained from all 4 subjects at the very end of the experiment. MT and CW reported that they did not count when the magazines were available, because they were seen as a sign that counting was not required; in the words of CW, "I didn't try to estimate the interval,

because you gave me something else to do." CW also stated that she gradually increased her response rates during the interval. In her own words, "When I was reading I would type FEED quite slowly at first and then get faster and faster until I got a point." Both MT and CW reported that when the magazines were withdrawn, they assumed that the experimenter wanted them to time the intervals more accurately. In the words of CW, "After the magazines were taken away, I really felt that you wanted me to make more of an effort at estimating the intervals."

Subjects PM and TD indicated in their final verbal reports that they used the magazine reading as a means for timing the intervals because they felt that the experimenter wanted them to do so. In the words of PM, "I worked out how much I could read, on average, before the interval was over. . . . I thought that you gave me the magazines to read so that I could do this." These subjects stated that when the magazines were withdrawn they assumed that the experimenter wanted them to find some other method of timing the intervals. For in-

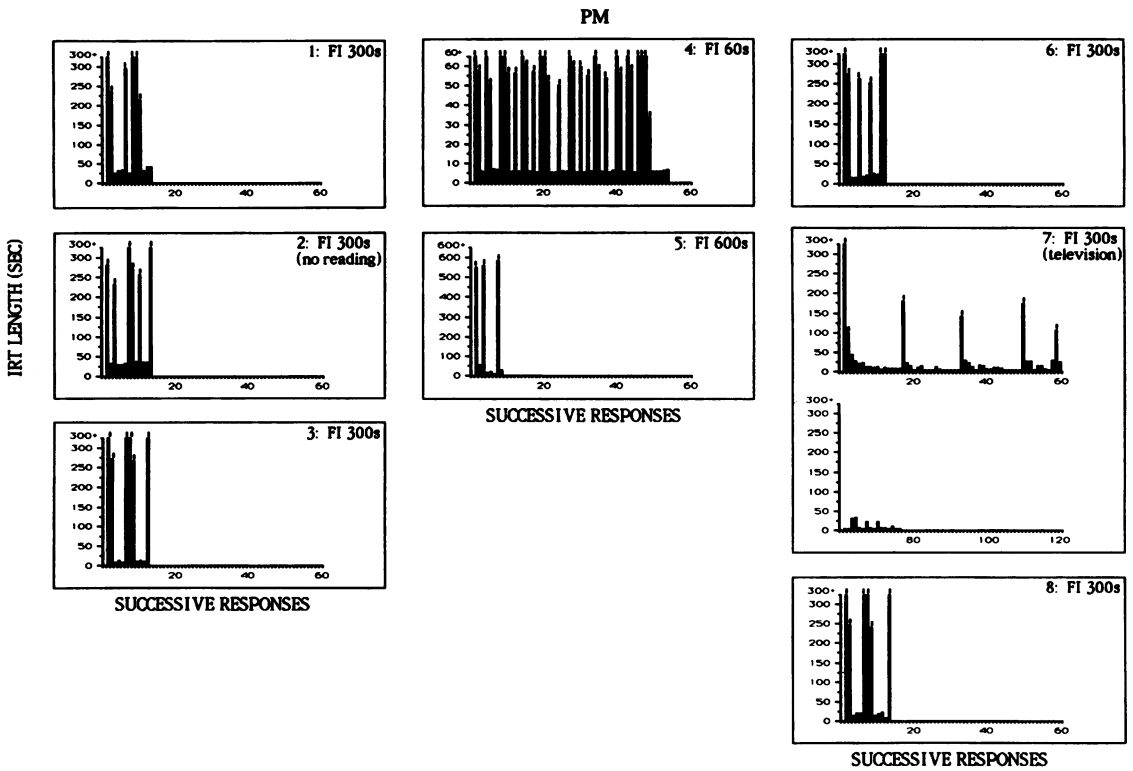


Fig. 5. Successive IRTs emitted by Subject PM during the final session of each condition (see caption to Figure 2 for details).

Table 2

Categories of verbal responses to the “describe” and “explain” questions for Subjects MT and TD. Figures in parentheses indicate the session(s) for which the category of report was obtained.

Subject	Condition	FI value (s)	Verbal report category and sessions	
			Describe	Explain
MT	1. Magazines	300	Regulation by counting (1 and 2) Reading only (3 to 7)	General experimental (1 and 2) Reading means no regulation (3 to 7)
	2. No magazines	300	Other responses (1) Regulation by counting (2 to 5)	Other responses (1) No reading means regulation (2 to 5)
	3. Magazines	300	Reading only (1 to 4)	Reading means no regulation (1 to 4)
	4. Magazines	60	Reading only (1 to 6)	Reading means no regulation (1 to 6)
	5. Magazines	600	Reading only (1 to 5)	Reading means no regulation (1 to 5)
	6. Magazines	300	Reading only (1 to 4)	Reading means no regulation (1 to 4)
	7. No magazines	300	Regulation by counting (1 to 5)	No reading means regulation (1 to 5)
	8. Magazines	300	Reading only (1 to 5)	Reading means no regulation (1 to 5)
TD	1. Magazines	300	Other responses (1 to 3) Regulation by counting (4 to 6) Regulation by reading (7 to 11)	Other responses (1 to 3) General experimental (4 to 6) Reading helps regulation (7 to 11)
	2. No magazines	300	Regulation by counting (1 to 6)	No reading means regulation (1 to 6)
	3. Magazines	300	Regulation by reading (1 to 4)	Reading helps regulation (1 to 4)
	4. Magazines	600	Regulation by reading (1 to 5)	Reading helps regulation (1 to 5)
	5. Magazines	60	Regulation by reading (1 to 5)	Reading helps regulation (1 to 5)
	6. Magazines	300	Regulation by reading (1 to 4)	Reading helps regulation (1 to 4)
	7. Television	300	Regulation by counting (1) Television only (2 to 5)	No reading means regulation (1) Television means no regulation (2 to 5)
	8. Magazines	300	Regulation by reading (1 to 5)	Reading helps regulation (1 to 5)

stance, PM stated, "I meditated and counted my breathing." Both subjects indicated they watched the television when it was made available, and that its presence was taken to mean that the experimenter did not want them to time the intervals. In the words of PM, "The television obviously meant that you did not want me to keep timing." PM also indicated that he started to type FEED earlier in the intervals and typed more often as the interval progressed. All 4 subjects expressed worry (in their final written reports) about "not doing the right thing" or "not being a good subject."

### DISCUSSION

For Subjects MT and CW, the availability of magazines was shown to have considerable influence over response patterning of FI schedules. Specifically, the local response-rate and IRT data show that these subjects produced scalloped patterning whenever they were given access to reading material. When this reading material was withdrawn across two ABA reversals, subjects showed a dramatic increase in PRPs and a shift to either break-and-run or low-rate patterns of responding. Access to reading material did not have the same effect for Subjects PM and TD. They tended to produce low-rate patterns in both the presence and absence of the magazines. However, when these subjects were given access to a television set during the second ABA reversal, they produced scalloped patterns comparable to those shown by MT and CW across reading conditions. These results clearly show that the scalloped pattern may be generated in the more traditional operant setting with just one concurrent activity and in the absence of the limited-hold contingency.

In the Barnes and Keenan (1989) study, concern was expressed over the effects of prolonged exposure to any one condition. It was felt that such an experimental history might reduce response variability and perhaps, therefore, sensitivity to changes in the contingencies (see Joyce & Chase, 1990). These concerns were unfounded; the present study employed a three-session stability criterion, and all 4 subjects demonstrated shifts in response patterning across at least one ABA reversal.

It is important to note that during the availability of the magazines, 1 of the 2 subjects (MT) who provided session-by-session reports produced scalloped patterns, whereas the other subject (TD) produced low-rate or break-and-

run patterns. A similar contrast in the effects of the magazines was also obtained between the 2 remaining subjects (PM and CW) who were simply required to give a single verbal report at the very end of the experiment. Although tentative, these findings indicate that obtaining verbal reports after each session did not differentially affect behavior on the schedules.

All subjects reported that they engaged in some form of verbal regulation when they produced break-and-run or low-rate patterns, but they did not mention any form of counting during those conditions in which they produced scalloped patterns. Given that the scalloped patterns closely resembled those observed with nonhuman subjects on FI (see Lowe, Harzem, & Bagshaw, 1978), these findings support the suggestion that verbal regulation on the FI schedule may help to account for the differences obtained between human and nonhuman subjects on this schedule (see Lowe, 1979). Although the present findings support this general view, it must be emphasized that focusing exclusively on verbal/nonverbal behavior relations as the basis for experimental design could be unwise, at least for a behavior analyst. As argued by Barnes (1989), concentrating on behavior-behavior analysis may distract the experimenter from the analysis of those contextual variables that control human behavior. It is important to understand, therefore, that the non-human-like pattern observed in this experiment is of interest only insofar as the pattern itself may be brought under contextual control. We will discuss this issue in greater detail towards the end of the paper.

In summary, the present findings suggest that for some subjects, at least, the presence of a television was more effective in bringing about behavioral change on FI than was access to reading material. In order to examine the behavioral effects of the television more systematically, the next experiment repeated the procedures using only the television as a concurrent activity.

## EXPERIMENT 2

### METHOD

#### *Subjects*

Four undergraduates, 2 female and 2 male, were recruited in same way as for Experiment

1. Subjects were aged between 19 and 28 years. They were asked not to tell anyone about their participation in the study until the experiment was over. No subject had any previous experience with psychology experiments.

*Apparatus and Materials*

The apparatus and materials were the same as for the previous experiment, except that magazines were never placed in the experimental room.

*Response Measurement*

All responses and response durations were recorded in exactly the same way as in Experiment 1. The mean response duration for each subject, calculated across all sessions for all conditions, was as follows (standard deviations are in parentheses): JE = 0.82 s (0.15 s), BS = 0.61 s (0.14 s), MM = 0.73 s (0.18 s), and CS = 0.59 s (0.09 s).

*Procedure*

All procedural aspects of this experiment were identical to the previous study, except that only the television set was provided as a concurrent activity (see Table 3). Accordingly, it was necessary to make a number of changes to the instructions where reference is made to the magazines. These were as follows. The seventh section from the general instructions now read:

A portable black and white television is available for your use. The television will be off when you go into the experimental room, but you can turn it on whenever you wish (in fact, you can turn it off and on whenever you feel like it during the session). Also feel free to change channels. All the buttons on the control panel are clearly marked.

For the first session in which the television was withdrawn, the instructions included on the note (which was pinned to the door of the experimental room) were as follows:

The time intervals operating during this session are exactly the same as yesterday. However, starting today there is no television in the room for you.

For the first session in which the television was reintroduced, the instructions included on the note were as follows:

The time intervals operating during this session are exactly the same as yesterday. How-

Table 3

Sequence of conditions, number of sessions per condition, and standard deviations of mean postreinforcement pauses calculated across the final three sessions in each condition for each subject.

Subject	Condition	FI value (s)	Sessions	Standard deviation (s)
JE	1. Television	300	9	43.6
	2. No television	300	7	26.5
	3. Television	300	4	41.3
	4. Television	60	6	8.3
	5. Television	600	6	78.4
	6. Television	300	4	49.6
	7. No television	300	6	29.2
	8. Television	300	4	21.3
BS	1. Television	300	8	64.0
	2. No television	300	6	26.0
	3. Television	300	4	60.9
	4. Television	60	6	8.1
	5. Television	600	5	92.2
	6. Television	300	6	57.6
	7. No television	300	6	30.6
	8. Television	300	5	61.7
MM	1. Television	300	10	68.3
	2. No television	300	7	22.9
	3. Television	300	5	72.7
	4. Television	600	5	88.6
	5. Television	60	6	9.4
	6. Television	300	7	49.1
	7. No television	300	6	23.7
	8. Television	300	3	58.8
CS	1. Television	300	10	73.0
	2. No television	300	8	24.5
	3. Television	300	5	71.5
	4. Television	600	6	82.5
	5. Television	60	7	9.3
	6. Television	300	4	68.7
	7. No television	300	4	24.8
	8. Television	300	4	46.7

ever, starting today there is a television in the room for you.

The same questions and procedures used in Experiment 1 for obtaining verbal responses, generating verbal response categories, and assigning responses to categories were employed in this second study. Subjects JE and MM provided their reports at the end of each session and at the end of the entire experiment. Subjects BS and CS provided their reports only once at the end of the experiment. For this study, only three categories of responses to the describe question were identified. These were Categories 1, 4, and 5 as specified in Experiment 1 (i.e., *verbal regulation by counting, tele-*

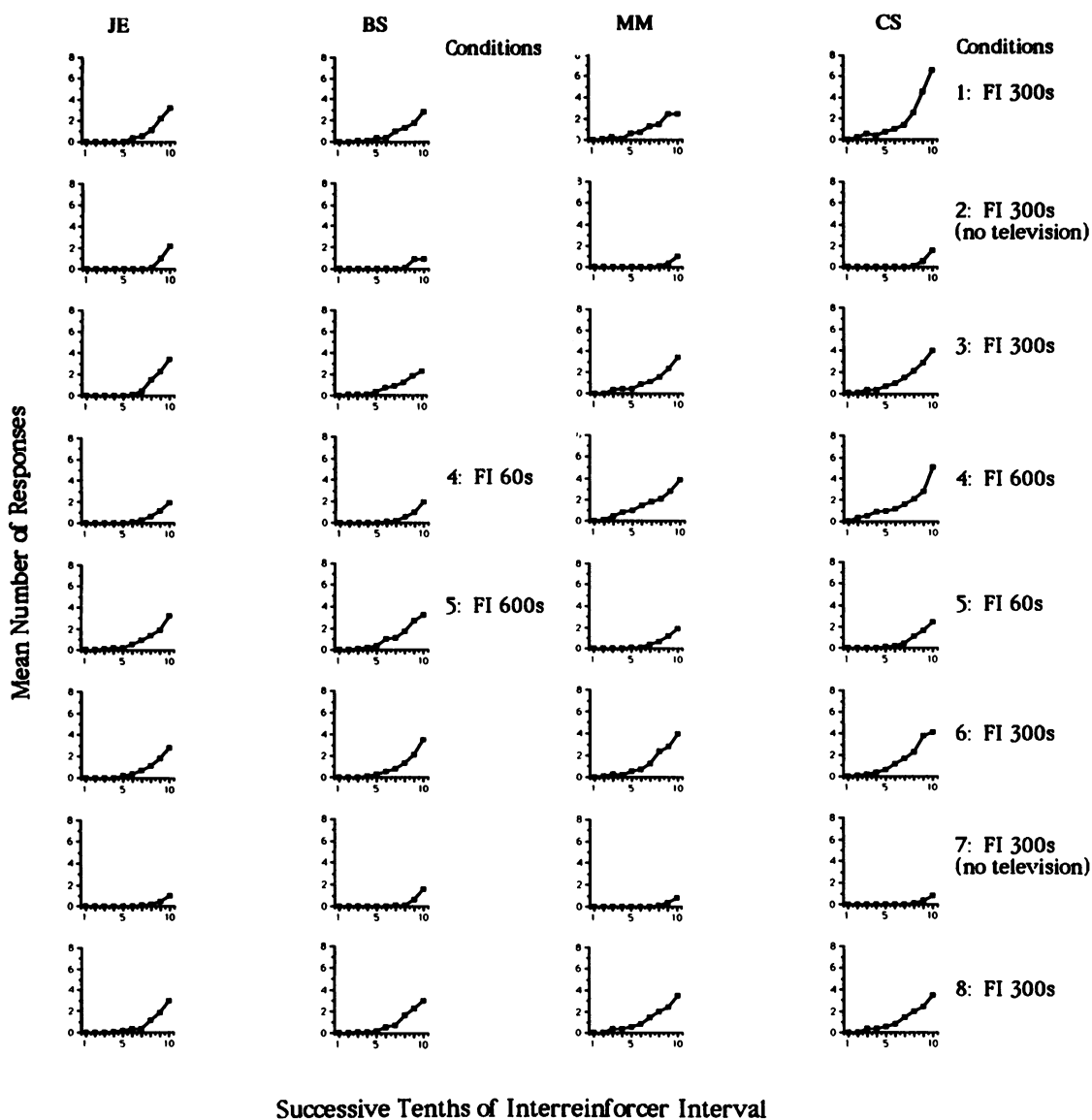


Fig. 6. Mean number of responses in successive 10ths of the fixed interval immediately after reinforcement for each subject in each condition. Data are from the final three sessions in each condition.

vision only, and other). Four categories of responses to the "Explain" question were identified. These were Categories 1, 5, and 6 as specified in Experiment 1 (i.e., *general experimental demands*, *television means no regulation*, and *other*) and an additional category designated *no television means regulation*, which referred to the absence of the television as discriminative for verbal regulation (e.g., "You took the telly away. I took this to mean that I should try to time the intervals more carefully"). Two new final-year undergraduate

students, and a new postgraduate arbiter were used for categorizing the reports in Experiment 2.

## RESULTS

Figure 6 gives local response-rate data averaged over the last three sessions. Across all conditions in which the television was present, subjects showed scalloped patterns. When the television was removed, scalloped patterns were replaced by low-rate patterns for all subjects across both ABA reversals, except for JE in

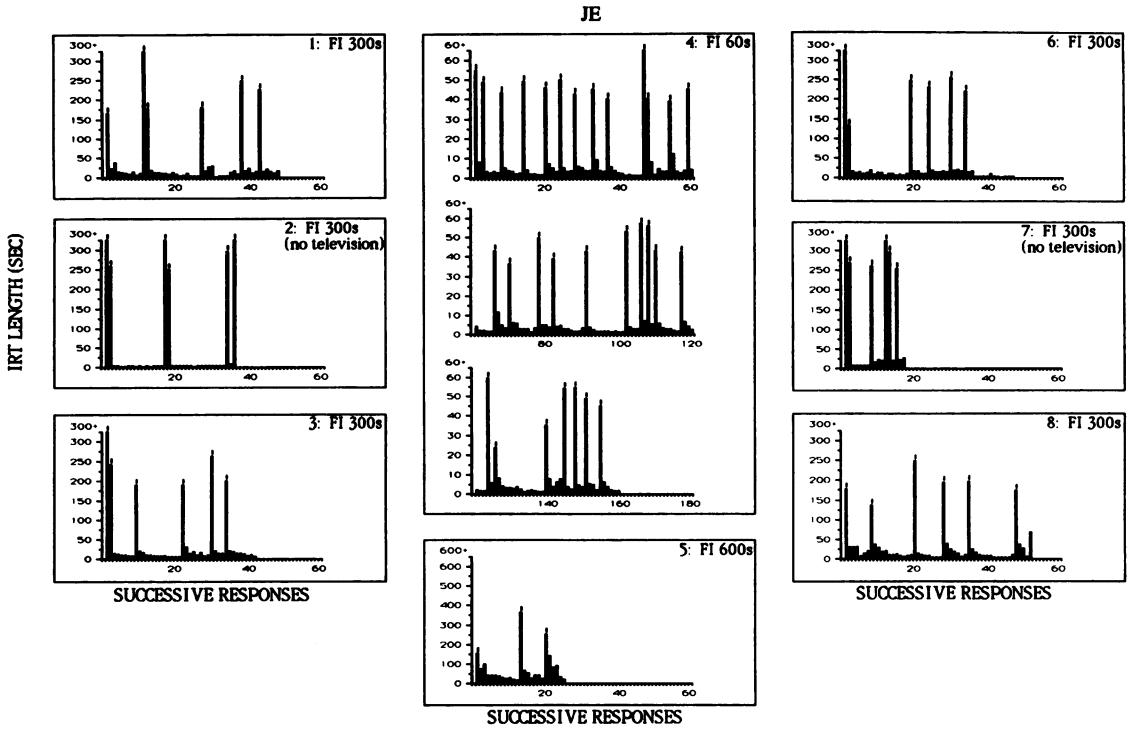


Fig. 7. Successive IRTs emitted by Subject JE during the final session of each condition (see caption to Figure 2 for details).

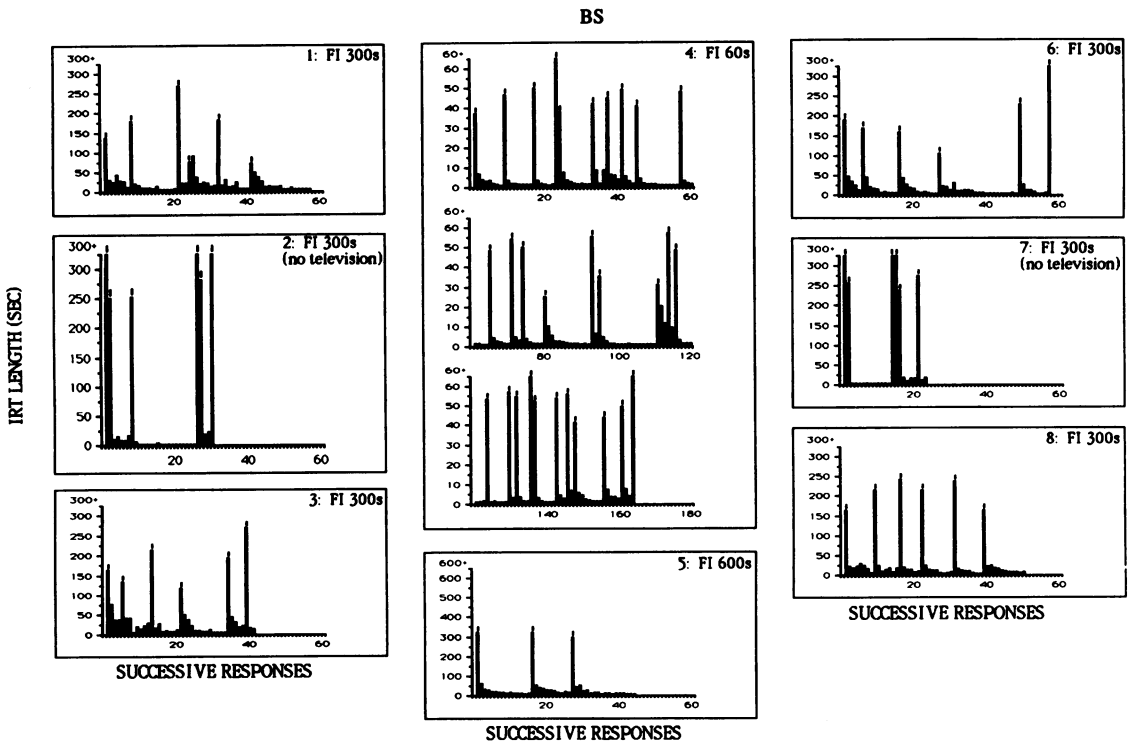


Fig. 8. Successive IRTs emitted by Subject BS during the final session of each condition (see caption to Figure 2 for details).

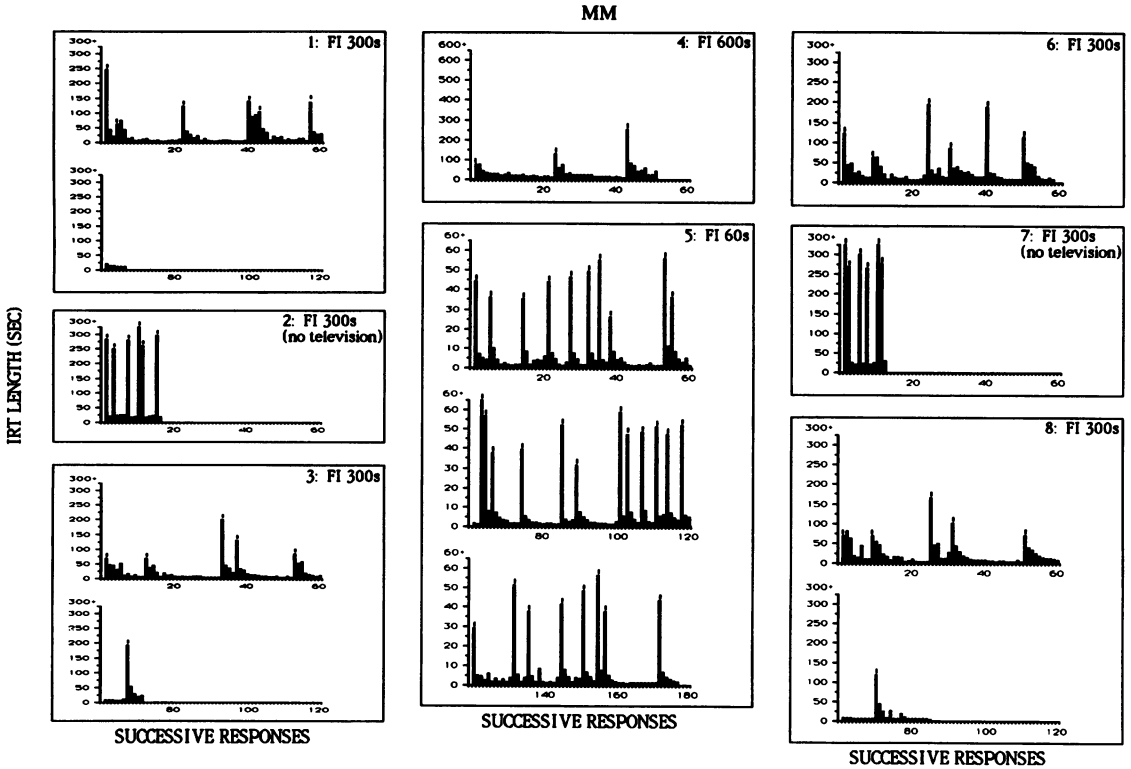


Fig. 9. Successive IRTs emitted by Subject MM during the final session of each condition (see caption to Figure 2 for details).

Condition 2, whose performance more closely resembled break and run.

Figures 7 to 10 show IRT data from the final session in each condition for each subject. When the television was present, all subjects most often emitted scalloped patterns of responding. When the television was withdrawn (Conditions 2 and 7), all subjects showed an increase in PRPs, with some exceeding the duration of the FI value itself. Subjects JE and BS (Figures 7 and 8, respectively) emitted both break-and-run and low-rate patterns across Conditions 2 and 7, whereas Subjects MM and CS (Figures 9 and 10, respectively) produced predominantly low-rate patterns across these conditions.

Inspection of the categorized, session-by-session verbal reports for Subjects JE and MM showed that within-subject differences in schedule performance were correlated with different types of written reports. The results of this analysis are summarized in Table 4. For both subjects, the availability of the television and the scalloped response patterns were re-

liably accompanied by reports that they had spent most of their time watching television and had assumed that the presence of the television meant that they should not try to count out the fixed intervals. When the television was withdrawn and both subjects produced low-rate or break-and-run patterns, they reliably reported counting and indicated that the removal of the television was taken to mean that they should attempt to count out the intervals. Two features of the verbal reports seen in Experiment 1 were also observed in this second study. After those sessions in which the subjects emitted scalloped patterns, their verbal reports sometimes included reference to this pattern, and both subjects reduced the amount of detail in their reports during the course of the experiment.

In their final written verbal reports (provided at the end of the entire experiment), all subjects indicated that when the television was available they watched it throughout the whole session and did not attempt to count out the intervals. All 4 subjects reported that they



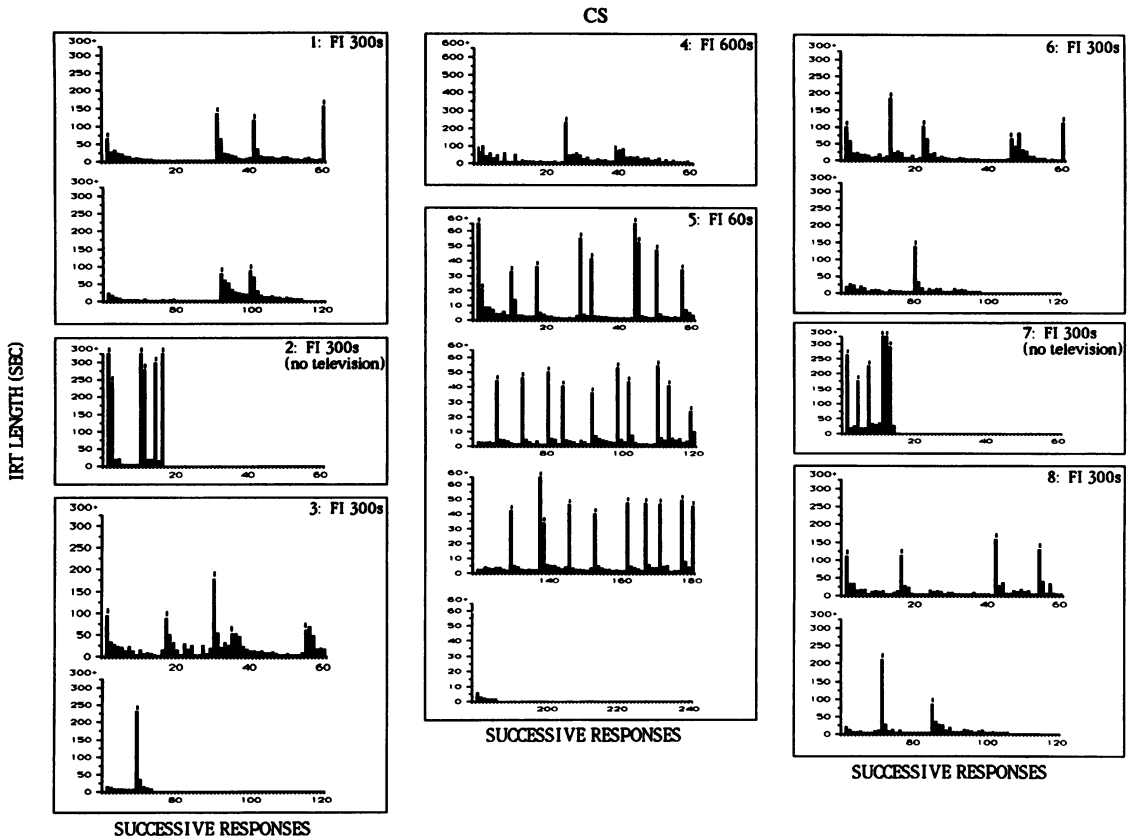


Fig. 10. Successive IRTs emitted by Subject CS during the final session of each condition (see caption to Figure 2 for details).

Table 4

Categories of verbal responses to the “describe” and “explain” questions for Subjects JE and MM. Figures in parentheses indicate the session(s) for which the category of report was obtained.

Subject	Condition	FI value (s)	Verbal report category and sessions	
			Describe	Explain
JE	1. Television	300	Television only (1 to 9)	General experimental (1) Television means no regulation (2 to 9)
	2. No television	300	Other responses (1) Regulation by counting (2 to 7)	Other responses (1) No television means regulation (2 to 7)
	3. Television	300	Television only (1 to 4)	Television means no regulation (1 to 4)
	4. Television	60	Television only (1 to 6)	Television means no regulation (1 to 6)
	5. Television	600	Television only (1 to 6)	Television means no regulation (1 to 6)
	6. Television	300	Television only (1 to 4)	Television means no regulation (1 to 4)
	7. No television	300	Regulation by counting (1 to 6)	No television means regulation (1 to 6)
	8. Television	300	Television only (1 to 4)	Television means no regulation (1 to 4)
MM	1. Television	300	Television only (1 to 10)	Television means no regulation (1 to 10)
	2. No television	300	Regulation by counting (1 to 7)	No television means regulation (1 to 7)
	3. Television	300	Television only (1 to 5)	Television means no regulation (1 to 5)
	4. Television	600	Television only (1 to 5)	Television means no regulation (1 to 5)
	5. Television	60	Television only (1 to 6)	Television means no regulation (1 to 6)
	6. Television	300	Television only (1 to 7)	Television means no regulation (1 to 7)
	7. No television	300	Regulation by counting (1 to 6)	No television means regulation (1 to 6)
	8. Television	300	Television only (1 to 3)	Television means no regulation (1 to 3)

tended to accelerate their response rates when they were watching television. In the words of BS, "When I was watching the television I typed FEED more often as time went on." All subjects reported engaging in some form of counting when the television was removed, because they felt that the experimenter wanted them to do so. In the words of CS, "When there was no television, I thought you wanted me to make a real effort at timing the intervals, so I worked them out by counting. Did I ruin the experiment?" All subjects expressed concern (in their written reports) over their performance not being what the experimenter expected or wanted.

### DISCUSSION

The availability of the television in this experiment was again shown to have considerable power over response patterns on FI schedules. Subjects produced scalloped patterns whenever they were given access to the television, but when the television was withdrawn across two ABA reversals, subjects showed an increase in PRPs and a shift to either break-and-run or low-rate patterns of responding. In accordance with the findings from Experiment 1, all subjects failed to report verbal regulation when they produced scalloped patterns, but did report counting during those conditions in which they produced low-rate or break-and-run patterns. Furthermore, given that all 4 subjects produced similar performances, these findings again suggest that asking the subjects to provide verbal reports after each session did not differentially affect behavior on the schedules. In summary, the presence of the television in this experiment demonstrated more consistent control, across subjects, over human FI performance than that shown by the availability of magazines in Experiment 1.

### GENERAL DISCUSSION

The two experiments reported here clearly showed that the availability of concurrent activities may have a powerful influence over human schedule-controlled performance. Although a degree of intersubject variability was evident during the first study, this experiment led to an important discovery. Specifically, all 6 subjects (across both studies) who were given access to a working television during exposure to the FI schedules reliably generated scal-

loped patterns. Furthermore, the ABA experimental design demonstrated that the occurrence of these scalloped patterns was reversible.

Three different response patterns were observed in these studies: scalloped, low rate, and break and run (see Lowe, 1979). In those conditions in which subjects did not emit scalloped patterns, they either showed low-rate or break-and-run patterns of responding. Indeed, some subjects produced some combination of both patterns across or, in certain cases, within sessions. The reasons for this variability are unclear. However, given that the presence of the television demonstrated reliable control over the occurrence of the scalloped pattern, perhaps future studies might examine whether some combination of other concurrent activities (e.g., art and craft materials, an exercise machine, computer games, etc.) would allow control over the occurrence of all three response patterns.

In addition to exploring the effects of a range of concurrent activities, future research might also address two other important issues. First, in the present experiments, reinforcement was contingent on an extended response unit (i.e., typing the word FEED), as opposed to a discrete response, such as a single key press. It is unclear what impact this difference had on the current results, but it would be interesting to know whether the schedule patterns observed here would also be obtained with a more discrete response unit. Second, the present procedures relied heavily on instructional control. The subjects were told when conditions changed and were given additional information about the contingency (e.g., that consequences were available at fixed times, and that the programmed intervals were ratios of intervals experienced in the previous conditions). It remains to be seen, therefore, whether the behavioral control demonstrated here by the concurrent activities would be maintained if subjects were provided with less detailed instructions, no instructions at all, or were encouraged to generate their own instructions (cf. Rosenfarb, Newland, Brannon, & Howey, 1992).

The results of the analyses of verbal reports from the current research support the idea that what a subject says, either covertly or overtly, in the experimental setting to some extent determines nonverbal schedule performance (e.g., Barnes, 1989; Hayes, 1986; Hines & Wan-

chisen, 1989; Lowe, 1979; Wearden, 1988). However, it is important to note that although all subjects in the current experiments reported verbal regulation during those conditions in which they also emitted low-rate or break-and-run response patterns, both verbal regulation and these patterns were most often seen when a previously available concurrent activity was removed from the experimental setting. In effect, the present research not only identified a correlation between counting and nonverbal schedule-controlled performance, but more importantly it also identified an environmental variable of which both counting and nonverbal responding appeared to be a function. The identification and manipulation of the concurrent activities as a source of environmental control over verbal regulation and nonverbal performance are critical to the complete functional analysis of human FI performance (see Barnes, 1989). As Hayes (1986) has pointed out,

In a behavior-analytical approach, all "causes" are ultimately restricted to environmental events. Behavioral causes are not ultimately acceptable because no one can change behavior without changing its context (e.g., through instructions, drugs, consequences, settings). Behavioral influences are often thought to be important aspects of an overall causal chain (Skinner, 1984), but for philosophical reasons the search is never ended until sources of environmental control are established. . . . If cognitive phenomena control other behavior, the task is to identify the environmental supports for such behavior-behavior relations. (p. 361)

Of course, the use of retrospective written verbal reports in the present studies for recording the occurrence, or nonoccurrence, of the subjects' verbal regulation places a question mark over the reliability of the verbal-regulation data (see Shimoff, 1986). However, use of retrospective reports was necessary at this stage, insofar as any other procedure for recording covert verbal behavior (e.g., the "think aloud" technique; see Hayes, 1986) would involve introducing two major changes to the typical human FI experiment (i.e., concurrent activities *and* novel verbal recording procedures). This would then raise the type of interpretative problem that the current studies specifically set out to avoid. At the present time, therefore, it seems best simply to acknowledge the tentative nature of the verbal

data and to be fully aware of the need to develop reliable procedures for recording covert verbal behavior in human operant experiments (e.g., Wulfert, Dougher, & Greenway, 1991).

The present studies demonstrated an important behavioral effect. However, this effect now requires an explanation that focuses on the context supporting the behavior. One approach could involve considering the present experimental manipulation as functionally equivalent to the presentation and removal of a concurrent schedule arrangement (see Lattal & Bryan, 1976). It may be, for example, that verbal regulation was negatively punished in the presence of the television because counting caused subjects to miss an entertaining program (i.e., they found it difficult to count and attend to the program at the same time). Therefore, future experimental analysis with human subjects might examine the consequential functions of various concurrent activities. For instance, it remains to be seen how FI performance would be affected if access to the activities were response dependent, as in requiring an observing response to gain access to the television or magazine. Another approach to the current findings could focus on the issue of antecedent control provided by the concurrent activities. For instance, subjects' verbal reports often indicated that the activities (and particularly the television) were discriminative for *not* timing the FI. That is, subjects often reported that the presence of the television was taken as a "message" from the experimenter that they should not attempt to count out the intervals. It may be useful, therefore, to regard subjects' behavior in the current study, at least in part, as an instance of rule-governed behavior (see Cerutti, 1989; Hayes, Zettle, & Rosenfarb, 1989; Schlinger, 1990; Skinner, 1966). Clearly, considerable research is needed on the effects of concurrent activities on human schedule-controlled performance, and it is important that this work systematically examine both the consequential functions of the activities and their antecedent or rule-governing properties.

The present studies go some way towards demonstrating that concurrent activities can be a powerful controlling variable in human schedule-controlled performance. As yet, the exact nature of this control and the conceptual ramifications remain unclear. Nevertheless, the present studies successfully demonstrated pre-

diction and control of human FI performance. This finding in itself represents a call for greater attention, both empirical and theoretical, to the effects of concurrent activities in human operant research.

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