JOURNAL OF THE EXPERIMENTAL ANALYSIS OF BEHAVIOR 1980, 34, 239-261 NUMBER 3 (NOVEMBER)

REINFORCEMENT OF HUMAN OBSERVING BEHAVIOR BY A STIMULUS CORRELATED WITH EXTINCTION OR INCREASED EFFORT

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Young men pulled a plunger on mixed and multiple schedules in which periods of variable-interval monetary reinforcement alternated irregularly with periods of extinction (Experiment 1), or in which reinforcement was contingent on different degrees of effort in the two alternating components (Experiment 2). In the baseline conditions, the pair of stimuli correlated with the schedule components could be obtained intermittently by pressing either of two observing keys. In the main conditions, pressing one of the keys continued to produce both discriminative stimuli as appropriate. Pressing the other key produced only the stimulus correlated with variable-interval reinforcement or reduced effort; presses on this key were ineffective during periods of extinction or increased effort. In both experiments, key presses producing both stimuli occurred at higher rates than key presses producing only one, demonstrating enhancement of observing behavior by a stimulus correlated with the less favorable of two contingencies. A control experiment showed that stimulus change alone was not an important factor in the maintenance of the behavior. These findings suggest that negative as well as positive stimuli may play a role in the conditioned reinforcement of human behavior.

Key words: observing behavior, conditioned reinforcement, information, multiple schedule, stimulus control, response effort, choice, vigilance task, adult humans

Although there is agreement that stimuli correlated with primary reinforcers may function as conditioned reinforcers, the precise character of the correlation is a matter of contention (D'Amato, 1974; Fantino, 1977). A common point of view is that the principles of conditioned reinforcement parallel the principles of Pavlovian conditioning (Fantino, 1977; Kimble, 1961; Mackintosh, 1974). Recent clarifications of Pavlovian conditioning (Rescorla & Wagner, 1972) suggest that a positive correlation between a stimulus and a reinforcer is required and that the underlying process is excitatory conditioning. Negative correlations, in which the stimulus is paired with omission of the reinforcer (Pavlovian inhibitory conditioning), should establish the stimulus as a conditioned punisher (cf. Mulvaney, Dinsmoor, Jwaideh, & Hughes, 1974).

A different conception of conditioned reinforcement ascribes reinforcing functions to stimuli that provide information about either the presentation or omission of reinforcers (Hendry, 1969). According to this view, a positive stimulus-reinforcer correlation is not needed for conditioned reinforcement; rather, the correlation may be positive or negative, since information depends on the reliability, not the sign, of the stimulus-reinforcer relationship.[1]

Wyckoff's (1952) observing procedure provides a way to test the Pavlovian and information accounts. In this procedure, stimuli cor-

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Portions of the results were reported at the meetings of the Midwestern Association of Behavior Analysis, Chicago, May 1977, and the Association for Behavior Analysis, Dearborn, Michigan, June 1979, as well as in a master's thesis prepared by Michael Perone under the direction of Alan Baron. The research was supported by Grant DA01080 from the National Institute on Drug Abuse and by the Graduate School and College of Letters and Science of the University of Wisconsin–Milwaukee. The authors are indebted to Dean Williams, JoAnne Carroll, and Cindy Wood for trustworthy assistance in the collection and analysis of the data, to Harold Schrubbe and the Milwaukee Labor Council for cooperation in the recruitment of subjects, and to Jay Moore for his helpful comments on the manuscript. Reprints may be obtained from Alan Baron, Department of Psychology, University of Wisconsin—Milwaukee, Milwaukee, Wisconsin 53201.

[1] Fantino (1977) classified two Pavlovian accounts, the pairing and delay-reduction hypotheses, under the term "conditioned reinforcement hypothesis," which he contrasted with the information hypothesis. Fantino's distinction implies that a stimulus that functions as a reinforcer because it is informative is not a "conditioned" reinforcer. We are not committed to such a view.

related with the components of a complex schedule are produced by responses. These observing responses in no way alter the occurrence of primary reinforcement; their only consequence is to present the stimulus correlated with the current schedule component. When the schedule of primary reinforcement involves periods of reinforced responding alternating with periods of extinction, the functions of a stimulus positively correlated with reinforcement (S+) can be compared with those of a stimulus negatively correlated with reinforcement (S−).

Both Pavlovian and information accounts ascribe reinforcing functions to S+; the major point of contention concerns S−. According to Pavlovian accounts, S− should function not as a conditioned reinforcer, but as a conditioned punisher. According to the information hypothesis, S− should serve as a positive reinforcer, because a stimulus correlated with the unavailability of primary reinforcement is as informative as a stimulus correlated with its availability.

Experiments designed specifically to assess the functions of S+ and S− have favored Pavlovian accounts. While S+ has been found to strengthen observing behavior, S− has suppressed it (Blanchard, 1975; Browne & Dinsmoor, 1974; Dinsmoor, Browne, & Lawrence, 1972; Jenkins & Boakes, 1973; Mulvaney et al., 1974). For example, Mulvaney et al. trained pigeons to peck two concurrently available observing keys to produce stimuli correlated with the components of a mixed variable-interval extinction schedule of food reinforcement. In the main phase, pecks on one key intermittently produced S+ or S−, and pecks on the other key produced only S+. Rates were lower on the key that produced both S+ and S− than on the key that produced only S+, and this difference was maintained when the roles of the keys were interchanged. These findings led Mulvaney et al. to conclude that S− was a conditioned aversive stimulus, since it decreased the probability of the response that produced it.

To our knowledge, only one study has directly examined the properties of the negative discriminative stimulus in subjects other than pigeons. Lieberman (1972, Experiment 3) trained rhesus monkeys on a mixed variable-ratio extinction schedule with discriminative stimuli available through an observing response. When S− was withheld as a possible consequence of observing, rates declined, suggesting that S− had been a conditioned reinforcer. Thus, whereas results obtained with pigeons support Pavlovian accounts, Lieberman's findings with monkeys support the information hypothesis. Although the methodological adequacy of Lieberman's study has been questioned (Dinsmoor et al., 1972; Fantino, 1977), the findings suggest at least the possibility that there may be species differences in the extent to which information is a determinant of conditioned reinforcement.

The present research analyzed observing behavior of humans. Experimental analyses of conditioned reinforcement in humans are scarce (but, see Birnbrauer, 1971), even though conditioned reinforcement plays a prominent role in theoretical accounts of human behavior (Miller & Dollard, 1941; Skinner, 1953). The reinforcing value of informative stimuli is an essential feature of Skinner's (1957) analysis of verbal behavior. The tact is a verbal operant in which the form of the response is controlled by some environmental event, so that the response may be said to "report" the event. Skinner suggested that tacts reinforce the attention of a listener by extending the listener's contact with events that are directly accessible only to the speaker. Similarly, in the observing paradigm the subject's observing behavior is reinforced by stimuli correlated with contingencies that may not be readily discriminable.

The reinforcing function of stimuli correlated with the less favorable of two contingencies was studied in the present research. Two experiments examined stimuli correlated with periods of extinction or increased effort, events generally considered aversive. A third experiment compared informative and noninformative stimuli to determine whether observing behavior depends on sensory aspects of stimulus presentation rather than on stimulus-reinforcer relationships.

EXPERIMENT 1

The first experiment studied the functions of stimuli positively and negatively correlated with monetary reinforcement. The basic procedure was derived from Holland's (1958) vigilance task. Young men pulled a plunger to view a meter, reporting occasional deflections of its pointer. Money was given for correct reports. Components in which deflections were presented on a variable-interval (VI) schedule alternated irregularly with components of extinction (EXT), and initially the components were correlated with colored stimulus lights. In the main phase, which replicated and extended research conducted with pigeons (Mulvaney et al., 1974), the stimuli were not presented unless either of two observing responses was made. The functions of S+, the stimulus correlated with the VI component, and S−, the stimulus correlated with the EXT component, were assessed in a series of comparisons. In the comparison of greatest interest, one observing response produced both S+ and S− (depending on the schedule component in progress) while the other response produced only S+. If S− is aversive, as predicted by Pavlovian accounts, then the response producing both S+ and S− should be suppressed relative to the response producing only S+. However, if S− is a reinforcer, as predicted by the information hypothesis, then the response producing both stimuli should be enhanced relative to the response producing only S+. Finally, in two further comparisons the consequences of the observing responses were S+ and S− vs. S− alone, and S+ alone vs. S− alone.

METHOD

Subjects

Male industrial workers, aged 26 to 34 years, volunteered to participate in a laboratory job simulation in which payment depended on performance.[2] They signed a contract to work at least 40 hr over a two-week period, scheduled 4 hr per day, 5 days per week. To ensure completion of the project, a bonus of $2.50/hr was contingent on completing all sessions. The bonus was in addition to money earned during the sessions.

Data from seven men are reported. Four (DL, JS, GK, and DB) were experimentally naive at the start of training. Two others (ST and JP) had experience with multiple schedules and concurrent observing schedules in pilot studies, and the seventh man (RV) served in Experiment 2 immediately before the present experiment. Two additional men participated, but their data are not reported. One failed to observe often enough to permit study; the other, while observing at high rates, developed a stereotyped pattern of alternations between the keys that was resistant to remedial procedures.

Apparatus

The work area was a sound-attenuated booth approximately 1.8-m square. The subject sat facing the console depicted in Figure 1. The console was constructed of wood and Plexiglas and consisted of an upper vertical panel, 51 by 40 cm, and a lower sloping panel, 51 by 33 cm. Mounted underneath and to the right was a rectangular wooden housing, 12 by 16 by 25 cm, containing a Lindsley plunger (Gerbrands No. G6310). On the vertical panel was a session lamp, two ammeters mounted behind one-way glass, a horizontal bank of five colored lamps above each meter, and a pushbutton between the meters. The left meter and bank of lamps were not used. The session

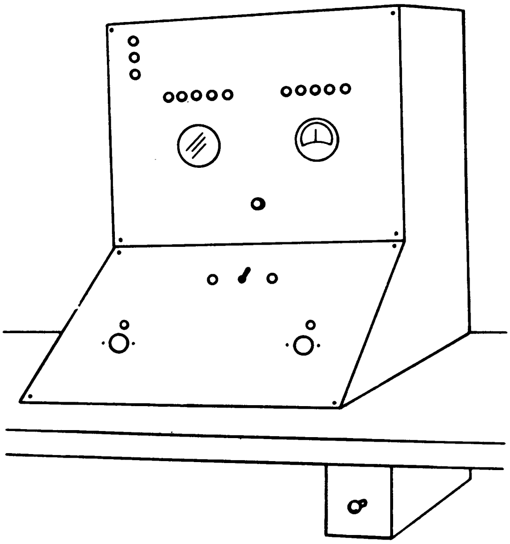

Fig. 1. Subjects' console as it appeared in Experiment 1. The right meter is shown illuminated, with its pointer deflected; the left meter and bank of lamps were not used. Modified versions of the apparatus were used in Experiments 2 and 3.

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[2] These subjects, as well as those in Experiments 2 and 3, had responded to an announcement from their local unions soliciting paid volunteers to provide data concerning job performance and drug use among industrial workers (e.g., Perone, DeWaard, & Baron, 1979). Their participation was in the nature of a temporary job held in addition to their regular employment. Selection was based in part on the subjects' histories of illicit drug use, with approximately half of the subjects classified as users and the others as nonusers. No systematic relationship was discerned between drug history and experimental performance.

lamp, in the upper left corner, was lit whenever the experiment was in progress. The meter was not visible unless illuminated by lamps mounted behind the one-way glass; otherwise the glass presented a mirror surface to the subject. The meter could be illuminated for .1 sec by pulling the plunger through a distance of 2.5 cm, which required a force of 5 lb dead weight (approximately 22 N).

On the lower sloping panel of the console was a toggle switch flanked by two white lamps; below this were two translucent keys (Grason-Stadler No. E8670A). Above each key was a small feedback lamp. The toggle served as a changeover switch. When the lower panel was activated, the subject could throw the switch to either side to illuminate the corresponding white lamp and the corresponding key. When illuminated, the key was operative and presses with a force of .5 to .9 N flashed its feedback lamp.

White masking noise was present at all times, and general illumination was provided by a 25-W wall lamp. Electromechanical programming and recording equipment was in a nearby room.

Procedure

Instructions and general procedure. Before the first session the subject read typewritten instructions about the meter and plunger, bank of colored lamps, and lower panel. A copy remained in the booth throughout the experiment. The instructions describing the meter and plunger were the most detailed. They informed the subject that: (a) occasionally the pointer of the meter would deflect; (b) his job was to report the deflections by pressing the button in the middle of the upper panel; (c) he could view the meter by pulling the plunger; and (d) he would be paid for each deflection reported. When a deflection was reported, the meter was illuminated for .5 sec while it reset, allowing the subject to confirm the pointer's return to its resting position (Laties & Weiss, 1960). With regard to the bank of colored lamps, the subject read that they "will provide you with more information about how the meter works, so you should pay attention to them. It will help you on this job to learn what the lights mean."

The instructions about the lower panel were the least explicit. In total, they read: "On the lower part of the console are two push buttons, a toggle switch, and some more lights. The two white buttons work only when they are lit. The toggle switch only works when one of the lights on either side of it is lit. Right now, these controls on the lower part of the console are not lit, so they are not working. Later on, they may light up. It is up to you to discover how to use this part of the console in your work." Finally, the instructions emphasized that "while you are in the room, you can do whatever you like, but remember that your pay depends on what you do."

There were eight 25-min sessions per day, Monday through Friday. After every other session, the subject was informed of his earnings and allowed to leave the booth for about 5 min. The rate of pay was 15 cents for each deflection reported, except for GK who responded on a leaner schedule and received 30 cents per deflection. The schedules of deflections and pay rates were arranged so that the maximum session earning was constant at $2.00 (not counting the bonus). Payment was deferred until the end of the experiment. Personal articles were not allowed in the work area.

Schedule of deflections. Throughout the experiment, the pointer of the meter deflected according to a two-component schedule. In one component, deflections occurred at variable times and held until they were illuminated by a pull on the plunger and reset by a push on the report button. Thus plunger pulling was reinforced by a VI schedule of deflections: VI 1-min for six men, VI 2-min for GK. Intervals were from the Fleshler-Hoffman (1962) series, modified so that the minimum interval was 5 sec. In the other, EXT, component, deflections never occurred. Except during Session 3 (see *Discrimination training,* below), the components alternated on the average of once every 5 min, with a range of 40 to 560 sec. During discrimination training, colored lights were correlated with the components (multiple schedule). For different subjects, S+ and S− were either green and red, blue and yellow, or yellow and blue. During the observing phase, S+ and S− were not present unless a key on the lower panel was pressed (mixed schedule).

Preliminary training. To simplify adjustment to the procedure, no stimulus lights were present during Sessions 1 and 2, and the only responses with scheduled consequences were pulling the plunger and pushing the report button.

Discrimination training. The VI schedule, accompanied by S+, was in effect continuously during Session 3. During Session 4 the EXT component, accompanied by S−, was in effect for the initial 560 sec (the longest component duration); thereafter, the components alternated as described above. (Exceptions were made for ST and JP; because they had previous experience with a multiple VI EXT schedule, this initial phase of discrimination training was not necessary.) So that plunger pulling in the presence of S− could not be adventitiously reinforced by onset of S+, offset of the EXT component was contingent on the absence of plunger pulling for at least 15 sec. (For ST the delay was 5 sec.) This delay contingency operated throughout the experiment when S− was present. The multiple schedule continued for 11 to 20 sessions, until discrimination ratios (S+ rates divided by the sum of S+ and S− rates) were at least .95 for five consecutive sessions.

Observing contingency. For the remainder of the experiment, the discriminative stimuli normally were absent. However, presses on the observing keys could produce 15-sec presentations of S+ or S− (depending on the current schedule component).

Observing behavior was shaped in a single session. Only one key was operative at a time. Initially, each press on that key produced the stimuli, while presses on the other key had no consequence (other than feedback). After a variable number (1 to 4) of stimuli was produced, the functions of the keys were reversed, and stimuli could be produced only by presses on the other key. The subject chose which key to press by throwing the changeover toggle switch to the corresponding side. The irregular alternation of the reinforcement schedule between the two keys was continued until responding on both the observing keys and the changeover switch was established.

When observing behavior was established, presses on either key produced the multiple-schedule stimuli according to identical, independent VI 30-sec schedules (concurrent VI 30-sec VI 30-sec). Again, a modified Fleshler-Hoffman series was used. During the 15-sec stimulus presentations, the keys were inoperative and the concurrent observing schedules were suspended. If the schedule of pointer deflections changed components during a stimulus presentation, the stimulus display changed accordingly.

Two additional delay contingencies were instituted during the observing phase. First, to avoid adventitious correlations between observing and pointer deflections, deflections could not occur within 2 sec of an observing response. Similarly, to avoid correlations between changeovers and the production of stimuli, observing responses could not produce stimuli within 2 sec of throwing the changeover switch.

Two men received additional training to facilitate their observing behavior. For JP, a limited-hold contingency required that deflections be reported within 1 sec after the meter was illuminated. The purpose of the limited hold was to require JP to remain near the console; during a pilot study his observing rate fluctuated widely because he often sat out of reach of the observing keys. The other subject, JS, rarely used the changeover switch; his observing behavior was restricted to one key for long periods. Consequently, a forced-choice procedure (Stubbs & Pliskoff, 1969) required that a stimulus presentation set up by one of the concurrent observing schedules be collected before a presentation could be set up by the other schedule. After 40 sessions under this procedure JS changed over regularly, and the experiment proper was begun with the independent observing schedules.

Observing comparisons. Table 1 presents the observing conditions, the number of sessions in each, and the order of occurrence (in parentheses) for each subject. In addition to a baseline in which either observing response could produce both S+ and S−, three experimental comparisons involved different stimulus consequences for the two responses. In the *S+/S− vs. S+* comparison, one response continued to produce S+ and S− as during baseline, but the other produced only S+. That is, the second observing response could produce stimuli only when the VI component was in progress; it had no consequence (other than feedback) during the EXT component. In the *S+/S− vs.* S− comparison, one response again produced both stimuli, but the other produced only S−. Finally, in the *S+ vs. S−* comparison, one response produced only S+ while the other produced only S−. After observing stabilized the stimulus consequences of the two

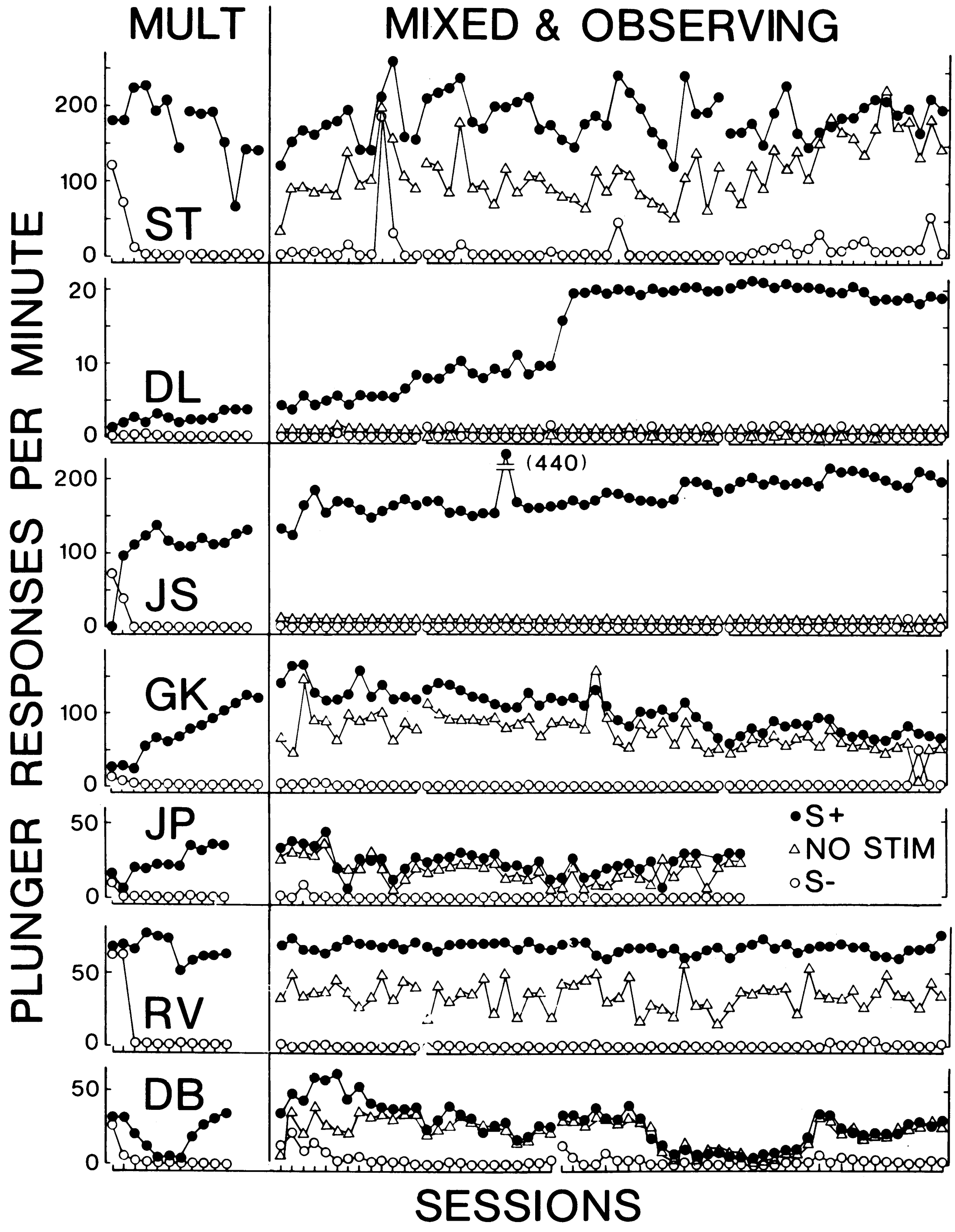

Fig. 2. *Experiment 1:* Plunger rates in the presence and absence of S+ (correlated with the VI component of a compound schedule) and S— (correlated with the EXT component). During sessions shown on the left, a multiple schedule was in effect; during sessions shown on the right, the stimuli were contingent on observing responses. Breaks in the horizontal axis indicate omissions of data to conserve space. Note that the scale of the vertical axis varies from subject to subject.

responses were interchanged to verify that they controlled differences in response rates.

Each experimental condition continued for 16 to 24 sessions, except DL's last two conditions and RV's last four conditions, which were abbreviated due to time constraints. Otherwise, conditions were continued until there was no increasing or decreasing trend in the proportion of presses on the two observing keys, and the same key was preferred, for five consecutive sessions—or for a maximum of 24 sessions.

RESULTS AND DISCUSSION

Rates of Plunger Pulling

Figure 2 summarizes rates of plunger pulling, the response that illuminated the meter. The left portion shows responding during the multiple-schedule phase and the right portion shows responding during the remainder of the experiment when the stimuli appeared only occasionally, according to the intermittent observing schedules. All men developed discriminated performances by the third session under the multiple schedule, with higher plunger rates in the presence of S+ (filled circles) than S− (unfilled circles). Although there was considerable subject-to-subject variability in S+ rates, all subjects showed essentially zero S− rates. This pattern continued throughout the subsequent observing phase. Depending on observing rates, the mixed schedule was in effect (neither stimulus present) from 55% to 90% of the time. When the schedule was mixed (triangles), plunger rates tended to be intermediate to rates in S+ and S−. Cumulative records revealed that these intermediate rates resulted from the averaging of high plunger rates, which occurred following presentations of S+, with lower rates, which occurred following S−. There were a variety of response patterns as the experiment progressed, including increasing trends (e.g., DL), decreasing trends (e.g., GK) and complex cyclical patterns (e.g., ST). But with only occasional exceptions, plunger rates were highest in the presence of S+ and essentially zero in the presence of S−.

Observing Responses

Table 1 presents the observing-response rates and the proportions of time that a response-produced stimulus was present, averaged over the last five sessions in each condition. All subjects produced the stimuli throughout the experiment, although there was considerable subject-to-subject and session-to-session variability in the absolute levels of the observing responses. Despite these differences, the proportion of time when the stimuli were present tended to be relatively stable, especially within individuals.

Relative observing rate (proportion of presses on a given observing key) and relative observing time (proportion of time that a given key was operative) are shown in Figures 3 and 4. Because the relative rates (filled circles) and times (unfilled circles) were highly related, the two measures will not be distinguished in describing the results. (In cases where only rate is shown, the rate and time measures were identical; an exception is ST, for whom time data were not available for the first two conditions.) Numbers in the lower right corner of each frame show the order of conditions. The broken horizontal line represents indifference toward the consequences of the two observing responses; points above this line indicate preference for the consequences of the left response and points below it indicate preference for the consequences of the right response.

The first five observing conditions are shown in Figure 3. (Data from DB are not shown because he was exposed to only one of the five conditions.) In the baseline condition (left frame), either response could produce both S+ and S−. ST, DL, JS, and RV pressed the two keys about equally (as did DB), whereas GK and JP preferred the left key during the terminal baseline sessions. In the remaining conditions in Figure 3, one response produced both S+ and S− and the other produced either S+ alone or S− alone. Five men (all except JS) clearly preferred S+/S− to S+ alone and continued this preference when the roles of the observing keys were reversed. Although RV's preference was weak, it was consistent through an additional reversal. Four men participated in the *S+/S− vs. S−* conditions. Three (ST, DL, and GK) preferred S+/S− to S− alone and continued this preference through a reversal. In both sets of conditions, JS's preferences were similar but transitory.

Four men also participated in the *S+ vs. S−* conditions, shown in Figure 4. Two (RV and DB) showed no consistent preference. The other two did show preferences, but they were

Table 1

Experiment 1: Sessions per observing condition, and mean observing rate and proportion of time stimuli were present during the last five sessions. Also shown (in parentheses) are the order of the conditions and the standard deviation for each mean.

Subject	*Comparison*	*Stimuli available*		*Sessions*	*Observing resp./min*		*Stimulus time ÷ Component time*	
		Left key	*Right key*		*Left key*	*Right key*	*S+*	*S−*
ST	[Baseline]	S+, S−	S+, S−	18(1)	111 (9)	112 (12)	.41 (.02)	.50 (.02)
	S+/S− vs. S+	S+, S−	S+	20(2)	99 (12)	63 (16)	.40 (.04)	.31 (.05)
		S+	S+, S−	19(3)	67 (19)	140 (49)	.41 (.02)	.30 (.05)
	S+/S− vs. S−	S+, S−	S−	22(4)	122 (7)	52 (14)	.31 (.05)	.39 (.05)
		S−	S+, S−	16(5)	58 (18)	98 (27)	.28 (.02)	.41 (.13)
DL	[Baseline]	S+, S−	S+, S−	9(1)	133 (35)	161 (41)	.43 (.04)	.43 (.04)
	S+/S− vs. S+	S+, S−	S+	16(2)	210 (27)	120 (18)	.39 (.05)	.32 (.06)
		S+	S+, S−	20(3)	84 (9)	319 (10)	.38 (.04)	.28 (.06)
	S+/S− vs. S−	S+, S−	S−	16(4)	347 (38)	67 (35)	.29 (.04)	.38 (.03)
		S−	S+, S−	16(5)	114 (34)	303 (34)	.33 (.04)	.36 (.06)
	S+ vs. S−	S−	S+	13(6)	175 (19)	238 (22)	.31 (.05)	.33 (.08)
		S+	S−	12(7)	271 (25)	147 (21)	.31 (.07)	.28 (.04)
JS	[Baseline]	S+, S−	S+, S−	15(3)	72 (24)	84 (23)	.45 (.02)	.47 (.04)
	S+/S− vs. S+	S+, S−	S+	24(2)	82 (32)	85 (56)	.44 (.02)	.30 (.04)
		S+	S+, S−	24(1)	119 (38)	110 (29)	.44 (.02)	.31 (.05)
	S+/S− vs. S−	S+, S−	S−	16(5)	130 (37)	66 (36)	.31 (.05)	.42 (.05)
		S−	S+, S−	16(4)	69 (23)	93 (30)	.31 (.04)	.47 (.06)
GK	[Baseline]	S+, S−	S+, S−	22(1)	1.3 (.3)	.0 (.0)	.15 (.04)	.22 (.03)
	S+/S− vs. S+	S+, S−	S+	16(3)	1.2 (.4)	.0 (.0)	.11 (.04)	.21 (.06)
		S+	S+, S−	16(2)	.0 (.0)	1.2 (.4)	.10 (.04)	.21 (.03)
	S+/S− vs. S−	S+, S−	S−	16(5)	1.2 (.0)	.0 (.0)	.10 (.04)	.18 (.02)
		S−	S+, S−	16(4)	.0 (.0)	1.0 (.3)	.09 (.03)	.21 (.03)
	S+ vs. S−	S−	S+	16(7)	1.8 (.4)	.0 (.0)	.00 (.00)	.24 (.04)
		S+	S−	16(6)	.0 (.0)	1.2 (.0)	.00 (.00)	.22 (.02)
JP	[Baseline]	S+, S−	S+, S−	10(1)	1.3 (.5)	.5 (.3)	.14 (.07)	.28 (.04)
	S+/S− vs. S+	S+, S−	S+	16(3)	1.1 (.7)	.0 (.0)	.12 (.04)	.21 (.04)
		S+	S+, S−	16(2)	.0 (.0)	2.0 (.7)	.23 (.09)	.26 (.02)
RV	[Baseline]	S+, S−	S+, S−	12(1)	31.3 (11.0)	24.6 (5.5)	.47 (.05)	.41 (.03)
	S+/S− vs. S+	S+, S−	S+	8(3)	33.9 (2.2)	29.9 (1.9)	.46 (.03)	.28 (.03)
		S+	S+, S−	16(2)	29.6 (1.6)	31.9 (1.7)	.47 (.02)	.31 (.02)
		S+	S+, S−[a]	12(4)	25.8 (7.1)	29.5 (5.5)	.45 (.04)	.29 (.09)
	S+ vs. S−	S−	S+	10(6)	17.9 (.9)	18.6 (1.5)	.21 (.09)	.23 (.02)
		S+	S−	10(5)	32.4 (8.9)	23.5 (4.3)	.25 (.03)	.16 (.05)
DB	[Baseline]	S+, S−	S+, S−	15(1)	6.9 (1.4)	6.5 (2.4)	.36 (.04)	.36 (.03)
	S+ vs. S−	S−	S+	24(2)	7.2 (3.4)	7.5 (1.9)	.24 (.05)	.20 (.06)
		S+	S−	24(3)	9.9 (5.0)	12.0 (7.7)	.22 (.02)	.22 (.02)

[a] Second determination

for different stimuli: DL preferred S+ and GK preferred S−.

The patterns of observing behavior shown in Figures 3 and 4 resulted in systematic changes in the proportion of time the discriminative stimuli were present. These data, summarized in Table 1, indicate that of the six men who participated in the first two comparisons, four (ST, DL, JS, and RV) produced S+ more often than S− during the *S+/S− vs. S+* comparison, and S− more often than S+ during the *S+/S− vs. S−* comparison. Thus, for these subjects the proportion of time a stimulus was present depended on whether the stimulus was available through one or both observing response, with the stimulus available through both responses being produced more often. The other subjects (GK and JP) produced S− more often than S+ in both comparisons. Finally, of the four men in the *S+ vs. S−* comparison, three (DL, RV, and DB) produced the stimuli about equally often in most conditions, whereas GK produced S− exclusively.

The major finding of Experiment 1 was that S−, a stimulus negatively correlated with reinforcement, showed a response-strengthening function similar to that of S+, a stimulus positively correlated with reinforcement. S− main-

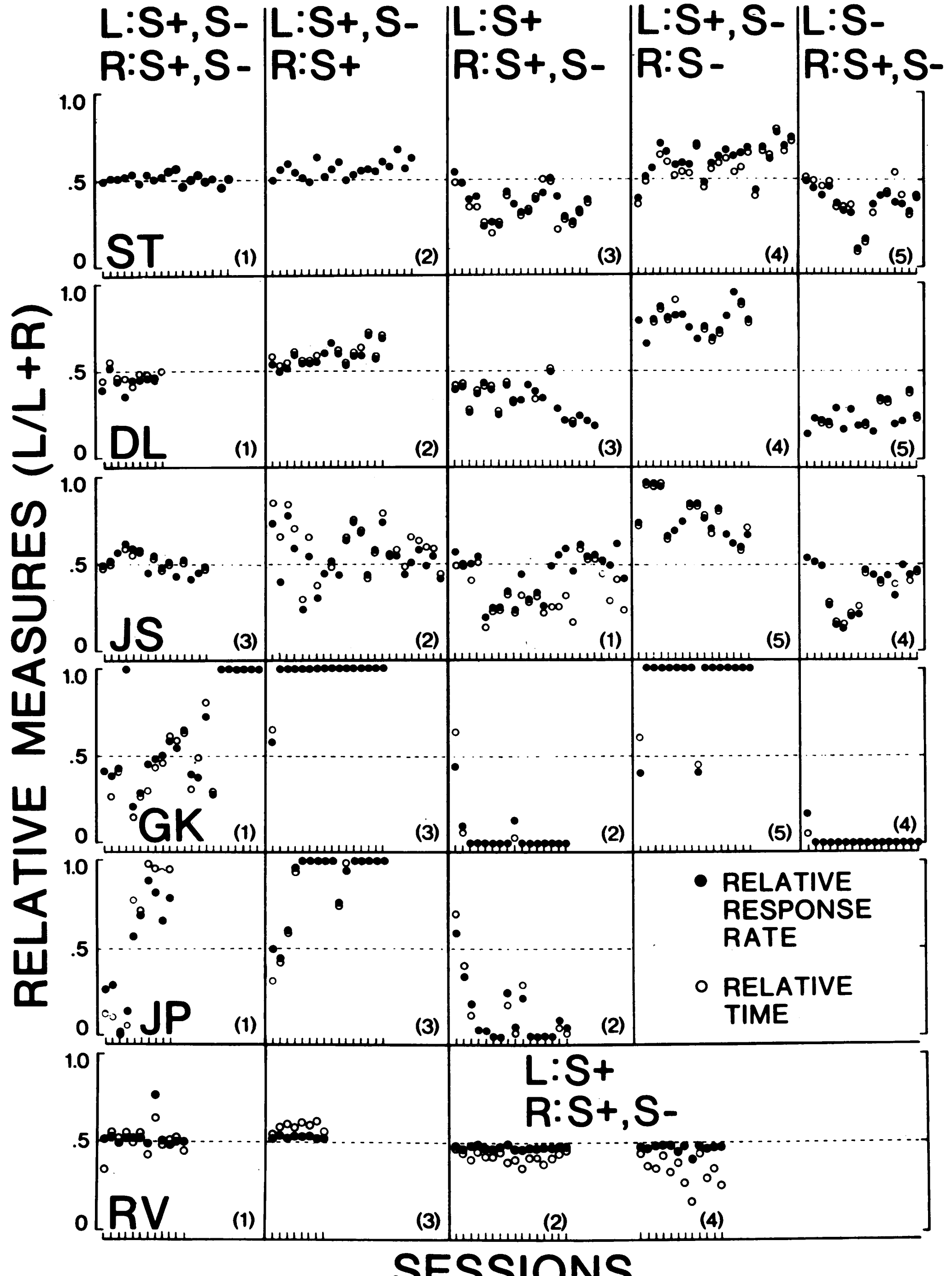

Fig. 3. *Experiment 1:* Relative observing-response rates and times during the baseline condition (left frame), the *S+/S− vs. S+* comparison (Frames 2 to 3), and the *S+/S− vs. S−* comparison (Frames 4 to 5). Points above and below the broken indifference line reflect preference for the consequences of the left and right observing responses, respectively. When rate and time measures are identical only rate is shown; however, time data were not available for ST's first two conditions. Numbers in parentheses give the order of the conditions.

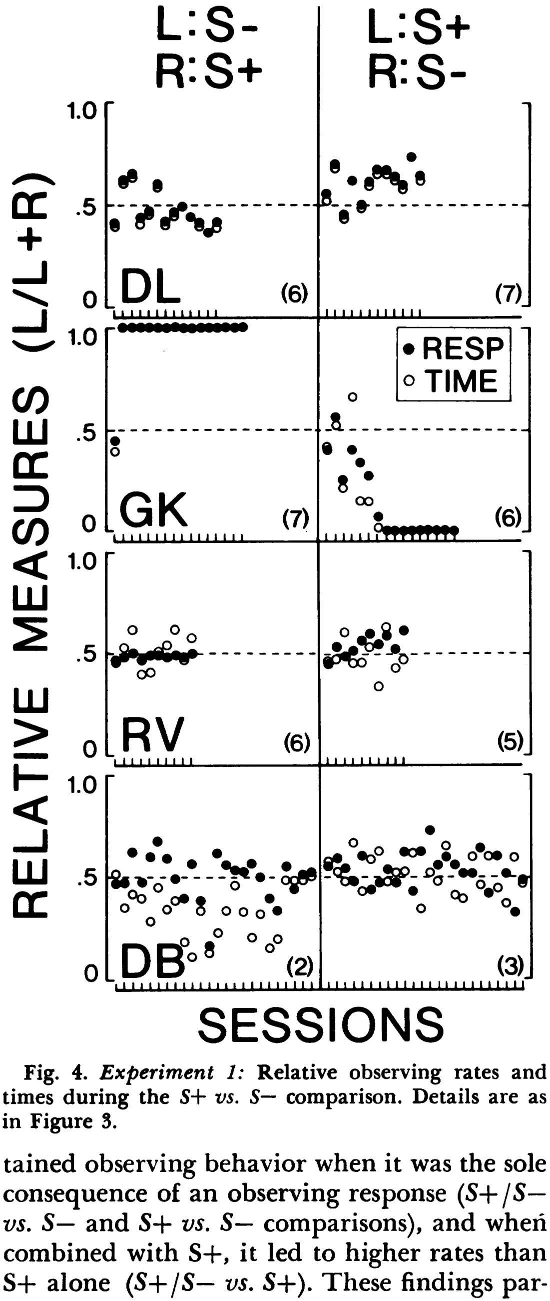

Fig. 4. *Experiment 1:* Relative observing rates and times during the *S*+ *vs. S*− comparison. Details are as in Figure 3.

tained observing behavior when it was the sole consequence of an observing response (*S*+/*S*− *vs. S*− and *S*+ *vs. S*− comparisons), and when combined with S+, it led to higher rates than S+ alone (*S*+/*S*− *vs. S*+). These findings paralleled those obtained with S+, which also strengthened behavior when it was the sole consequence of an observing response (*S*+/*S*− *vs. S*+ and *S*+ *vs. S*−) and when presented in combination with S− (*S*+/*S*− *vs. S*−).

By showing that the negative discriminative stimulus as well as the positive one served as reinforcers, these findings appear to support the information hypothesis of conditioned reinforcement. As such, the results are contrary to those of similar experiments using pigeons as subjects (e.g., Mulvaney et al., 1974), but are consistent with Lieberman's (1972) findings with rhesus monkeys.

EXPERIMENT 2

Although previous research has shown that a stimulus correlated with the extinction component of a multiple schedule becomes aversive (e.g., Mulvaney et al., 1974; Rilling, Kramer, & Richards, 1973), Experiment 1 indicated that such a stimulus also can serve as a reinforcer, perhaps because of its informative function. Another, Pavlovian, explanation is suggested by the finding that periods of timeout from interval schedules (Brown & Flory, 1972; Spealman, 1979) and ratio schedules (Dardano, 1973; Thompson, 1964) may serve as reinforcers. Thus, the extinction periods in Experiment 1 may have terminated an aversive task requiring continuous responding and sustained vigilance.

Previous research suggests that the plunger response of Experiment 1 was not aversive. Miller (1968) trained humans to pull a plunger whose force requirement varied from 1 lb to 40 lb. Aversiveness of responding was investigated by allowing subjects to escape to a condition in which a 1-lb plunger was available. Although high rates of escape behavior occurred when the force requirement was 15 lb or greater, virtually none occurred when the requirement was 5 lb, as it was in Experiment 1. Miller's findings suggest that reinforcement of observing behavior by the extinction-correlated stimulus in Experiment 1 is not interpretable as timeout from an aversive response requirement. Nevertheless, conclusive evidence on this point requires direct assessment.

In Experiment 2, plunger pulling was maintained on a VI schedule with monetary reinforcement contingent on different degrees of effort in two alternating components. Thus, neither of the stimuli correlated with the schedule components signaled a timeout from responding. Interest was in the function of the stimulus correlated with increased effort, since high force requirements are aversive (Miller, 1968). According to Pavlovian accounts, this stimulus also should become aversive. According to the information hypothesis, however, the high-effort stimulus should become reinforcing, because it provides information about the response required for monetary reinforcement.

METHOD

Subjects

Three male workers, aged 23 to 27 years, participated in the main phases. A fourth subject's stimulus preference did not appear until late in training and his data are not reported. Limited additional data were collected from a fifth subject to clarify the role of the discriminative stimuli in efficient plunger pulling. This subject (BJ) did not particpate in the differential observing conditions, and only his data pertaining to plunger-pulling efficiency in the other conditions are presented. All of the men were experimentally naive at the start of training.

Apparatus

The apparatus was modified by mounting a second plunger under the table to the right of the console. Pulling the first plunger required a force of 5 lb dead weight (approximately 22 N); pulling the second required 15 lb (67 N) for RV and GC and 20 lb (89 N) for FB. In addition, the changeover toggle switch was replaced with a pushbutton, allowing deactivation of the changeover operandum during stimulus presentations and before and after sessions. Electromechanical equipment controlled experimental events, and a computer (Digital Equipment Corporation PDP 11/40) recorded the data.

Procedure

Schedule of deflections. A VI 1-min schedule of pointer deflections was programmed in each of two irregularly alternating components. A reported deflection was worth 8 cents. In both components, pulls on either plunger illuminated the meter, but the further consequences of the plunger responses differed across the components. In the low-effort component, pulls on both the low-effort (5-lb) and high-effort (15- or 20-lb) plungers revealed deflections. In the high-effort component, only high-effort pulls revealed deflections, although low-effort pulls continued to illuminate the meter. A .3-sec delay separated initiation of either plunger response and meter illumination; during this delay the plunger had to be held in the extended position and feedback was provided by the white light above the meter. In the high-effort component, if the pointer was deflected, a pull on the low-effort plunger reset it momentarily so that the deflection was not revealed. The .3-sec delay ensured that the pointer had returned to its resting position by the time the meter was illuminated. Even though neither plunger response reset pointer deflections in the low-effort component, the delay was included in both schedule components so that it could not function as a discriminative stimulus.

The use of two plungers required contingencies in addition to those of the first experiment. To prevent simultaneous pulls on the two plungers, a pull on one plunger deactivated the other plunger until the first was released. To prevent adventitious reinforcement of alternations between the two plungers, a changeover delay arranged that pulls on one plunger were not reinforced by a deflection within 2 sec of a pull on the other plunger.

In summary, the main features of the schedule were as follows: (a) the pointer of the meter deflected at variable times in two components; (b) the high-effort plunger response revealed deflections regardless of the component; (c) the low-effort response revealed deflections in only one component, and in the other component it illuminated an undeflected meter; (d) thus, the operant contingency involving the low-effort response was a multiple (or later mixed) VI EXT schedule comparable to that of Experiment 1.

During multiple-schedule training, colored stimulus lights accompanied the components; in later phases the stimuli were contingent on observing responses. The stimuli are designated S+ and S− on the basis of the reinforcement and extinction of the low-effort plunger response in the two components. Thus, S+ (two blue lights) was correlated with the low-effort component and S− (two yellow lights) was correlated with the high-effort component.

Preliminary training. To ensure experience with the high-effort plunger, only pulls on this plunger illuminated the meter during the first session. In subsequent sessions, both plungers illuminated the meter.

Discrimination training. Multiple-schedule training was along the lines of Experiment 1. The low-effort component, accompanied by S+, was in effect continuously for the second session. The third session began with the high-effort component, accompanied by S−;

thereafter, the components alternated on the average of every 5 min. So that pulling the low-effort plunger in the presence of S− was not adventitiously reinforced by the appearance of S+, offset of the high-effort component was prevented within 15 sec of a pull on the low-effort plunger in S−. Discrimination training continued until plunger selection was differentially controlled by the stimuli. This required 14 to 30 sessions.

Observing comparisons. For the remainder of the experiment, a mixed schedule prevailed unless an observing response was made. After shaping, observing responses were reinforced according to independent, concurrent VI 30-sec schedules. Table 2 presents the observing conditions and number of sessions in each, in order of occurrence. During the baseline condition, either observing response produced both S+ and S−. During the experimental conditions, one response continued to produce both stimuli whereas the other produced only S+. The stimulus consequences of the responses were reversed as many as three times. Except for FB's last condition, which was abbreviated due to time constraints, the experimental conditions were terminated according to the criteria of Experiment 1.

Uncorrelated stimulus training. A final condition determined whether S+ and S− were needed for efficient plunger pulling. The observing keys were deactivated and stimuli were presented as in the multiple-schedule phase, except that alternation of the stimuli was uncorrelated with alternation of the schedule components. Uncorrelated stimulus training continued for 11 to 14 sessions, until plunger selection was about equal in the presence of the two stimuli.

Other procedural details duplicated those of Experiment 1.

RESULTS AND DISCUSSION

Rates of Plunger Pulling

Figure 5 shows plunger rates in both the multiple-schedule and observing phases of the experiment (left and right portions, respectively). Rates on the low-effort and high-effort plungers are shown in separate panels. Discriminative stimulus control of responding during multiple-schedule training is evident in all three cases. In the presence of S− (unfilled circles), the stimulus correlated with nonreinforcement of the low-effort response, most pulls occurred on the high-effort plunger. By comparison, in the presence of S+ (filled circles), when both high- and low-effort responses could reveal deflections, pulls occurred almost exclusively on the low-effort plunger. Thus, behavior in the presence of S+ was consistent with Miller's (1968) finding that effortful responding is aversive: when given a choice between a 5-lb response and a 15- or 20-lb response, the subjects almost invariably chose the 5-lb response.

Although discriminated performances developed rapidly in RV and GC, FB required special training (not shown in the figure). When FB's plunger pulling failed to come under stimulus control after six sessions of the standard procedure, the high-effort response requirement was increased to 20 lb and 12 sessions were conducted in which the schedule components were lengthened. For the first four sessions, components lasted a full session and pulls on only one plunger illuminated the meter: the low-effort plunger in the low-effort component and the high-effort plunger in the high-effort component. Subsequently, components lasted four sessions, pulls on either plunger illuminated the meter, and the changeover delay between the plungers was increased from 2 to 10 sec. The upper left frames of Figure 5 show FB's responding before and after these procedures, which clearly enhanced stimulus control. With the exception of the high-effort response requirement, which remained at 20 lb, the standard procedure was reinstated for the remainder of the experiment.

Discriminated plunger performances continued in the observing phase, despite the intermittent appearance of S+ and S−. When the schedule was mixed (about 60% to 80% of the time), all three men showed plunger rates falling between rates in S+ and S− (triangles in Figure 5). Cumulative records revealed that the intermediate rates resulted from the averaging of periods of high rates with periods of low rates. Rates on the low-effort plunger tended to be high following S+ and low following S−, whereas rates on the high-effort plunger tended to be high following S− and low following S+.

Observing Responses

Table 2 presents the means and standard deviations of the absolute observing rates and

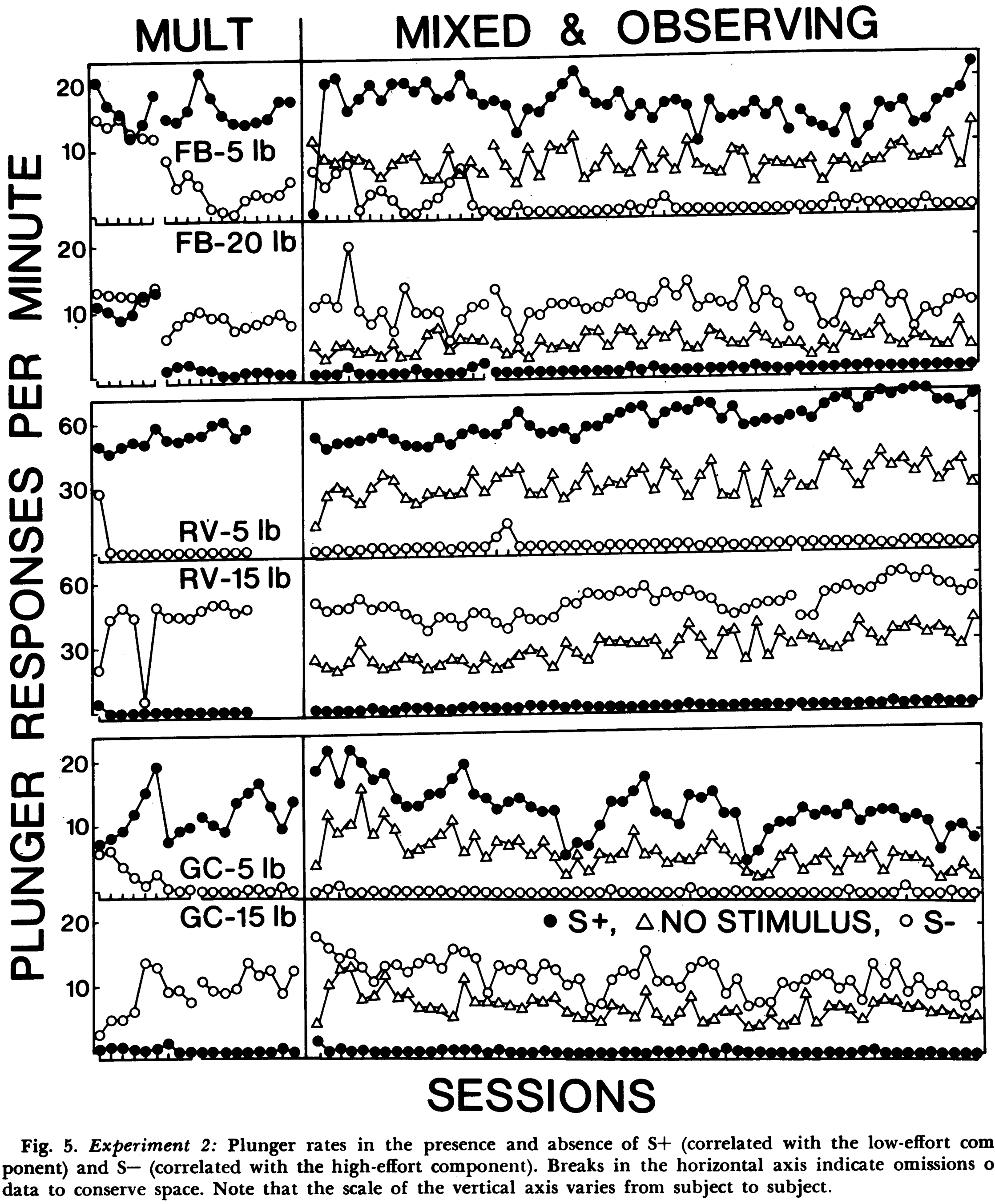

Fig. 5. *Experiment 2:* Plunger rates in the presence and absence of S+ (correlated with the low-effort component) and S− (correlated with the high-effort component). Breaks in the horizontal axis indicate omissions of data to conserve space. Note that the scale of the vertical axis varies from subject to subject.

of the proportions of time spent in the presence of the discriminative stimuli for the last five sessions of each condition. Observing behavior was maintained by the contingencies throughout the experiment, and all three men consistently produced both S+ and S−.

Relative observing rates and times are shown in Figure 6. During baseline sessions, when both observing responses produced S+ and S−, RV and GC pressed the two keys about equally, but FB tended to press the right key. In subsequent conditions, when one observing response continued to produce S+ and S− but the other produced only S+, all three men

Table 2

Experiment 2: Sessions per observing condition, and mean observing rate and proportion of time stimuli were present during the last five sessions. Also shown (in parentheses) are the order of the conditions and the standard deviation for each mean.

		Stimuli available			*Observing resp./min*		*Stimulus time ÷ Component time*	
Subject	*Comparison*	*Left key*	*Right key*	*Sessions*	*Left key*	*Right key*	*S+*	*S−*
FB	[Baseline]	S+, S−	S+, S−	22(1)	.5 (.2)	.7 (.2)	.18 (.06)	.19 (.04)
	S+/S− vs. S+	S+, S−	S+	24(2)	.9 (.2)	.9 (.2)	.19 (.01)	.15 (.05)
		S+	S+, S−	16(3)	.8 (.2)	1.4 (.5)	.24 (.04)	.18 (.03)
		S+, S−	S+	16(4)	1.8 (.5)	1.5 (.4)	.28 (.05)	.17 (.03)
		S+	S+, S−	8(5)	.7 (.4)	1.4 (.5)	.20 (.03)	.19 (.04)
RV	[Baseline]	S+, S−	S+, S−	15(1)	7.4 (.8)	7.3 (.9)	.42 (.03)	.44 (.02)
	S+/S− vs. S+	S+, S−	S+	16(2)	17.0 (2.2)	14.6 (2.0)	.40 (.05)	.28 (.03)
		S+	S+, S−	16(3)	15.5 (.8)	18.1 (1.3)	.45 (.05)	.28 (.05)
		S+, S−	S+	17(4)	22.1 (3.5)	18.4 (2.6)	.47 (.03)	.30 (.04)
GC	[Baseline]	S+, S−	S+, S−	17(1)	2.8 (.3)	3.9 (1.5)	.36 (.03)	.34 (.02)
	S+/S− vs. S+	S+, S−	S+	24(2)	1.6 (1.0)	.7 (.4)	.24 (.04)	.19 (.04)
		S+	S+, S−	17(3)	.8 (.3)	1.5 (.4)	.26 (.07)	.16 (.03)

preferred both stimuli to S+ alone. FB's preference was least consistent, but close inspection indicates that the distribution of his presses shifted systematically as the stimulus consequences varied across three reversals. Although RV's preference was weak, it was consistent across two reversals. GC's preference was clear after a single reversal.

As in Experiment 1, the proportion of time a stimulus was present depended on whether it was a consequence of one or both observing responses. Thus, as Table 2 shows, S+ and S− were produced about equally during the baseline, but, in subsequent conditions when only S+ was produced by both responses, S+ was produced more often than S−.

An important issue raised by the findings is whether S+ and S− maintained observing behavior because they were needed to maximize monetary reinforcement or minimize effort. Thus, the stimuli may have been produced because performance in their presence was more efficient than in their absence. One way to evaluate this possibility is to examine reinforcement rates and effort expended when plunger pulling was under discriminative control and when such control was not possible. Table 3 shows such data for RV, GC, and BJ: (a) during multiple-schedule training that preceded the observing phase; (b) during baseline observing training when both S+ and S− were available through either observing response; and (c) during the final condition when alternation of the stimuli was uncorrelated with alternation of the schedule components. When the stimuli were uncorrelated, plunger pulling was not under discriminative control, whereas during the multiple-schedule and observing conditions discriminative control was present (see Figure 5).

Table 3 shows that the average number of reinforcers per session did not depend on discriminative-stimulus control of plunger pulling (compare the multiple-schedule and observing conditions with the uncorrelated condition). In all three cases, the range of 22 to 25 reinforcers was close to the limit imposed by the VI 1-min schedule during the 25-min sessions. Table 3 also presents the amount of effort expended per session, expressed as the number of plunger pulls and the number of ft-lb of work required to operate the plungers. The pattern of results indicates that effort was not necessarily less when plunger pulling was under discriminative control than when it was not. For RV, total work and work per reinforcer did increase when the discriminative stimuli were replaced with the uncorrelated stimuli, but for GC and BJ work was about the same regardless of whether the stimuli were correlated or uncorrelated. Taken as a whole, these data indicate that S+ and S− were not necessary for the maintenance of high rates of monetary reinforcement (all three subjects) nor for reductions in the amount of effort required for the plunger response (two of three subjects). Thus, the results argue against the interpretation that the conditioned rein-

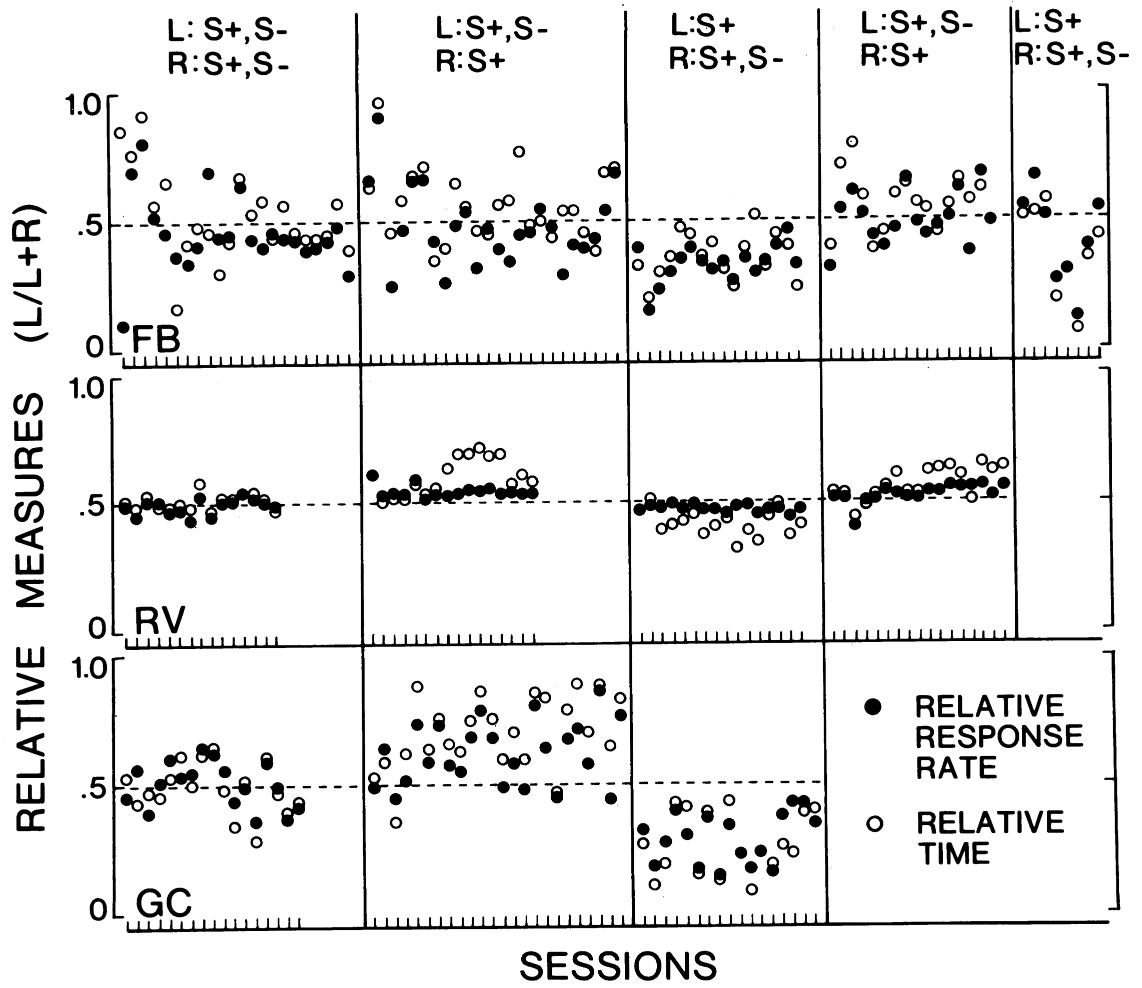

Fig. 6. *Experiment 2:* Relative observing-response rates and times during the baseline condition (left frame) and the *S+/S– vs. S+* comparison (remaining frames). Conditions are shown in order of occurrence. Other details are as in Figure 3.

Table 3

Experiment 2: Mean number of plunger pulls and reinforcers, work in ft-lb, and work per reinforcer during the last five sessions when stimuli were correlated (Multiple Schedule and Observing conditions) and uncorrelated with the schedule components. Standard deviations are shown in parentheses.

		5-lb plunger		*15-lb plunger*				
Subject	*Condition*	*Responses*	*Work*	*Responses*	*Work*	*Total work*	*Reinforcers*	*Work per reinforcer*
RV	Multiple	671 (152)	296 (63)	635 (111)	794 (139)	1073 (82)	25 (2)	43 (6)
	Observing	677 (105)	282 (44)	509 (52)	636 (65)	918 (49)	24 (3)	39 (5)
	Uncorrelated	783 (95)	326 (40)	1016 (31)	1270 (39)	1596 (40)	23 (2)	69 (5)
GC	Multiple	170 (29)	71 (12)	155 (23)	194 (29)	265 (34)	22 (4)	13 (3)
	Observing	182 (30)	76 (13)	193 (39)	241 (49)	317 (47)	23 (2)	14 (3)
	Uncorrelated	94 (25)	39 (10)	183 (25)	229 (31)	268 (28)	23 (2)	12 (2)
BJ[a]	Multiple	632 (23)	263 (10)	355 (124)	444 (155)	707 (154)	24 (3)	30 (8)
	Observing	384 (84)	160 (35)	314 (47)	393 (59)	553 (81)	22 (3)	26 (6)
	Uncorrelated	85 (28)	36 (12)	539 (72)	674 (91)	709 (96)	23 (3)	31 (3)

[a] This subject did not participate in the main phases of Experiment 2.

forcing properties of S+ and S− during the observing phases of the experiment required correlation of the stimuli with more primary reinforcing events, that is, increased monetary gain or reduced effort.

The foregoing analysis cannot eliminate the possibility that the discriminative stimuli may have facilitated effective behavior in more complex ways. For example, Table 3 shows that the relative distribution of low- and high-effort responses differed in the presence of the correlated and uncorrelated stimuli, with the proportion of high-effort responses increasing when the stimuli were uncorrelated. It also is likely that the temporal patterns of responding differed across the stimulus conditions. However, the relevance of such differences is unclear. Furthermore, humans have been found to engage in observing behavior even when it involves increased work (Baron & Galizio, 1976; Galizio, 1979).

Finally, any interpretation of the present findings in terms of increased efficiency, response effectiveness, and the like must show why such considerations do not apply to the observing behavior of other species. According to such interpretations, stimuli that reduce unnecessary responding should become conditioned reinforcers. But research with pigeons has shown that stimuli correlated with extinction suppress, rather than maintain, observing behavior (e.g., Mulvaney et al., 1974).

EXPERIMENT 3

An alternative to the information account of the present findings is in terms of sensory reinforcement (Kish, 1966). Varied visual stimulation can reinforce human behavior under conditions of sensory deprivation (e.g., Jones, Wilkinson, & Braden, 1961). A similar process may have operated in Experiments 1 and 2, in which subjects performed a monotonous vigilance task under homogeneous environmental conditions and preferred an observing response that produced two stimuli over a response that produced only one.

Experiment 3 compared responses that produced stimuli having similar sensory characteristics but different degrees of association with reinforcement. One observing response produced stimuli correlated with the components of a mixed VI EXT schedule of monetary reinforcement, while the other produced uncorrelated stimuli. The correlated and uncorrelated stimuli were identical in color and availability, thus equating the responses in terms of stimulus variety. If observing behavior is reinforced simply by its sensory effects, then the two responses should occur at equal rates; but if reinforcement depends on information, then responding should favor the correlated stimuli.

METHOD

Subjects

Four male workers, aged 21 to 28 years, participated. Although none had previous training on observing schedules, only RH was experimentally naive. The others (MG, DF, and DW) had served in an experiment using schedules of pointer deflections similar to those of the present study.

Apparatus

The console was modified so that there were two parallel banks of five colored lamps above the right meter. From left to right, each bank consisted of two green lamps, one white lamp, and two red lamps. Of the two plungers mounted under the table, only the 5-lb plunger was used. Electromechanical equipment controlled experimental events, and a computer recorded the data.

Procedure

Instructions. The instructions differed from earlier versions in two respects. First, to prepare the subjects for conditions in which the stimulus lights were uncorrelated with the schedule of meter deflections, the subjects read that ". . . in real life machines sometimes malfunction. The part of the apparatus controlling the lights is designed to simulate such malfunctions." Second, the subjects were told the purpose of the changeover button: "It deactivates the large white button that is currently working and activates the other white button. Thus, it lets you choose which of the large white buttons to press." The instructions did not mention the function of the observing keys. This second portion of the instructions was given immediately before introduction of the observing contingencies, several days after the start of the experiment. By comparison, in Experiments 1 and 2 all instructions were given before the first session.

Discrimination training. Discrimination training consisted of three phases. The first was similar to the early sessions of Experiment 1. After preliminary training under a mixed VI 1-min EXT schedule of deflections in which 16 cents were given for each report of a deflection, multiple-schedule training was given with the *lower bank* of colored lights serving as the discriminative stimuli. Alternation of the green lights (S+) and red lights (S−) was correlated with the alternation of the VI 1-min and EXT components. The multiple schedule was continued for 12 to 19 sessions, until discrimination ratios (plunger rates in green divided by the sum of rates in green and rates in red) were at least .95 for five consecutive sessions. In Experiment 1, discrimination training included a delay procedure in which onset of the VI component was prevented within 15 sec of a plunger pull in the presence of S−. However, in the present experiment it was necessary to increase the delay to 60 sec to eliminate S− responding in all subjects. The instructions about malfunctions of the stimulus lights may have prompted the increased responding in the presence of S−.

During the second phase, the stimuli were uncorrelated with the components of the mixed VI 1-min EXT deflection schedule. The *upper bank* of colored lights served as the uncorrelated stimuli. The green lights (S1) and red lights (S2) alternated at the same rate as the schedule components (every 5 min on the average), but independently of the components. The uncorrelated phase lasted eight sessions, during which plunger rates in S1 and S2 were about equal.

During the third phase of discrimination training, sessions of the correlated and uncorrelated stimulus conditions alternated irregularly across 16 to 17 sessions. Stimulus control of plunger pulling was similar to that of the previous phases: Rates in S+ and S− were well differentiated (session-by-session discrimination ratios of .91 to 1.00) whereas rates in S1 and S2 were not differentiated (ratios of .43 to .62).

Observing comparisons. A mixed schedule prevailed for the remainder of the experiment, and stimuli were contingent on observing responses. Presses on the two observing keys had different consequences. Presses on one key produced the correlated stimuli and presses on the other produced the uncorrelated stimuli. To facilitate discrimination of the different consequences of the two observing responses, the white center light of the appropriate bank of stimuli was illuminated whenever the observing key associated with that bank was activated by a changeover response.

The observing contingency was introduced in a single session. The changeover button was not operable during this session. During the first half of the session, only the key producing the correlated stimuli (S+, S−) was activated, and during the second half only the key producing the uncorrelated stimuli (S1, S2) was activated. In both cases key presses were reinforced according to a fixed-ratio (FR 1) schedule. Since the procedure did not shape changeover responses, they were prompted by instructions, as noted above.

Conditions are summarized in Table 5. In the initial comparison, one response produced S+ and S− and the other produced S1 and S2 on concurrent FR 1 schedules. As the table shows, the consequences of the two responses were interchanged twice. Conditions were terminated by the criteria of the first experiment, except that a maximum of 15 to 16 sessions was allotted per initial exposure to a condition, and 10 sessions for redetermination of a prior condition.

Following training with concurrent FR 1 FR 1, MG and DF were studied further under the concurrent VI 30-sec observing schedules of the previous experiments. There were two comparisons, each consisting of a differential observing condition and a reversal. In the first, one response produced S+ and S− and the other produced S1 and S2. In the final comparison, the choice was between S− alone and S2 alone.

Other procedural details duplicated those of the first experiment.

RESULTS AND DISCUSSION

Rates of Plunger Pulling

Table 4 shows the means and standard deviations of the plunger rates in the presence of each stimulus during the terminal sessions of discrimination training. Rates were well differentiated in the presence of the correlated stimuli and about equal in the presence of the uncorrelated stimuli. As in the previous experiments, the stimulus control evident during discrimination training continued when the stimuli were contingent on observing responses.

Table 4

Experiment 3: Plunger pulls per min in the presence of the correlated and uncorrelated stimuli during discrimination training. The means (with standard deviations in parentheses) are based on the last five sessions of phase 1 (correlated stimuli) and phase 2 (uncorrelated stimuli), and on the last 10 sessions of phase 3, in which five sessions of correlated training and five sessions of uncorrelated training occurred in irregular order.

	Phase 1		*Phase 2*		*Phase 3*			
	Correlated		*Uncorrelated*		*Correlated*		*Uncorrelated*	
Subject	*S+*	*S−*	*S1*	*S2*	*S+*	*S−*	*S1*	*S2*
MG	18 (2)	.3 (.1)	13 (1)	13 (1)	16 (1)	1.2 (.4)	12 (1)	13 (3)
DF	40 (4)	.1 (.1)	5 (3)	4 (1)	26 (2)	.1 (.2)	9 (6)	9 (3)
RH	67 (5)	1.7 (.8)	71 (11)	74 (13)	59 (9)	1.3 (.5)	75 (13)	77 (11)
DW	26 (2)	.2 (.1)	18 (1)	19 (3)	21 (2)	1.4 (.3)	17 (4)	13 (4)

Observing Responses

Table 5 presents the means and standard deviations of the absolute observing rates and of the proportions of time spent in the presence of the correlated and uncorrelated stimuli for the terminal sessions of each condition. As in the previous experiments, responding was maintained throughout the observing phase, although there were subject-to-subject differences in the absolute levels of responding. In addition, all four subjects produced S+ and S−, whereas only two (RH and DW) produced S1 and S2.

Figure 7 shows the relative observing rates and times for the first comparison (including two reversals) under the FR 1 schedules. (A computer failure lost time data for DF's second condition and DW's first condition.) Three of four subjects (MG, DF, RH) preferred the correlated over the uncorrelated stimuli; by comparison, DW preferred the un-

Table 5

Experiment 3: Sessions per observing condition, and mean observing rate and proportion of time stimuli were present during the last five sessions. Also shown (in parentheses) are the order of the conditions and the standard deviation for each mean.

		Stimuli available			*Observing resp./min.*		*Stimulus time ÷ Component time*			
Subject	*Comparison*	*Left key*	*Right key*	*Sessions*	*Left key*	*Right key*	*S+*	*S−*	*S1*	*S2*
				Concurrent FR 1 FR 1 Observing Schedules						
MG	*S+/S−*	S1,S2	S+,S−	10(1)	.2(.2)	30.4(4.2)	.83(.02)	.92(.02)	.01(.01)	.00(.01)
	vs. S1/S2	S+,S−	S1,S2	10(2)	43.4(8.9)	.0(.0)	.90(.02)	.93(.02)	.00(.00)	.00(.00)
		S1,S2	S+,S−	5(3)	.0(.0)	52.2(2.0)	.91(.02)	.94(.01)	.00(.00)	.00(.00)
DF	*S+/S−*	S1,S2	S+,S−	15(1)	.1(.1)	17.0(8.9)	.72(.24)	.82(.06)	.00(.00)	.00(.01)
	vs. S1/S2	S+,S−	S1,S2	10(2)	20.9(6.6)	.1(.2)	.79(.05)	.87(.04)	.00(.01)	.00(.00)
		S1,S2	S+,S−	5(3)	.0(.0)	16.9(11.2)	.70(.21)	.76(.19)	.00(.00)	.00(.00)
RH	*S+/S−*	S1,S2	S+,S−	16(1)	18.4(3.0)	22.2(8.6)	.72(.17)	.20(.03)	.42(.14)	.41(.08)
	vs. S1/S2	S+,S−	S1,S2	15(2)	29.7(5.0)	18.3(2.3)	.88(.01)	.23(.05)	.38(.20)	.33(.15)
		S1,S2	S+,S−	10(3)	17.2(1.3)	25.5(3.6)	.86(.03)	.20(.03)	.29(.08)	.45(.06)
DW	*S+/S−*	S1,S2	S+,S−	15(1)	1.0(.3)	.6(.5)	.16(.15)	.04(.03)	.23(.05)	.13(.03)
	vs. S1/S2	S+,S−	S1,S2	15(2)	1.2(1.1)	2.6(1.0)	.24(.18)	.07(.02)	.40(.12)	.24(.07)
		S1,S2	S+,S−	10(3)	1.6(.3)	.6(.2)	.13(.07)	.08(.03)	.31(.06)	.21(.04)
				Concurrent VI 30 VI 30 Observing Schedules						
MG	*S+/S−*	S1,S2	S+,S−	10(4)	.2(.2)	4.6(1.3)	.22(.03)	.27(.04)	.01(.01)	.01(.02)
	vs. S1/S2	S+,S−	S1,S2	10(5)	5.4(2.1)	.0(.1)	.21(.02)	.26(.04)	.00(.00)	.01(.01)
	S− vs. S2	S−	S2	10(6)	2.8(.6)	.0(.1)	—	.24(.07)	—	.00(.01)
		S2	S−	10(7)	.0(.0)	4.1(.4)	—	.21(.05)	—	.00(.00)
		S−	S2	9(8)	3.5(.3)	.0(.0)	—	.25(.04)	—	.00(.00)
DF	*S+/S−*	S1,S2	S+,S−	10(4)	.1(.2)	18.5(9.5)	.23(.06)	.28(.05)	.01(.02)	.00(.00)
	vs. S1/S2	S+,S−	S1,S2	15(5)	35.3(7.6)	2.0(3.4)	.32(.11)	.30(.04)	.04(.06)	.03(.04)
	S− vs. S2	S−	S2	9(6)	29.6(8.2)	2.5(3.6)	—	.31(.02)	—	.05(.03)
		S2	S−	9(7)	2.2(2.2)	9.8(1.6)	—	.26(.04)	—	.06(.04)

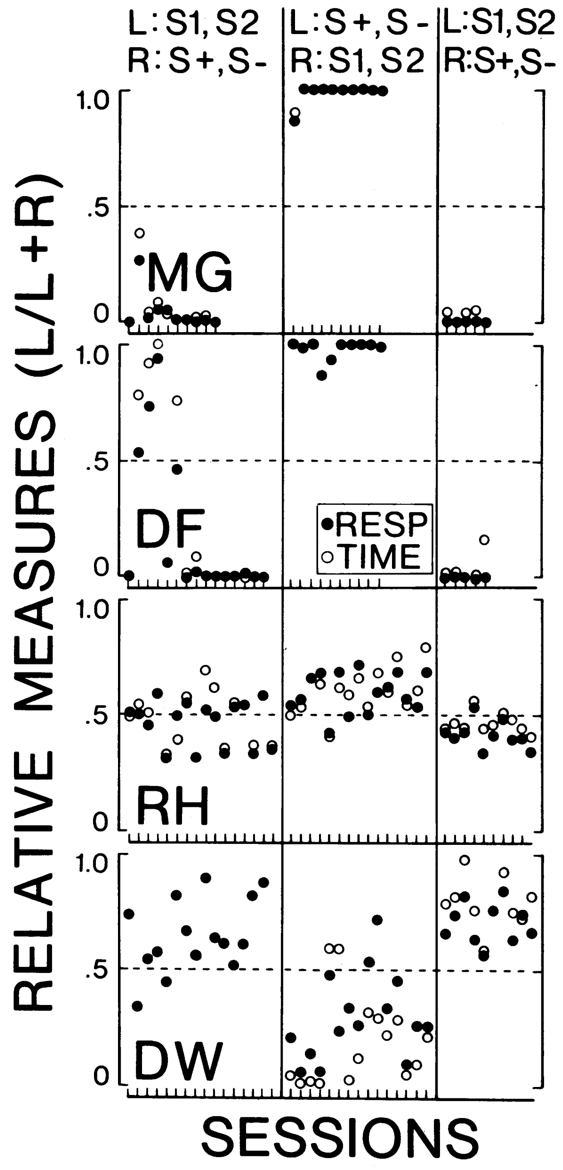

Fig. 7. *Experiment 3:* Relative observing rates and times during the first *S+/S− vs. S1/S2* comparison, in which observing responses produced stimuli according to concurrent FR 1 schedules. Conditions are shown in order of occurrence. Time data were not available for DF's second condition and DW's first condition. Other details are as in Figure 3.

correlated stimuli. The upper part of Table 5 shows that absolute observing rates during the first comparison ranged from low (about 2 to 4 responses per min for DW) to nearly as high a rate as possible under the FR 1 schedules (about 40 to 50 responses per min for MG). Stimulus production also varied across subjects. Two (MG and DF) produced both S+ and S− at high rates and virtually never produced S1 and S2. The patterns of stimulus production in the others (RH and DW) were more complex. These men pressed the observing keys differently in the two components of the mixed schedule. During the VI component they produced S+ in preference to the uncorrelated stimuli, but during the EXT component they produced the uncorrelated stimuli in preference to S−. Overall, RH produced S+ at the highest rate, S− at the lowest rate, and the uncorrelated stimuli at intermediate rates. DW produced S+, S1 and S2 at low-to-moderate rates while rarely producing S−.

Data from the two men exposed to the concurrent VI observing schedules are summarized in Figure 8 and the lower part of Table 5. Both MG and DF continued nearly exclusive preferences for the correlated over the uncorrelated stimuli when the intermittent observing schedules replaced the continuous schedules, and both preferred S− over S2. Table 5 also shows that they continued to produce both S+ and S− with notable consistency, although the VI observing schedules did not allow stimulus production at the high levels that were possible under the FR 1 schedules. Again, MG and DF rarely produced the uncorrelated stimuli.

The results of Experiment 3 must be interpreted cautiously. Two patterns can be discerned. First, the results obtained with MG and DF suggest that when stimuli are correlated with the presence or absence of reinforcement, they gain reinforcing strength which surpasses that attributable to their sensory qualities alone. These men preferred the correlated stimuli over physically similar uncorrelated stimuli under both continuous and intermittent observing schedules, and preferred a stimulus correlated with the absence of reinforcement over an uncorrelated stimulus in whose presence reinforcement could occur. This last comparison demonstrates the maintenance of a response having S− as its sole consequence, a finding also obtained in the *S+ vs. S−* and *S+/S− vs. S−* comparisons of Experiment 1. The performances of MG and DF, then, are in accord with the information hypothesis.

The second pattern involves the relative levels of stimulus production by RH and DW. Although their observing-response distribu-

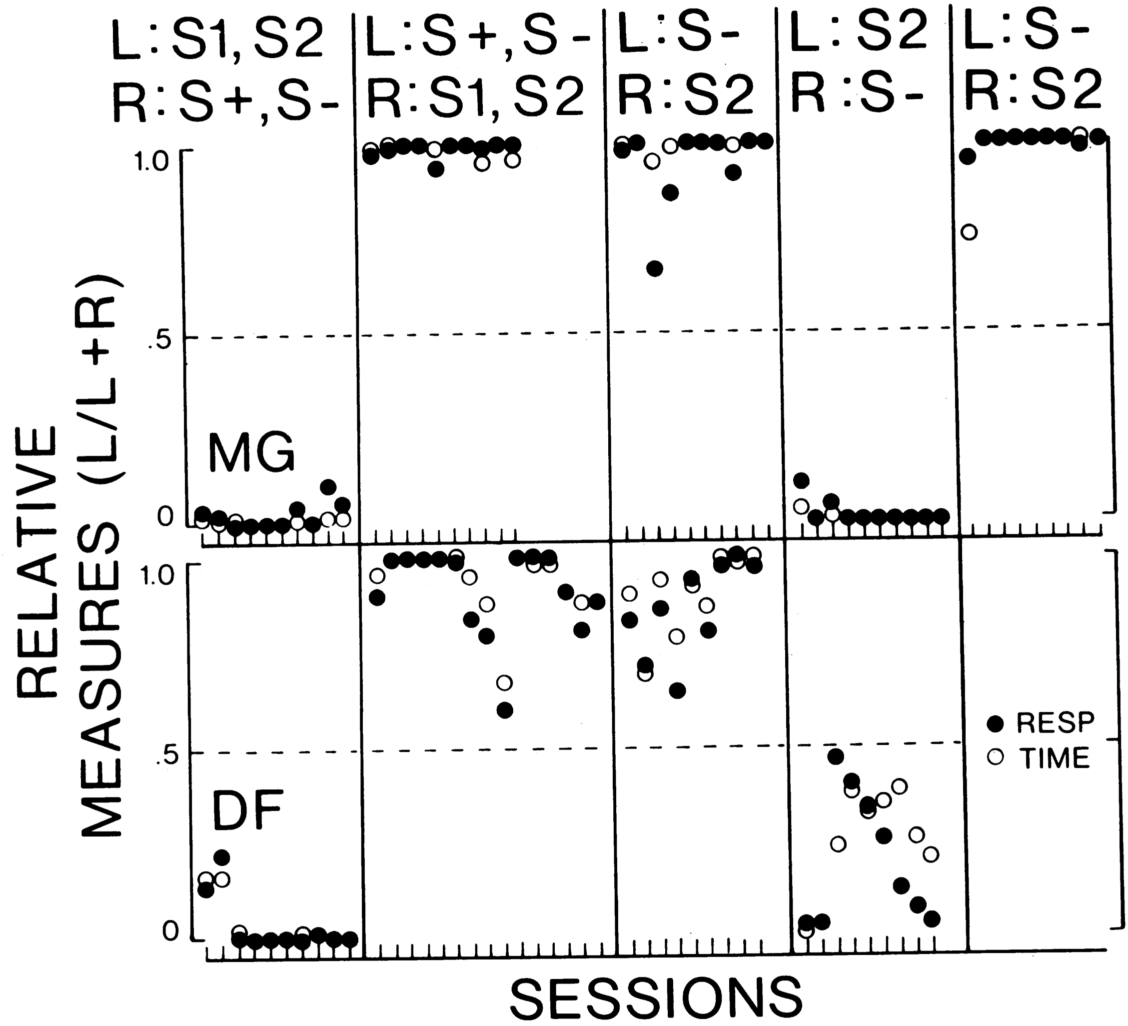

Fig. 8. *Experiment 3:* Relative observing rates and times during the second *S+/S— vs. S1/S2* comparison (Frames 1 to 2) and the *S— vs. S2* comparison (remaining frames); concurrent VI schedules were used. Conditions are shown in order of occurrence. Other details are as in Figure 3.

tions differed (Figure 7), both men consistently produced the uncorrelated stimuli at higher levels than S—, a correlated stimulus. During the EXT component of the mixed schedule, they pressed the key that produced S1 and S2 more than the one that produced S—. Stimulus production by RH was correlated with the reinforcement rates in the four stimuli. In S+ reinforcers were scheduled at a rate of 1/min (the value of the VI schedule), in S1 and S2 at .5/min (because both the VI and EXT components were accompanied by these stimuli), and in S— at 0/min (EXT); production of these stimuli by RH followed the same rank order. By comparison, DW produced about equal levels of the stimuli under which reinforcement occurred (S+, S1, S2) but, like RH, relatively low levels of S—. The finding that S— was the least produced stimulus does not allow the inference that S— was a conditioned aversive stimulus, since preferences under the procedures of Experiment 3 do not demonstrate response suppression by S—. Such a demonstration requires a comparison of two responses whose consequences differ only with regard to S—, as in the *S+/S— vs. S+* comparison of Experiments 1 and 2. The present data show only that for RH and DW, S— was less reinforcing than either S+ or the uncorrelated stimuli—a finding inconsistent with the information hypothesis.

The results of Experiment 3 do not support an account of observing behavior in terms of sensory reinforcement. According to this account, rates of the two observing responses should have been equal, since their sensory consequences were equal, but instead all subjects showed consistent preferences through at least two reversals.

GENERAL DISCUSSION

Previous research has shown that a stimulus correlated with the more favorable of two contingencies will reinforce observing behavior in pigeons. For example, a stimulus correlated with the shorter of two interreinforcement intervals or one correlated with a reinforcement component that alternates with extinction can function as a reinforcer (cf. Auge, 1974). By comparison, the present experiments found that observing in humans could be reinforced by stimuli correlated with the less favorable, as well as the more favorable, of two contingencies. In Experiment 1, observing responses were maintained by stimuli correlated with monetary reinforcement or nonreinforcement, and in Experiment 2 by stimuli correlated with periods of low effort or high effort. Experiment 3 provided control data showing that the sensory properties of stimulus change were not sufficient to account for these results.

The present findings are in line with the prediction of the information hypothesis that stimuli correlated with nonreinforcement or other aversive events are reinforcing when they provide information about those events. According to Pavlovian views, such stimuli should become conditioned punishers. Although the concurrent observing response procedure in Experiments 1 and 2 was designed specifically to assess the suppressive effects of a stimulus correlated with the less favorable of two contingencies, no suppression was detected. In both experiments, a response producing both positive and negative stimuli occurred at higher rates than a response producing only the positive stimulus, thus providing evidence of the reinforcing, rather than punishing, effects of the negative stimuli. However, the reinforcing properties of the negative stimulus in Experiment 3 were less consistent, appearing in only two of four subjects. Nevertheless, when all three experiments are considered together, the contention that negative stimuli can serve as reinforcers is supported in 12 of 14 cases. Our results, then, conflict with studies of observing behavior in pigeons, and seem to be at odds with Pavlovian accounts of conditioned reinforcement.

How might the discrepancy between the present findings with humans and previous findings with pigeons be resolved? It is tempting to attribute the discrepancy to some predisposition of primates to attend to informative stimuli, since the only previous experiment purporting to show reinforcement by a negative stimulus used monkeys (Lieberman, 1972). However, as noted in the Introduction, the methodological adequacy of this study has been criticized (Dinsmoor et al., 1972; Fantino, 1977), leaving the significance of the results open to question. Further research with a variety of species is needed before conclusions can be reached about species variables in susceptibility to reinforcement by informative stimuli.

Of necessity, there were several procedural differences between the present study with humans and previous studies with pigeons. One difference was that in the first and third experiments S− was correlated with the absence of an opportunity to earn money, whereas in analogous research with pigeons S− was correlated with the absence of food, a biologically relevant stimulus of which the birds were deprived. However, money has been shown to be functionally equivalent to biologically relevant stimuli in positive reinforcement (e.g., Matthews, Shimoff, Catania, & Sagvolden, 1977), negative reinforcement (e.g., Baron & Kaufman, 1966), and punishment (e.g., Bradshaw, Szabadi, & Bevan, 1977) procedures. Moreover, in the second experiment S− was correlated with increased response effort, a biologically relevant event, and reinforcing effects were comparable to those found in Experiment 1.

A more significant procedural difference concerns the extra-experimental experiences of the subjects. The conditioning histories of adult humans are extensive and for the most part unspecifiable, whereas the histories of other species often are under experimental control and may be highly restricted. The potential role of historical variables in observing behavior is suggested by the finding that the function of a negative stimulus depends on the specific procedures used during discrimination training (Rilling et al., 1973; Terrace, 1971). For example, Rilling et al. found that a stimulus correlated with extinction was least likely to become aversive (as evidenced by escape responses that terminated the stimulus) when introduced early in training. Thus, the behavioral functions of a stimulus are not dependent exclusively on the current rate of reinforcement in its presence, but also on events in the history of the organism. This analysis suggests why a negative discriminative stimulus need not *suppress* observing behavior, but leaves unclear why a negative stimulus should *reinforce* observing behavior.

On more theoretical grounds, Pavlovian and informational interpretations of the present findings might be reconciled by taking account of the special histories of adult humans. Skinner (1957) suggested that a disposition to attend to stimuli may be shaped by contingencies which arise in a verbal community, as illustrated in the following quotation:

> One may respond *book* to an actual book lying on a table when someone asks *What is on the table?*, but the response is slightly less likely to be made to the question *What was on the table a moment ago?* when the book has been removed and concealed. We say that we did not "notice the book." A more technical analysis is possible. In the first case the question can evoke an observing response, sharpening the effect of the book as a stimulus. This is not possible in the second case. If, however, the second question is often repeated, and especially if other variables are powerful, one may engage in explicit observing behavior before questions are asked. One begins to "notice objects one may be asked about." (p. 415)

Thus, by adulthood an individual's history may include extensive reinforcement for attending to environmental events regardless of their current value. According to this account, negative discriminative stimuli may become reinforcing, ultimately, through a positive Pavlovian association with reinforcement provided by a verbal community. The critical requirement is that stimuli which are *negatively* correlated with one primary event (e.g., monetary reinforcement) be *positively* correlated with some other event (e.g., social reinforcement) that exerts a greater influence on behavior. The finding that humans respond to produce stimuli correlated with periods of extinction and increased response effort can be taken to reflect the consequences of such a history. This account is, of course, speculative, since it is impossible to specify the conditioning histories of the men in the present study or to analyze in detail the variables which might have maintained their observing behavior within the experimental environment. However, even in the absence of such data the hypothesis remains plausible that reinforcement by informative stimuli may itself be a product of Pavlovian processes, rather than a basic principle of behavior to be contrasted with Pavlovian accounts of conditioned reinforcement.

The apparent contradiction of the present findings — that a stimulus can reinforce one response (observing) and inhibit another (plunger pulling)—illustrates the multiple functions that stimuli can serve, depending on the context in which they occur (cf. Catania, 1979). Such variables as the history of the organism, the characteristics of ongoing behavior, the parameters of the stimulus, and the contingency in which the stimulus is involved all need to be taken into account. (Morse and Kelleher, 1977, make a similar point about the multiple properties of a primary event such as food or electric shock.) Regarded in this light, the present findings bear an interesting parallel to outcomes when shocks are preceded by a warning stimulus under free-operant avoidance schedules. Rats characteristically pause until the stimulus is presented, suggesting that pausing is positively reinforced by the opportunity to observe the stimulus. However, following stimulus onset the rats quickly press the lever to terminate the stimulus, suggesting that its continued presence is aversive (Ulrich, Holz, & Azrin, 1964).

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Received September 10, 1979
Final acceptance June 16, 1980