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HUMAN OBSERVING: MAINTAINED BY NEGATIVE INFORMATIVE STIMULI ONLY IF CORRELATED WITH IMPROVEMENT IN RESPONSE EFFICIENCY

DAVID A. CASE, EDMUND FANTINO, AND JOHN WIXTED

UNIVERSITY OF CALIFORNIA, SAN DIEGO

Two experiments investigated the effect of observing responses that enabled college students to emit more efficient distributions of reinforced responses. In Experiment 1, the gains of response efficiency enabled by observing were minimized through use of identical low-effort response requirements in two alternating variable-interval schedules. These comprised a mixed schedule of reinforcement; they differed in the number of money-backed points per reinforcer. In each of three choices between two stimuli that varied in their correlation with the variable-interval schedules, the results showed that subjects preferred stimuli that were correlated with the larger average amount of reinforcement. This is consistent with a conditioned-reinforcement hypothesis. Negative informative stimuli—that is, stimuli correlated with the smaller of two rewards—did not maintain as much observing as stimuli that were uncorrelated with amount of reward. In Experiment 2, savings in effort made possible by producing S− were varied within subjects by alternately removing and reinstating the response-reinforcement contingency in a mixed variable-interval/extinction schedule of reinforcement. Preference for an uncorrelated stimulus compared to a negative informative stimulus (S−) decreased for each of six subjects, and usually reversed when observing permitted a more efficient temporal distribution of the responses required for reinforcement; in this case, the responses were pulls on a relatively high-effort plunger. When observing the S− could not improve response efficiency, subjects again chose the control stimulus. All of these results were inconsistent with the uncertainty-reduction hypothesis.

Key words: conditioned reinforcement, observing, choice, information, response efficiency, lever pressing, adults

Observing responses are those that may produce stimuli correlated with the components of a mixed schedule of reinforcement. In a mixed schedule of reinforcement, the schedules of reinforcement that operate independently in each component all share the same stimulus. Other than identifying the component currently operative, by effectively converting the mixed to a multiple schedule, observing responses have no effect on primary reinforcement (Wyckoff, 1952).

A large number of experiments investigating why the contingent stimuli reinforce observing have produced results consistent with the conditioned-reinforcement hypothesis (see Fantino, 1977; Fantino & Case, 1983). This hypothesis proposes that the stimuli are reinforcing because of their positive correlation with primary reinforcement. Although extensive support has been found in several studies using pigeons (Bowe & Dinsmoor, 1983; Case & Fantino, 1981; Dinsmoor, Browne, & Lawrence, 1972; Killeen, Wald, & Cheney, 1980; Mulvaney, Dinsmoor, Jwaideh, & Hughes, 1974; and others reviewed by Fantino, 1977), controversy surrounds studies conducted with adult humans (Fantino & Case, 1983; Perone & Baron, 1980). In particular, Perone and Baron reported data that were apparently inconsistent with the conditioned-reinforcement hypothesis, because they showed that observing could be reinforced by a negative discriminative stimulus (S−). In light of the evidence on pigeon observing,

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Perone and Baron accounted for the discrepancy by proposing that for organisms higher on the phylogenetic scale (e.g., primates) the information or uncertainty-reduction provided by a stimulus (i.e., telling subjects that extinction is currently in effect) is a more powerful determinant of observing than is conditioned reinforcement (Schrier, Thompson, & Spector, 1980; see also Berlyne, 1960; Bloomfield, 1972). The results of Fantino and Case (1983) challenged this interpretation, however, for these authors found no evidence of reinforcement by uncertainty reduction in their study of adult observing. Fantino and Case proposed a resolution of the findings based upon a potentially important difference. Subjects produced reinforcement in the Perone and Baron experiments by pulling a plunger (or plungers, depending on the experiment) that required minimum forces of from 5 to 20 ft-lbs to operate, which is approximately 25 to 100 times the minimum force required to operate the observing levers. In contrast, reinforcement occurred independent of any responding in the experiments of Fantino and Case. In the Perone and Baron study, the possibility that observing was reinforced by S− because it reduced uncertainty is confounded with the possibility that observing S− permitted a more efficient distribution of the considerably more effortful responding. Specifically, subjects could reduce ineffective responding by ceasing to pull the plunger after producing S−. Thus, the increased response efficiency made possible by observing S− could have masked any effect of its negative correlation with reinforcement (a possibility considered, but not favored, by Perone and Baron). The response-independent reinforcement procedure used by Fantino and Case eliminated the possiblitiy that observing could affect the rate or distribution of either reinforcement or responding required for reinforcement. In this case, S− failed to reinforce observing.

The present report describes two experiments with human adults, testing the interpretation of Fantino and Case (1983). Observing maintained by S−, a less positive discriminative stimulus, was measured in different conditions in which observing either could or could not be correlated with a more efficient distribution of responses required for reinforcement. Experiment 1 used response-dependent reinforcement, as in Perone and Baron's (1980) research, but this time contingencies were arranged so as to minimize the improvement in response efficiency permitted through observing a less positive discriminative stimulus. Experiment 2 closely duplicated response contingencies employed by Fantino and Case in one condition, and those employed by Perone and Baron in another, in order to vary within the same subjects the response efficiency made possible by observing S−. The critical comparison throughout is whether subjects prefer observing S− over a stimulus that is uncorrelated with reinforcer rate or amount (S^U). The uncertainty-reduction hypothesis predicts preference for the former stimuli because only they are informative about reinforcement; the uncorrelated stimulus is by definition uninformative.The conditioned-reinforcement hypothesis predicts preference for the uncorrelated stimulus, provided observing does not permit substantially more efficient responding, because S^U has a more positive correlation with reinforcement.

EXPERIMENT 1

The explanation proposed by Fantino and Case (1983) in accounting for Perone and Baron's (1980) results depends upon there being differences between the studies with respect to response efficiency permitted through observing S− (less positive discriminative stimuli). Fantino and Case elected to use response-independent reinforcement in order to eliminate all possible considerations of response efficiency in accounting for their results. Response-independent reinforcement per se was assumed not to be critical except for considerations of response efficiency. The present experiment tested this assumption, and the generality of the results of Fantino and Case, by using a response-dependent reinforcement procedure in which observing enabled only a minimal saving of effort in making the reinforced response. Specifically, a mixed schedule was used; it was comprised of two identical variable-interval 30-s (VI 30-s) schedules. In one component, reinforcement consisted of one count on the subject's displayed tally of points (for which the subject was later paid). In the other component, reinforcement consisted of five counts. Thus, the stimuli were correlated with different amounts of reward but with identical response requirements. For subjects to obtain all the scheduled reinforcers, responding on the point-producing lever had to be maintained at a moderate rate throughout both components. In addition, the minimum force required to operate the point lever was small and approximately the same as that required for the observing levers in this study and in the studies of Fantino and Case (1983) and Perone and Baron (1980). Hence, should the relative rate of point-lever responding be lower in the presence of the less positive discriminative stimulus (which might be expected because of the differential correlation of the discriminative stimuli with amount of reward), the amount of effort saved by observing would be small. We predicted, therefore, that subjects would more closely replicate the preferences found by Fantino and Case than those found by Perone and Baron—that is, that observing would be consistent with the conditioned-reinforcement hypothesis.

METHOD

Subjects

Subjects recruited were 9 men and 3 women. One subject, who exhibited nearly zero rates of responding, was dismissed after the first session. Data from this subject are not pertinent to the hypotheses under test because responding was unreliable and because stimuli were produced too infrequently to test either hypothesis. Apparently, discovering when the 1- versus the 5-point reinforcers were likely to be available was not reinforcing for this subject. Another subject occasionally defeated the automatic scheduling circuit by adopting an unusual response topography. Data from this subject are presented separately from those of the remaining 10 subjects and have been excluded from statistical analysis.

Subjects were obtained through a recruitment sheet posted in a hallway of the Psychology Department. They were paid $2.00 per session for their participation plus the amount earned by getting points in the task; point earnings averaged about $2.50 per session (for a total of approximately $4.50 per session). Money earned from points was paid after each session; payment for participation was made at the end of the experiment.

Apparatus

Subjects were seated at a table in a small room otherwise devoid of furniture. The room was sound-insulated and had one door containing a small mirrored observation window. Typical indoor environmental conditions prevailed.

A display panel and three levers were on the table. The display panel was an 80-cm by 54-cm metal stand that contained two Sodeco counters (Model TCeBZ4E) and four Sylvania miniature lamps (Model 28PSB). One counter was located on each side of the panel and 10 cm above the table top. The lamps were arranged in a vertical line 2 cm apart and centered on the panel 10 cm above the table top. Lens caps were placed on the bottom three lamps. From highest to lowest they were green, red (or blue), and blue (or red).

The levers were identical Microswitch switches (Model BZ-2RW) equipped with a plastic button 1 cm in diameter. Two had yellow buttons and were located 30 cm apart, symmetrically in front of the subject. The third lever had a green button and was centered between the other levers. The switches required a force of 1.2 N to operate and lever travel was 1 cm. A lever operation was accompanied by an audible click and illumination of a Sylvania miniature lamp that was attached to the lever mounting.

Procedure

Points were obtained according to two randomly alternating VI schedules of reinforcement. Points were produced, after a varying time averaging 30 s since the last reinforcement, by pressing the green-button lever. The VI schedules differed in the number of points per reinforcement. Reinforcement on one schedule consisted of a single count on one of the counters accompanied by a brief flash of the green lamp. Reinforcement on the other schedule consisted of 5 rapid green-light flashes and 5 counts on the other counter. Component duration (i.e., 1 trial) was 60 s. In each of three observing conditions, instructions accurately described the relation of stimuli to the VI schedules, the function of pressing the levers, and the significance of points. In one condition—a standard observing condition—the instructions read:

> In this experiment you have the chance to occasionally produce points which are worth 1 cent each at the end of today's session. In front of you are three levers and two counters. Points can be produced only by pressing the center lever. Some of the time points will be recorded on the right counter and at other times they will be recorded on the left. When a successful press is recorded on the right counter, five points will be added at a time. When a successful press is recorded on the left counter, one point will be added each time. You have no control over the counter that records points. Half the time it will be the right counter and half the time it will be the left.
>
> You can occasionally cause the red or blue lights to turn on by pressing the two remaining levers. The red light can be turned on by pressing the right lever and the blue light can be turned on by pressing the left lever. [When the red light is on, it means that successful presses will be recorded on the right (5 point) counter. When the blue light is on, it means that successful presses will be recorded on the left (1 point) counter.] If neither light is on you do not know which counter will record a successful press.
>
> Please press the levers with your finger using only one hand (your preferred hand). This will insure that only one lever is pressed at a time. You may otherwise select to press the levers as you wish in any order. The light directly above each lever will turn on to let you know you have pressed hard enough.

In two other conditions, the portion of the instructions in brackets was replaced with other phrases appropriate to the different conditions. For an alternative in which the blue stimulus was uncorrelated with reward amount (S^U), for example, the instructions in the brackets read: "When the blue light is on, it means that half the time successful presses will be recorded on the right counter and half the time they will be recorded on the left."

In all conditions, presses on the two observing manipulanda (levers with yellow buttons on each side of the point-producing lever) produced stimuli (illumination of the red or blue lamps) in 50% of the trials according to a VI 15-s schedule. A stimulus, once produced, remained present until the end of the trial. In a standard observing condition, responses on one yellow-button lever illuminated one of the lamps when the 5-point schedule was in effect (i.e., S_5 or S+); responses on the other yellow-button lever illuminated the other lamp when the 1-point schedule was in effect (i.e., S_1 or S−). Two other conditions separately tested each of these observing alternatives relative to a third alternative, in which responses produced a stimulus uncorrelated with amount (i.e., S^U). That is, in one of these conditions responses on one lever produced S+ when the 5-point schedule was in effect while responses on the other lever produced S^U. Similarly, the final condition arranged for responses on one lever to produce S− when the 1-point schedule was in effect while responses on the other lever produced S^U.

Subjects served in each of the three observing conditions for one session. The side position of the alternatives and the color of the lights were counterbalanced and the order of conditions was varied across subjects. The design is summarized in Table 1.

The top, unfiltered lamp on the panel accompanied the mixed schedule. It was illuminated at the start of a session and was darkened when the session ended. A session consisted of 32 trials, 16 of each component, prearranged by a stepping switch to occur in an irregular sequence.

The sequence of events surrounding a session was as follows. After the subject was seated in the experimental room and the in-

Table 1
Design and Principal Results of Experiment 1

		Design		*Rate of Observing[a] and Number of Questionnaire Items Answered Incorrectly[b]*								
				A: S^D_5 (vs. S^D_1)			*B: S^D_1 (vs. S^U)*			*C: S^D_5 (vs. S^U)*		
Subject	*Order of Conditions[c]*	*S1[d] Color*	*S1 Side*	*S^D_5*	*S^D_1*	*Errors*	*S^D_1*	*S^U*	*Errors*	*S^D_5*	*S^U*	*Errors*
1	ACB	red	left	17	5.8	0	9.5	13	0	12	11	0
2	CAB	blue	left	27	12	0	37	33	0	22	6.7	1
3	BAC	red	left	3.4	0	0	1.7	13	0	1.3	.2	0
4	ABC	blue	right	89	65	0	1.0	3.0	0	1.7	3.6	0
5	CBA	red	right	17	0	0	0	.7	0	10	9.8	0
6	BCA	blue	right	3.0	2.3	0	.1	5.8	0	7.8	6.2	0
7	CAB	blue	left	94	0	0	.6	2.2	1	54	2.9	0
8	ABC	blue	right	28	23	1	28	21	0	64	13	0
9	CBA	red	right	80	3.3	0	4.3	38	0	70	16	0
10	BCA	blue	right	9.7	9.3	0	14	37	0	20	21	3

[a]Expressed in responses per min.
[b]Questionnaires contained six items.
[c]The conditions were A = S^D_5 (vs. S^D_1); B = S^D_1 (vs. S^U); and C = S^D_5 (vs. S^U).
[d]Stimulus S1 was associated with the 5-point schedule in Condition A and C and was the uncorrelated stimulus in Condition B.

structions were given, the experimenter demonstrated the apparatus. Both 5-point and 1-point reinforcers were produced and each observing lever was used to turn on its corresponding light once. (Although one might be concerned that this demonstration may have artifically increased the frequency of responding through role playing, it is not plausible to argue that it could have influenced responding more on one lever than the other; indeed, if role playing were paramount, then no systematic preferences should have resulted.) Additional instructions were then given to introduce the subsequent 10-min trial run in the observing procedure. A questionnaire was administered following the trial run in order to test the subject's understanding of the function of responding and the relation of the lights to points. Answers to the questions were immediately evaluated. If a question was answered erroneously, the subject was carefully corrected before proceeding with the full session. After the full session, the same questions and one additional item were asked. The new question asked about the subject's strategy of responding.

Results and Discussion

The error rate was nearly zero in answering items on questionnaires administered following full sessions of observing (Table 1). Because subjects apparently understood the procedure and instructions well, lever pressing may be analyzed with some confidence. The mean overall rate of pressing the center (point-producing) lever was 133 (standard deviation, $SD = 68$) responses per minute in the mixed schedule and 191 ($SD = 79$) responses per minute in the presence of stimuli produced by observing responses. The mean relative rate of responding on the point lever during S+, S^U, and S− was calculated with respect to the more positive contingent stimulus in each condition. This relative rate, averaged over subjects and conditions, was .59 ($SD = .18$)—that is, more point-lever responding occurred during the contingent stimuli correlated with the larger average amount of reinforcement. The mean absolute rates of responding maintained during the S+, S^U, and S− stimuli, averaged over subjects and conditions, were 202, 167, and 185 per minute, respectively. It is noteworthy that unequal response rates were maintained despite the fact that identical variable-interval response contingencies prevailed during each contingent stimulus and in their absence.

Mean overall rate of pressing the side levers in the mixed schedule (i.e., total observing rate summed over levers) was 37 ($SD = 36$) responses per minute averaged over subjects and conditions. The principal finding is that a measure of choice, the mean relative rate of observing averaged over subjects, was consistent with the conditioned-reinforcement hypothesis in each preference test (individual observing response rates are presented in Table 1). The results also were inconsistent with the uncertainty-reduction hypothesis in the critical comparisons. In each condition, subjects preferred the stimulus that accompanied the larger average amount of reinforcement significantly more, even though the alternative stimulus available for observing may have been equally or more informative. The results show that the mean relative rate of observing maintained by the stimulus correlated with the 5-point schedule (S+) compared to a stimulus correlated with the 1-point schedule (S−), was .76, which is significantly greater than .50 [$t(9) = 3.7$, $p < .01$]. The more positive discriminative stimulus was preferred even though the stimuli were equally informative. In addition, the mean relative rate of observing maintained by the stimulus uncorrelated with amount (S^U) was .75 when subjects chose between it and the stimulus correlated with the 1-point schedule. This was also significantly greater than .50 [$t(9) = 3.8$, $p < .01$]. That is, an uninformative stimulus was preferred to a negative informative stimulus in the most critical comparison. Finally, the mean relative rate of observing maintained by S+ compared to S^U was .66, again significantly greater than .50 [$t(9) = 2.4$, $p < .05$]. Although both the conditioned-reinforcement and uncertainty-reduction hypotheses correctly predicted preference for the stimulus correlated with the 5-point schedule in this latter choice, the total set of results of all three conditions is consistent only with the conditioned-reinforcement hypothesis.

The pattern of results across conditions may be tested for consistency with the principle of transitivity in choice patterns within individual subjects (Fantino & Navarick, 1974; Navarick & Fantino, 1974). Subjects 1, 3, 5, 7, and 9 exhibited strong stochastic transitivity in their choices. That is, preference for Alternative A (the stimulus correlated with the 5-point schedule) relative to Alternative C (the stimulus correlated with the 1-point schedule) was greater than or equal to preferences for Alternative A relative to Alternative B (the stimulus uncorrelated with amount) and Alternative B relative to Alternative C. Subjects 2, 4, 6, 8, and 10 exhibited morderate stochastic transititity in their choices. That is, preference for Alternative A relative to Alternative C was greater than or equal to only one of the preferences, A relative to B or B relative to C. In general, only results that show strong stochastic transitivity can be described by a unidimensional choice theory (Navarick & Fantino, 1974). Therefore, two or more variables may be required to account adequately for the pattern of preferences in the latter subjects.

A strong version of the conditioned-reinforcement hypothesis would require absolute observing response rates to correlate with the amount of reward obtained during the contingent stimuli in choice procedures. Analysis of absolute observing rates from this experiment shows that the means were indeed ranked in agreement with this hypothesis. Mean rates of observing maintained by the 5-point correlated, point uncorrelated, and 1-point correlated stimuli were 31, 13, and 11 responses per minute, respectively, and a within-subjects analysis of variance revealed that the stimuli maintained significantly different rates of observing as predicted [$F(2, 18) = 4.6$, $p < .05$]. Although the less positive 1-point discrimitive stimulus did not maintain significantly less observing than the stimulus uncorrelated with amount, as required by the strong version of the conditioned-reinforcement hypothesis ($F < 1$), neither was there any evidence in these data to support the uncertainty-reduction hypothesis.

Subjects gave a variety of answers when asked for their strategy of responding. Frequently answers were a description of what they did, not why (e.g., how they distributed their responses among the levers). Also, some answers explicitly claimed no particular strategy. Other subjects answered that they either sought or detected different patterns in the procedure (e.g., that points were produced in clusters rather than uniformly).

Eleven answers to the strategy question by 6 subjects were more revealing and relevant to the hypotheses under test. Answers by 4 of these subjects (3, 5, 7, and 9) emphasized the relative rate of getting points associated with a stimulus as a reason for preferring a stimulus. For example, one subject wrote, "The [uncorrelated stimulus] told me I could get points on the [5-point counter] as well as the [1-point counter], so I pressed the [corresponding observing] lever more often." Answers by the 2 remaining subjects (6 and 8), on the other hand, emphasized the informativeness of the stimuli. For example, Subject 6 distributed observing responding as predicted by the conditioned-reinforcement hypothesis despite reporting a strategy that took informativeness of the stimuli into account. The subject who responded most consistently with the predictions of the information hypothesis (Subject 8) wrote, "I pressed the [observing lever that produced S−] more because the [uncorrelated stimulus] provided no information." Other results for this subject were anomalous: The highest average rate of point-lever responding was maintained during S− (although the rate during S+ was higher than during S^U).

Certain aspects of the planned contingencies of reinforcement were reliably circumvented by one subject whose data were excluded from the statistical analyses. In particular, for this subject two successsive presses on the point lever each produced a point for every one scheduled during the stimulus correlated with the 1-point schedule, provided the momentary response rate was extremely high just after the first point was produced. The subject became inexplicably skilled at producing the unplanned reinforcer and was much more successful than the experimenters ever became during their attempts to reproduce the effect. Extra points were produced at nearly every opportunity throughout the experiment soon after the rapid-burst response pattern developed in the subject's first session. It is noteworthy that this was the only subject who strongly preferred observing the stimulus reliably correlated with the 1-point schedule compared to an uninformative stimulus (choice proportion = .77). However, for this subject it is possible that efficiency of responding and total earnings could be detectably increased by observing the less positive discriminative stimulus: Point-lever responding could accelerate during the 1-point stimulus, thus increasing the chance of producing an unplanned reinforcer, and could slow during the other stimulus, allowing the subject to relax somewhat without endangering loss of scheduled reinforcers. The answers to the strategy questions indicated that these considerations were evident to the subject and that they controlled responding. It is unclear why the contingency was so powerful in shaping and maintaining the high rates of point-lever pressing during the 1-point stimulus, but meeting the inadvertently scheduled high response rate requirement did mean that the efficiency of point-lever responding could increase through producing the stimulus correlated with the 1-point schedule.

EXPERIMENT 2

The results of Experiment 1 were generally consistent with predictions of the conditioned-reinforcement hypothesis regarding preference in choice procedures, replicating those of Fantino and Case (1983). The results suggest that discrepant findings between that study and the one by Perone and Baron (1980) were not due to presence or absence of a response-reinforcer contingency per se, but could have resulted from differences in response efficiency enabled by observing S−. However, many other seemingly minor differences between the studies exist that could also be responsible. Thus, the response-efficiency argument requires a more direct test. One such experiment might compare within the same subjects the effect of varying response efficiency permitted through observing. To that end, we attempted in Experiment 2 to duplicate the response requirements in the previous studies in different conditions. In one case responding on a 5-lb plunger was required to produce points in the reinforcement component, whereas in the other case reinforcement was not contingent on any responding. (In this usage, by reinforcement we mean the same event that under similar circumstances maintains responding that is contingent upon it—that is, in situations like this people will typically press a lever when pressing produces points exchangeable for money.) We predicted that in these circumstances the rate of observing maintained by S^U in the noncontingent condition would be greater than that maintained by S−. On the other hand, we predicted that in the response-dependent condition, preference for S− might result depending upon the relative importance of effort saved versus the negative correlation of S− with points. In any event, if the previous analysis is correct, preference for S− should increase when it enables more efficient responding.

METHOD

Subjects

We recruited 5 men and 3 women from a pool of Introductory Psychology students who were required by their instructor to act as subjects for credit towards their course grade. Subjects were paid approximately $2.00 per session in exchange for points obtained in the experimental task.

The data from two subjects, one from each condition (see Procedure), were excluded from analysis. Both ceased responding altogether on the observing levers in the second session, thus precluding meaningful interpretation with respect to the hypotheses under investigation.

Apparatus

The same room and for the most part the same apparatus that were used in Experiment 1 were used in Experiment 2. One difference was that this time the display panel contained a single counter that was positioned in the center next to the column of stimulus lamps. Also, a plunger (Gerbrands Model G6310) was mounted just beneath the table top and centered with respect to the display and the levers. The force required to operate it was 5 lbs, the same as that usually used in the experiments by Perone and Baron (1980).

Procedure

VI or variable-time (VT) schedules of reinforcement randomly alternated with extinction (EXT) within a session, in different conditions of the experiment. Both VI (or VT) and EXT schedules were correlated with the top (unfiltered) panel light (inasmuch as it was illuminated throughout a session) and were in effect for 60 s before alternating. In the response-dependent reinforcement condition, pulls on the plunger illuminated the green (reinforcement available) light according to a VI 60-s schedule. Once the green light was illuminated, a press on the center lever (consummatory response) produced a point by incrementing the counter. The press also darkened the green light and started the next inter-reinforcement interval of the VI schedule. Pulls on the plunger during EXT had no effect and the green light always remained dark. In the response-independent reinforcement condition, the green light was illuminated according to a VT 60-s schedule independent of any responding. Otherwise, the two conditions were identical. That is, the VT schedule alternated with EXT and pressing the center lever in the presence of the green light incremented the point counter once and then darkened the lamp. Most other aspects of the procedure (e.g., the schedule by which presses on the observing levers produced stimuli, session protocol, use of questionnaires, etc.) were the same as in Experiment 1. However, in order to simplify the experiment, only one observing condition from Experiment 1 was used in Experiment 2. The condition selected—observing a stimulus correlated with EXT versus observing one uncorrelated with the schedules—is the one for which the predictions of the conditioned reinforcement and the information hypotheses are most discrepant.

The instructions for the response-dependent reinforcement condition read as follows:

> [In this experiment you have the chance to occasionally earn points which are worth 10 cents each at the end of today's session.] Points are more likely during certain periods than during others as you will soon see for yourself.
>
> In front of you are a plunger, three levers, and some lights. Points are produced by pulling the plunger. The white light will normally be on. You can occasionally cause the red or blue lights to turn on by pressing

the side levers. When the red light is on, some of the time points are twice as likely as normal. However, at other times when the red light is on, no points can be produced. No points can be produced when the blue light is on.

Please press the levers with your finger and pull the plunger using only one hand (your preferred hand). This will insure that only one thing is operated at a time. You may otherwise select to pull the plunger and press the levers as you wish in any order. The light directly above each lever will turn on when you press to let you know that you have pressed hard enough.

The green light will turn on when you produce a point. Press the center lever once when the green light comes on in order to acknowledge that you got it. This press on the center lever will also cause the green light to turn off and the counter in front of you to increment. The counter shows the number of points that have accumulated so far. Remember, these points are worth 10 cents each.

The instructions for the response-independent reinforcement condition were the same except that all references to the plunger were deleted and the portion in brackets was replaced by the following:

In this experiment you have the chance to occasionally receive points which are worth 10 cents each at the end of today's session. However, nothing you can do will affect the total number of points that you receive—it cannot be either increased or decreased by your responding.

Half the subjects were studied in the two conditions in an ABA sequence for a total of three sessions. The other half were studied in a BAB sequence. Side and color of the observing alternatives were also roughly counterbalanced across subjects. Table 2 summarizes the design.

Results and Discussion

The results from questionnaires administered after full sessions of observing are summarized in Table 2. Subjects apparently understood the procedure well, as evidenced by near-zero error rates in answering items on questionnaires. Plunger pulling was maintained well by response-dependent points and came under the control of the discriminative stimuli. The absolute rate of pulling the plunger in the response-dependent reinforcement condition was 82 ($SD = 59$) responses per minute in the mixed schedule, 110 ($SD = 53$) responses per minute in the presence of the discriminative stimulus that was uncorrelated with the VI and EXT schedules, and nearly zero in the presence of the discriminative stimulus correlated with EXT. Negligible plunger pulling occurred in the response-independent reinforcement condition.

Substantial rates of observing were maintained in both experimental conditions. Absolute rate of pressing the observing levers was 39 ($SD = 42$) responses per minute when pulling the plunger produced reinforcement and 57 ($SD = 59$) responses per minute when reinforcement was independent of responding. The principal results, the relative rate of responding on the observing lever that produced S− in each condition, are plotted in Figure 1. The deviation lines on the bars of the results for individual subjects show the standard deviation of the initial determination and the replication. Mean preference (relative response rate) for observing the stimulus correlated with EXT was .36 ($SD = .15$) when reinforcement was presented independent of responding. This replicated prior studies in that it was significantly less than .50 (hatched bars, $t(5) = 2.1$, $p < .05$). On the other hand, preference for observing S− increased for every subject when pulling the plunger produced reinforcement. A within-subjects analysis of variance revealed that preference for S− was significantly greater in the response-dependent reinforcement condition [$F(1,5) = 9.8$, $p < .05$]. Although mean preference reversed in the response-dependent reinforcement condition—that is mean relative rate of observing maintained by S− was .57 ($SD = .25$), the mean was not significantly different from equal preference (open bars, $t(5) = .63$, $p < .1$). S− was preferred to S^U in six of nine replications ($p < .1$, binomial test).

Table 2
Design and Principal Results of Experiment 2

				Rate of Observing[a] and Number of Questionnaire Items Answered Incorrectly[b]					
				Independent			Dependent		
Subject	*Order of Conditions*[c]	*Design S1*[d] *Color*	*S1 Side*	S^U	*S−*	*Errors*	S^U	*S−*	*Errors*
1	ABA	red	right	173	3.5	0	77	21	0
Replication				86	18	0			
2	BAB	red	left	2.4	2.4	0	3.0	6.4	0
Replication							3.4	4.2	0
3	ABA	red	right	120	67	0	50	37	0
Replication				28	19	0			
4	BAB	blue	left	2.1	1.3	1	5.9	10	0
Replication							1.9	1.5	0
5	ABA	blue	right	34	11	0	5.2	15	0
Replication				44	24	0			
6	BAB	blue	left	11	10	1	1.8	12	0
Replication							.2	11	0

[a]Expressed in responses per min.
[b]Questionnaires contained 8 items.
[c]The conditions were A = Independent; B = Dependent.
[d]Stimulus S1 was uncorrelated with the components.

Responses to the strategy question were frequently revealing and indicated that several subjects attempted to use S− to save effort in pulling the plunger in the response-dependent reinforcement condition. Other answers indicated that most subjects avoided S− in the response-independent reinforcement condition because no points would be delivered while it was present.

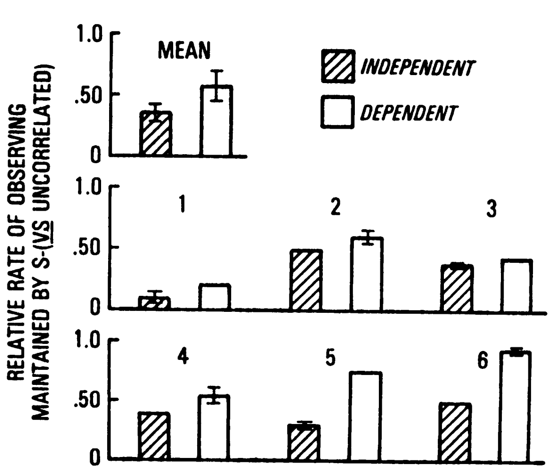

Fig. 1. Mean and individual relative rates of observing responses maintained by S− in Experiment 2. Subjects chose between S− and a stimulus uncorrelated with reinforcement. Only one condition was replicated for each subject, so only the result from one condition for each subject has an error bar (representing error variance of the initial determination and one replication). Error bar length is one standard deviation.

GENERAL DISCUSSION

Mean preferences of college students in this study were consistent with predictions of the conditioned-reinforcement hypothesis of observing. With few exceptions (notably Subject 8 in Experiment 1, whose results were anomalous in other respects) subjects preferred the more positive contingent stimulus with respect to points, except in the response-dependent reinforcement condition of Experiment 2. In this condition, production of the less positive stimulus enabled a substantial improvement in response efficiency because subjects could, and did, reduce ineffective responding on a relatively high-effort manipulandum. Because the stimulus correlated with EXT in this case was also correlated with the saving of considerable effort, the preference predicted by the conditioned-reinforcement hypothesis cannot be specified, given the precision of its present formulation. Both relationships should contribute to conditioned reinforcement, but their relative importance is unclear. However, the hypothesis correctly predicted decreased preference for S− for every subject in Experiment 2 when obeserving no longer could affect the efficiency of responding. That is, the results show that, for the same subjects, S− was not preferred in the response-independent reinforcement condition of the experiment. In Experiment 1 also, observing did not permit a substantial improvement in response efficiency. In this case, too, subjects did not prefer a negative informative stimulus. Therefore, the results show that negative informative stimuli maintained observing only to the extent that improved response efficiency was enabled through producing them. These data are thus consistent with Fantino and Case's analysis of the ostensibly anomalous findings of Perone and Baron (1980). These data also argue against the hypothesis that uncertainty reduction is a determinant of observing for more highly evolved organisms. Contrary to the uncertainty-reduction hypothesis, preference for informative stimuli depended upon whether they were positively or negatively correlated with reinforcement and whether or not producing them permitted a more efficient distribution of responding required for reinforcement.

Recent research on observing in children lends further support to these conclusions. Mulvaney, Hughes, Jwaideh, and Dinsmoor (1981) studied two normal and two retarded children in an observing procedure in which subjects could control the duration of exposure to the contingent stimuli. They found that S+ was preferred to S− in both groups. Although the difference in duration of exposure declined over sessions in the normal children (as did total observing), a different measure of preference remained clearly consistent with the conditioned-reinforcement hypothesis for both retarded and normal subjects throughout the entire experiment. Fantino, Case, and Altus (1983) studied normal children of three different ages in a procedure identical to that used in the response-independent reinforcement condition of our Experiment 2. They found that the total absolute rate of observing increased with age but preference for the more positive contingent stimulus (in one condition, S+ vs. S−, and in another, uncorrelated vs. S−) was constant across ages. In each of two conditions where differing predictions were made, the results were consistent with the conditioned-reinforcement hypothesis (preference for S+ and for the uncorrelated stimulus) and inconsistent with the uncertainty-reduction hypothesis. In addition, they found that preference for the more positive contingent stimulus was maintained with extended testing (as it was in Fantino & Case, 1983).

The definition of observing behavior specifies that it be independent of primary reinforcement. This independence is critical for dissociating contingencies of conditioned reinforcement from those of delayed primary reinforcement; it is what distinguishes observing schedules and, for example, chained schedules. The reinforcement that the definition makes reference to is that provided according to the mixed schedule of reinforcement (such as points in the present study). Another potential reinforcer in response-dependent reinforcement procedures is the cost or effort involved in emitting responses required for reinforcement. As far as we know, all would agree that observing which permits increased efficiency of responding should be maintained relative to a control condition. Therefore, one might ask why reinforcement of observing by negative informative stimuli in response-dependent reinforcement procedures has never been found in any pigeon study. One explanation is that in such studies the response required for reinforcement does not entail substantially more effort than the observing response. Therefore, the improvement in response efficiency made possible by observing is small because the absolute amount of effort saved is small. This hypothesis is currently being tested directly in our laboratory.

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