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Persistence during extinction: Are judgments of persistence affected by contingency information?

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The partial reinforcement extinction effect (PREE), defined as increased behavioral persistence following intermittent reward, is considered an important outcome of instrumental learning contingencies, both inside and outside the laboratory. Since adults have a rich experience with situations in which desired outcomes depend on instrumental responding, we asked whether that experience affects judgments of persistence when relevant contingency information is manipulated. Subjects read simple scenarios with information about behaviors generated by high vs. low reward rate, and then judged the resultant persistence of these behaviors under no-reward conditions. Studies 1 and 2 found no evidence that persistence judgments were affected by contingency information in naıve subjects. Studies 3 and 4 compared groups with and without explicit knowledge about behavioral psychology and thus tested possible effects of that knowledge for persistence more directly. Judgments in naıve subjects were not reliably influenced by reward rate information, but subjects possessing expert knowledge demonstrated judgments that were reliably affected by contingency information. The results indicate that people do not generate generalized knowledge from normal experience with occasional vs. regular reward. Possible explanations and implications of these findings are discussed.

Key words: Judgment of persistence, persistence, reward, extinction, PREE.

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A robust finding within the field of instrumental learning is that persistence of learned performance is inversely related to reward rate during acquisition. Following intermittent reinforcement, persistence during extinction conditions is greater compared to persistence following continuous reinforcement. This effect, the partial reinforcement extinction effect (PREE), is most reliably observed in comparisons of separate groups of subjects exposed to continuous vs. intermittent reinforcement (e.g., Capaldi, 1994; Flora & Pavlik, 1990). PREE may be highly adaptive, since it reflects the optimal strategy of persisting longer when reward is uncertain (Staddon, 1983), and is documented experimentally in a number of species, including humans (e.g., Pittenger, Pavlik, Flora, & Kontos, 1988; Svartdal, 2000a).

PREE typically is measured under laboratory conditions as group differences in behavioral persistence. However, given its robust nature, PREE should be observed also under less formalized conditions. For example, a dog's begging for food should be quite persistent under no-reward conditions following occasional reinforcement, but less persistent following regular reinforcement. Similarly, how human behavior survives protracted nonreward is of practical interest in many contexts. One example is the survival of therapy after intervention has been completed (extinction) (Nation & Woods, 1980). In such situations, even though the behavior changing contingencies involved in therapy are less formalized than those in laboratory conditions, laboratory findings on persistence may be of significance in understanding of the duration of therapeutic effects. In general, persistence effects according to PREE should be observed in a variety of situations outside the laboratory (e.g., Ferster, Culbertson, & Boren, 1975).

Furthermore, PREE should also be reflected in a variety of measures. Although persistence is typically conceptualized in terms behavioral indices such as running speed (e.g., Capaldi, 1994), number of responses (Skinner, 1938), or slope of response rate reduction (Nevin, 1988), persistence should not be restricted to such measures. For example, following exposure to reward contingencies, cognitive measures (e.g., judgments about persistence) might be expected to indicate effects correlated with behavioral measures. This assumption is even more reasonable if interpretations of PREE are given in terms of cognitive and emotional states (e.g., Amsel, 1958, 1994; Capaldi, 1967, 1994; Lawrence & Festinger, 1962; Weiner, 1986). If such states are assumed to be crucially involved in PREE, differential and measurable effects of learning contingencies on cognitive and emotional states should be expected.

Another assumption—maybe less obvious but nonetheless reasonable—is the following: When people over time experience various kinds of natural learning contingencies, accumulation of generalized knowledge about such contingencies should be expected. Effects of extended experience from experimental learning contingencies on behavioral and cognitive functioning is well documented in a variety of contexts (e.g., Harlow, 1949; Schwartz, 1996), and need not be conscious to affect behavior and judgments (Lewicki, Czyzewska, & Hill, 1997). Furthermore, Nevin (e.g., 1988) showed that persistence effects evolve as experience with relevant contingencies is accumulated. It may be assumed, therefore, that extended experience from

individual learning episodes with reliable vs. unreliable reward generates sensitivity to such situations and their effects. This generalized knowledge should be possible to measure in alternative ways, one being judgment of persistence. Given relevant contingency information, judgments of persistence should then reflect such generalized experience.

Generalized knowledge about reliable vs. unreliable reward contingencies should reflect at least some of the variables that are shown to affect persistence during extinction. For PREE, the frequency of desired outcomes during training is a crucial variable. Research shows that people are sensitive to differences in frequency of outcomes and stimuli associated with reinforcer frequency (e.g., Shanks & Dickinson, 1991), and to cues indicating the presence or absence of behavioral control (e.g., Langer, 1975). This sensitivity permits relatively easy discrimination between reliable vs. unreliable reward conditions, or between cues that signal such contingencies. Hence, if people accumulate experience from various reward situations, an important cue for applying this information to new situations is information about reward rate. This implies that information about low reward rate in a particular situation should activate expectations about increased persistence in this situation; if information about high reward rate is provided, expectations about reduced persistence should be activated.

The present studies explored these ideas. We asked students to judge behavioral persistence following described reward scenarios, where contingency information was manipulated over independent groups of subjects. Contingency information was manipulated in the simplest way possible to optimize judgmental sensitivity to accumulated knowledge of reward contingencies. Our main question throughout was whether or not manipulations of contingency information in the scenarios would affect judgments of extinction performance. Sensitivity to contingency information in this context implies that subjects judge persistence effects in accordance with the behavioral sensitivity typically observed in corresponding situations when actual contingencies are manipulated.

The existence of accumulated knowledge of learning contingencies is particularly likely if cognitive mediation is regularly involved in behavioral adaptation to such contingencies. A number of studies have demonstrated that adaptation to learning contingencies is indeed reflected in cognitive and verbal measures (e.g., Chatlosh, Neunaber, & Wasserman, 1985; Shanks & Dickinson, 1991; Shanks & St John, 1994). If adaptation to learning contingencies is regularly associated by verbalization of the contingency, it follows that crucial elements of the learning process are available to conscious apprehension. Hence, explicit knowledge from individual learning episodes should accumulate over time and generate a generalized knowledge of learning episodes and their correlates. Note, however, that judgmental sensitivity to learning contingencies need not be a consequence of explicit awareness of those contingencies, and judgmental sensitivity need not be explicit. Just as many measures of cognitive processes are of assumed, non-observable constructs or processes rather than consciously available content (e.g., Nisbett & Wilson, 1977), judgmental sensitivity to learning contingencies may well be unavailable to explicit report. Following intermittent reinforcement, a person might demonstrate both increased behavioral persistence and increased judged persistence, but this might occur without this person being able to explicitly report this sensitivity. Thus, although the existence of accumulated experience from learning contingencies is especially likely when individual learning episodes are explicit, such accumulated knowledge may occur even when learning has been implicit. Similarly, judgments about persistence effects should be sensitive to accumulated knowledge, regardless of whether or not that knowledge is explicit.

In the present context, we asked whether PREE, reliably demonstrated behaviorally in experiments with humans, is represented cognitively as a function of normal experience with naturally occurring reward situations. This question was investigated in four groups of studies. Studies 1 and 2 assumed that people have general knowledge of learning contingencies, and tested possible effects of contingency knowledge for persistence in an indirect way. Studies 3 and 4 compared groups with and without explicit knowledge about persistence effects and thus tested possible effects of that knowledge for persistence more directly.

STUDY 1

Study 1 manipulated information about reinforcer rate for discrete-trial instrumental responding. Discrete-trial responding (i.e., responding performed in experimenter-defined trials rather than freely) is reliably associated with a standard PREE when reward rate is manipulated over independent groups (e.g., Capaldi, 1994). Different groups of students read a scenario describing a habit having being established by continuous (CRF) or intermittent reinforcement (PRF). Subjects were then told that reward was discontinued (extinction), and asked to judge the resulting resistance to extinction. This should parallel the information contained in corresponding situations where a reliable PREE is observed: (1) Between-group manipulation of reinforcer rate; (2) discrete-trial reinforcement situation; and (3) extinction defined as discontinuation of reinforcement.

The specific scenario described—a dog's begging at the dinner table—was tested in a pilot study and found to be easily understood. The pilot study also indicated that prior experience with dogs affected judgments of persistence, but since the experience factor did not affect judgments differentially over reward conditions, this effect was considered unproblematic for the present purposes.

METHOD

Subjects

Participants were 79 students at Examen Philosophicum (an introductory philosophy course required for all new students enrolling in Norwegian universities) and 92 students at two colleges located in Tromsø.

Material and procedure

Half the subjects (CRF group) read the following story:

> "A family has for a long time given their dog food at the dinner table. During each meal, the dog has approached the table and begged for food. It has then received food almost every time it begged for food. We can thus assume that the dog has learned that every attempt is followed by the desired outcome (food).
> Now this family has decided to stop this practice. They have decided not to give the dog any food when it begs at the table. This decision is carried through with no exceptions: The dog now never receives any food when begging at the dinner table (of course, it receives food in its own food tray as usual)."

Subjects in the PRF group were told that the dog "... received food only occasionally when it begged for food. We can thus assume that the dog has learned that some attempts, but not every attempt, will be followed by the desired outcome (food)."

For the college student subjects, the CRF scenario stated that the dog "received food every time it begged for food" rather than "received food almost every time it begged for food". Otherwise the descriptions were identical. The CRF and PRF questionnaire sets were randomly distributed among students at the outset of a lecture.

After reading the scenarios, participants were asked to estimate how long they believed the dog would continue to beg for food at the table when food delivery at the table was discontinued. Answers were given by indicating the number of times per week they believed that the dog would beg for ten weeks following extinction onset. Thus, for each week, the maximum score was 7 (begging at every meal during this week), and the minimum score was 0 (never begging). The subjects were also asked to give a short rationale for their answer, and to (a) indicate whether they had a dog themselves (as a control for extensive vs. little experience with this type of learning situation) and (b) whether they had any knowledge of psychology.

Finally, all subjects were asked to judge the outcome of a reversed scenario. The reversed scenario question was presented on the back of the questionnaire. Subjects judged whether persistence would have been lower, equal, or higher compared to the persistence judged on the front page of the questionnaire, given that performance in the reward scenario had been rewarded all the time (PRF group) or intermittently (CRF group).

RESULTS

There were no differences in judgments between the two samples, so they were collapsed for all analyses. Further, self-ratings of knowledge of psychology did not affect judgments significantly, so this factor was ignored in the analyses. The judgment data were subjected to ANOVA with the reward rate manipulation (CRF vs. PRF) and experience with dogs (yes or no) as the between-subjects factors, and judgments over weeks (1–7) as a repeated measures factor. The effect of the repeated measures factor was significant, $F(9, 1476) = 173.89$, reflecting that persistence was judged to diminish over weeks.[1] Further, experience with dogs affected judged persistence, $F(1, 164) = 5.65$, $p < 0.025$, as subjects who reported experience with dogs judged persistence to be higher

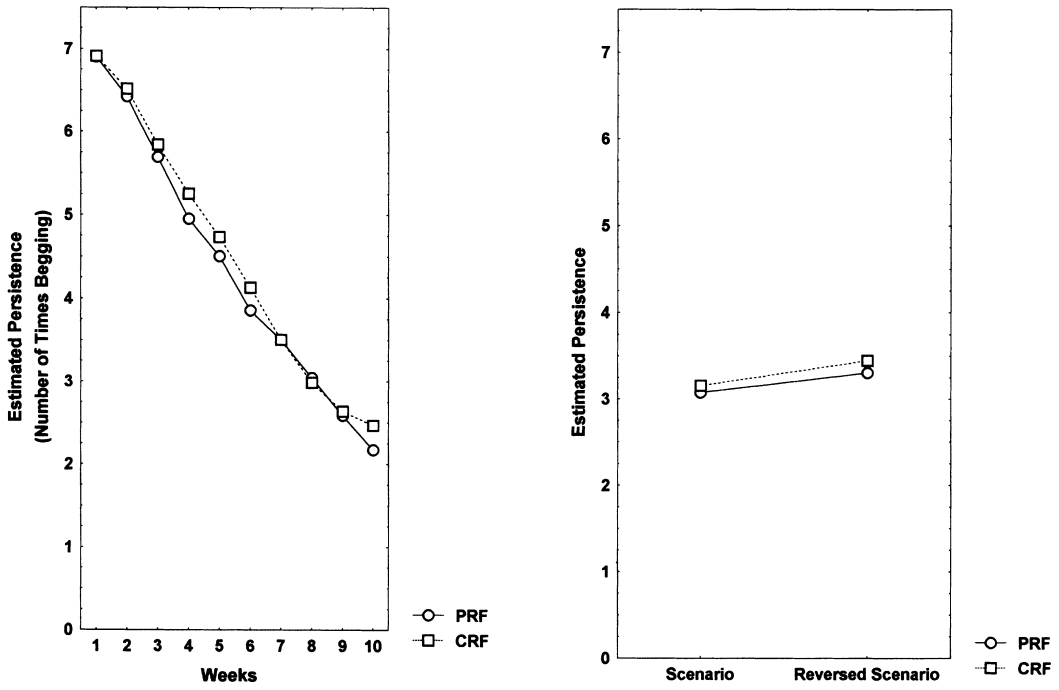

Fig. 1. Estimated persistence under non-reward following CRF and PRF (left panel); judged persistence on final five weeks vs. reversed scenario (right panel).

than subjects without such experience. Finally, no effect of the reward rate manipulation was apparent in the judgment data, $F(1, 164) = 0.19$. None of the interaction effects were significant. Since the dog experience factor did not interact with the reward manipulation, this factor was considered to be of no significance for the present investigation. The relevant data are displayed in Fig. 1, left panel.

Because the judgment of the reversed scenario was made relative to the first judgment, judgments to the reversed scenario were computed as a relative change from a reference judgment in the direction indicated (i.e., lower, equal, or increased persistence). Since it is the direction of change and not the actual change that is important here, a "lower" judgment was defined as a 40% decrease in persistence, and a "higher" judgment as a 40% increase in persistence. The reference judgment was calculated as the mean persistence level of the final 5 weeks of the scenario. If the "increased" or "decreased" judgments were systematically related to reward condition, an interaction effect is predicted: Subjects in the CRF condition should indicate an increased level of persistence, while subjects in the PRF condition should indicate a reduced level. The ANOVA showed a main effect of scenario vs. reversed scenario, $F(1, 165) = 11.34$, $p < 0.005$, as all subjects, independently of reward condition, judged persistence to be higher under the reversed scenario. The effect of the dog experience factor was marginally significant, $F(1, 163) = 3.90$, $p = 0.05$, reflecting that dog experience increased persistence in judgments. However, there was no effect of the reward manipulation, $F(1, 165) = 0.09$, and no interaction effects were significant. Thus, judgments of the reversed scenario did not reveal sensitivity to the reinforcer rate manipulation. The relevant data are displayed in Fig. 1, right panel.

DISCUSSION

The present data indicate that the continuous vs. partial reinforcement (CRF vs. PRF) manipulation did not affect judgments of persistence. Comparison between groups under CRF vs. PRF conditions is considered the most likely condition to produce between-groups PREE (e.g., Flora & Pavlik, 1990). However, the present data reveal no indication that the groups receiving CRF information demonstrated judgments that differed from those receiving PRF information. This is, of course, inconsistent with the hypothesis that people accumulate and apply knowledge from everyday experience with reward contingencies.

It should be noted that experience with dogs affected persistence judgments, most probably because people with dog experience have experienced that habits in dogs may be difficult to change. This indicates that although reward rate information did not affect judgments, judgments were affected by another apparently relevant factor. Also note that subjects agreed that some begging would persist even after the 10-week extinction period. Other research (Svartdal, 2000a) has found that persistence is best measured in late extinction trials. The present judgment data thus indicate that subjects overall judged the begging behavior as being quite persistent.

The hypothesis that extended experience with natural learning contingencies generates generalized knowledge of such contingencies implies that such knowledge accumulates over time. Older students should therefore possess more knowledge than younger. As a specific test of this hypothesis, all participants of Study 1 were split in two age groups, one above the mean age of the total sample and one below the mean age. However, the ANOVA indicated no effect on persistence judgments of the age factor, $F(1, 161) = 0.01$, thus further supporting the conclusion that people do not apply accumulated knowledge of reward contingencies in judgments about persistence under extinction.

Finally, a methodological issue related to measurement of persistence must be considered. In the present study, persistence estimates were given for 10 consecutive weeks. Is it possible that subjects simply responded by indicating maximum persistence (7) for the first week and minimum persistence (0) for the last week, and then adjusted the intervening judgments to fit a linear decreasing trend? The answer appears to be no. First, a separate group of subjects ($N = 88$) estimating persistence in terms of a single estimate (number of days that begging would persist) did not demonstrate any sensitivity to reward rate manipulations (Svartdal, 1999). This indicates that the measurement method is not crucial. Second, judgments of persistence late in the extinction period did not reach minimum (see Fig. 1); subjects overall agreed that begging at the table was a difficult habit to extinguish. Third, judgments *were* sensitive to the dog experience factor. The two latter observations indicate that the measurement method applied in these studies is indeed sensitive to persistence effects.

STUDY 2A

Studies 2a and 2b extended the investigation of judged PREE to a free-operant situation. In a free-operant situation, the subject is free to emit the instrumental response without intervention by the experimenter. The predictions for this situation are somewhat more complex than for the discrete-trial situation. Although several reports have indicated an ordinary PREE in free-operant tasks (e.g., Skinner, 1938), Nevin (1988) argued that the standard outcome for this situation is the opposite, i.e., a reversed PREE. Nevin's conclusion is based on analyses of slope of response rate reduction during extinction, not of absolute number of responses. Thus, for well-learned behaviors, the slope of the response rate reduction is steeper following intermittent reinforcement compared to continuous reinforcement. Still, even if the reversed PREE in terms of rate change is observed, a conventional PREE defined in terms of the absolute number of responses may occur (e.g., Nevin, 1985). Thus, if number of responses is used as the dependent measure, it is safe to conclude that the expected outcome of

intermittent reinforcement for a free operant is increased persistence under extinction, compared to a response being reinforced continuously.

Study 2a presented a simple scenario about a free-operant response being rewarded only occasionally or very often, and then asked participants to rate the resulting persistence under subsequent extinction conditions. The scenario chosen—playing a slot machine—is a frequently cited example of human operant behavior, and slot machine playing has been used in investigations of human extinction performance, with a conventional PREE as the outcome (Lewis & Duncan, 1956). Slot machines used for charity fund-raising are quite commonly seen in Norway.

METHOD

Subjects

Participants were 155 students at the University of Tromsø and the Teaching College of Tromsø.

Material and procedure

The scenarios and corresponding questionnaires were handed out to students at the outset of a lecture. The high reinforcer rate group read the following story:

> "An eight-year old often visits a shopping-center with his parents. At the shopping-center there is a slot machine on which the boy loves to play. The boy has often played on this machine, and has experienced that it renders a very high rate of winnings.
> Then, for a long period of time, the slot machine was empty. The eight-year old continued to play, but he would of course at some point stop playing."

For the low reinforcer rate group, the last part of the final sentence in the first paragraph was phrased as follows:

> "... and has experienced that it renders winnings once in a while."

The questionnaire then asked participants to estimate how often the boy would continue playing until quitting. Possible estimates were 0–7 times per week for five weeks following extinction onset.

Results and discussion The ANOVA indicated a significant effect of weeks, $F(4, 612) = 284.28$, as playing rate was judged to diminish over weeks (see Fig. 2). However, the effect of the reward rate manipulation was not significant, $F(1, 153) = 0.39$, neither was the group × weeks interaction. Thus, no indication of sensitivity to the reward rate manipulation was observed.

A subset of the questionnaires ($n = 94$) asked the participants to judge extinction performance under the described scenario as well as under reversed reward conditions. In addition, this subset made the reward properties of the situation more explicit by eliminating a possible confounding personality variable in judgments of persistence. Thus, the sentence *"At the shopping-center there is a slot machine on which the boy loves to play"* was changed to *"At the shopping-center there is a slot machine."* The subset judgment data are depicted in Fig. 3. The subset did

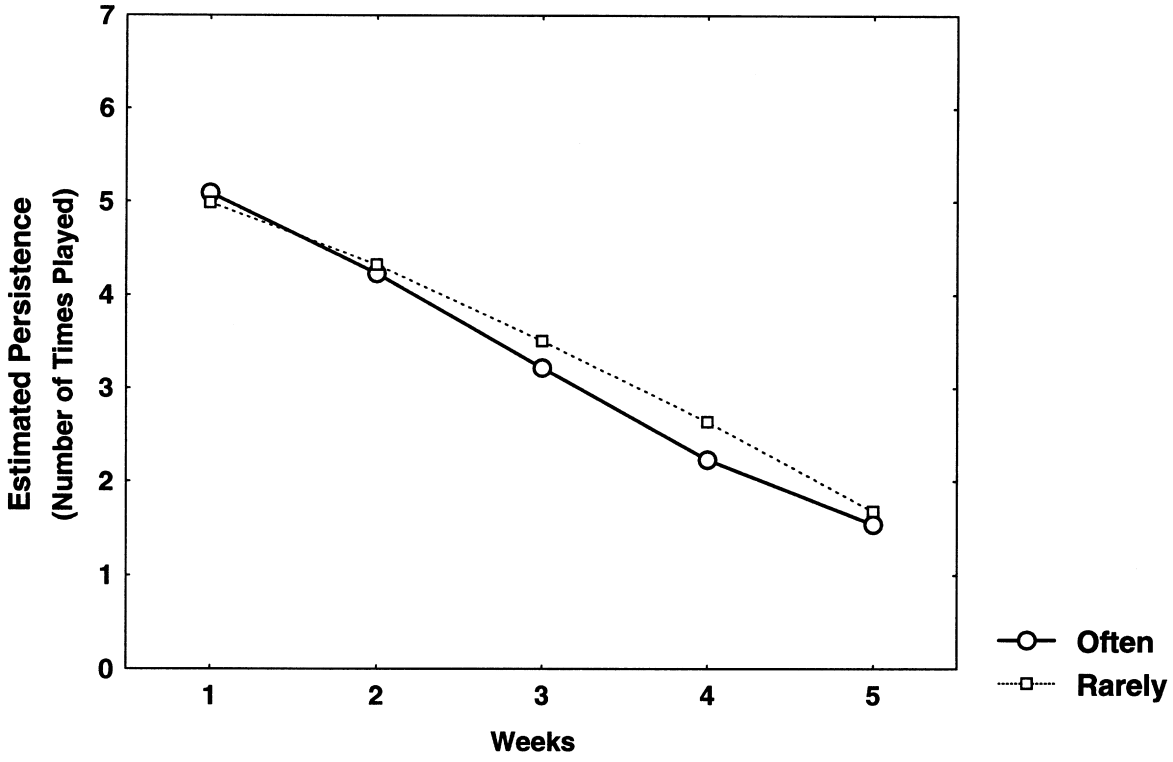

Fig. 2. Extinction performance as a function of high and low reinforcer rate.

not differ from the rest of the sample, $F(1, 151) = 1.95$, $p > 0.16$, and the subset judgments did not differ between reward conditions, $F(1, 92) = 0.14$ (Fig. 3, left panel). The reverse judgments were computed in the same manner as earlier, with the reference judgment now defined as the mean of the final 3 weeks. An ANOVA indicated that these judgments changed differentially over groups, $F(1, 90) = 11.19$, $p < 0.005$. As is indicated from Fig. 3 (right panel), subjects in the high reward rate group indicated that there would have been *fewer* responses under extinction if reward rate had been low, and subjects in the low reward rate group indicated *more* responses under extinction if reward rate had been high. However, this outcome is the opposite of what is predicted from PREE and therefore again indicates no sensitivity in judgments to the reward manipulation in the direction predicted by that principle. As is apparent from Fig. 3, left panel, there were no differences in rate change of persistence judgments between the groups. Thus, although the reverse scenario judgments indicated a reversed PREE, this was not the case for the scenario judgments.

STUDY 2B

Study 2b was performed as an extension and partial replication of Study 2a. First, Study 2b specified the reward rate differences in terms of numerical rather than verbal descriptions of reward rate, and the reward rates specified both described PRF schedules. Although no clear between-groups differences are to be expected when extinction performance following two PRF schedules are compared (Flora & Pavlik, 1990), extinction persistence should be elevated compared to CRF schedules (e.g., often condition of Study 2a). Second, the extinction period was extended to 10 weeks to obtain an extended measure of persistence and to permit a comparison of judgments between 5 and 10 weeks as a check for potential effects on judgments by the available time scale for extinction judgments. The reversed scenario judgments were not included in this study.

METHOD

Subjects

Participants were 81 students at Examen Philosophicum at the University of Tromsø.

Material and procedure

The questionnaire used in Study 2a was modified to the following story, given to the 50% group:

> "An eight-year old visits a shopping-center on a daily basis with his parents. The boy has developed a habit of playing on this slot machine, and he has experienced that it renders a very high rate of winnings (typically in 50% of all attempts).
> For a period of time the slot machine has been out of order (there were no signs about this, so the boy had to learn about this failure through his own experience). The eight-year old continued to play, but he would of course at some point stop playing.

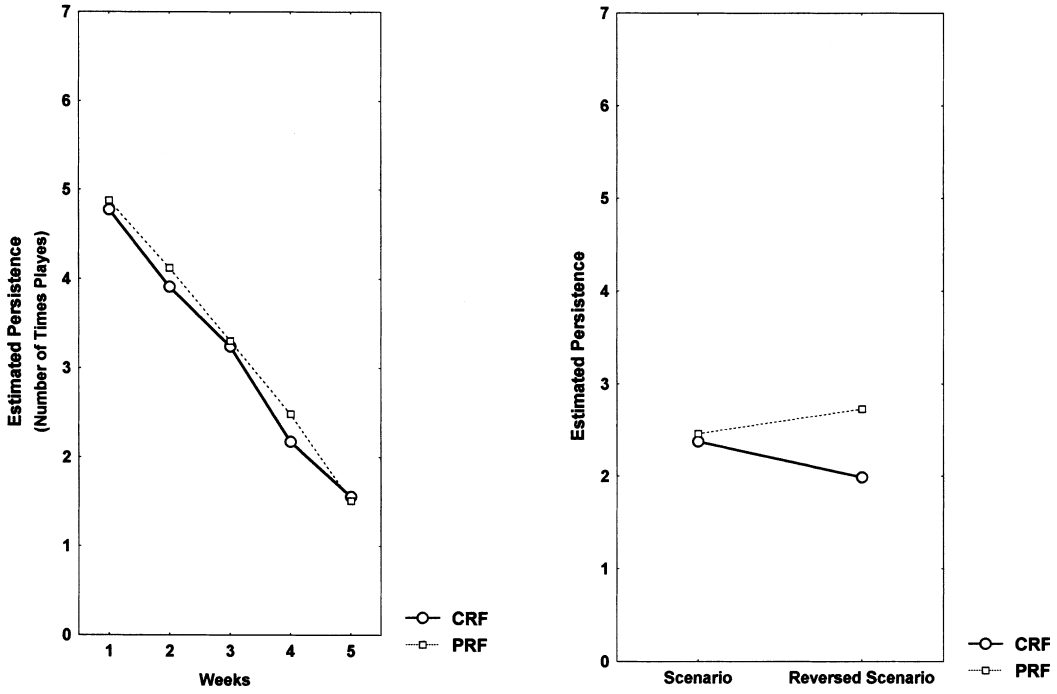

Fig. 3. Estimated persistence under nonreward following reward at every response or only some of the responses (left panel); judged persistence if reversed scenario (right panel).

For the 10% group, the last part of the second sentence in the first paragraph was phrased as follows:
"... and he has experienced that it renders a winnings quite rarely (typically in 10% of all attempts)."

The questionnaires, half with the 50% reinforcer rate information and half with the 10% reinforcer rate information, were randomly distributed among the students at the outset of a lecture.

RESULTS AND DISCUSSION

As is apparent from Fig. 4, the reward rate manipulation did not cause any group differences in estimated persistence during slot machine failure (extinction), $F(1, 79) = 0.04$, but persistence was judged to diminish over weeks, $F(9, 711) = 63.91$. Thus, as in the previous studies, there was no indication that reinforcer rate information affected judgments of extinction persistence.

ANOVA of extinction judgments of both Studies 2a and 2b (first 5 weeks) indicated a nonsignificant effect of study (2a vs. 2b), $F(3, 229) = 0.24$, a highly significant effect of weeks, $F(4, 916) = 265.87$, and a significant interaction effect, $F(12, 916) = 1.97$, $p < 0.025$. These data are shown in Fig. 4. The nonsignificant effect of Study indicates that reward manipulation in terms of verbal or numerical description of reward rate, and the time scale available for persistence judgments, had no overall effect on judgments. However, the interaction effect indicates that one of these factors, or both, created slight differences in judgment patterns over weeks. The magnitude of these differences are, however, small.

The effect of age on judgments was assessed in the same manner as in Study 1. Both experiments of Study 2 indicated a tendency for older subjects to judge playing in the low-reward conditions as more persistent. For Study 2a, that effect was marginally significant, $F(1, 74) = 3.69$, $p = 0.06$, but it was much weaker in Study 2b, $F(1, 150) = 1.78$, $p > 0.18$.

STUDY 3

An assumption of the present studies is that people, through experience with learning contingencies, accumulate some sort of generalized knowledge from such contingencies. In this context we asked whether or not such accumulated knowledge, if it exists, affects judgments of persistence. Given relevant contingency information, judgments of persistence should be greater when information about PRF is given, and lower if information about CRF is given.

So far, we have obtained very scarce support for this assumption. An interpretation of the present data, therefore, is that people have no cognitive representation of increased or decreased persistence after different reinforcement schedules, based on everyday experience with reinforcement contingencies. However, the null effects of reward rate manipulations seen here may in principle be attributed to a number of task or subject variables. Thus, although

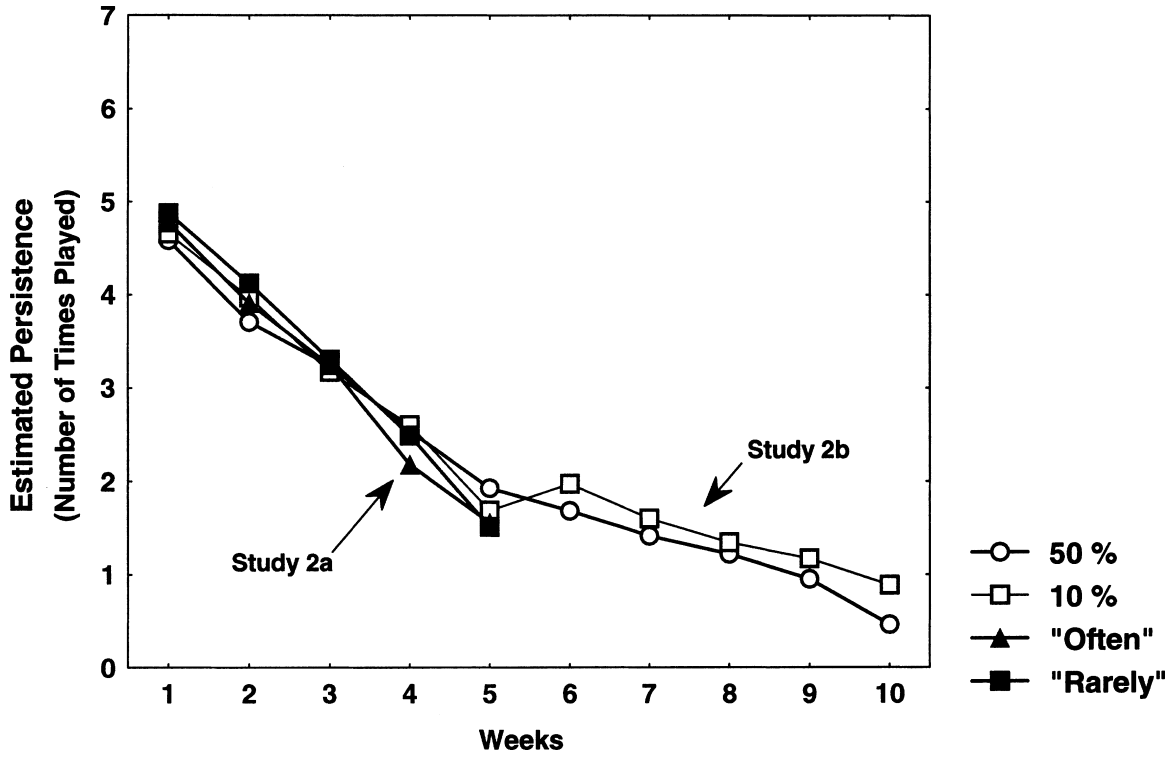

Fig. 4. Judged persistence of playing under nonreward following 50% or 10% reward over 10 extinction weeks. Comparable data from Study 2a are included. See text for explanation.

insensitivity to the reward rate information manipulation is consistent with an assumption that people have no cognitive representation of increased or decreased persistence after information about different reinforcement schedules, such insensitivity is also consistent with a number of other explanations. A much stronger case would be made if it could be shown that explicit contingency knowledge under experimental control would affect persistence judgments as predicted.

Study 3 provided participants with explicit knowledge of persistence effects before judgments were performed. One group received information that occasional reward causes more persistent responding when reward is discontinued, and another group received the opposite information. Following this manipulation of knowledge, we should expect contingency judgments to be affected accordingly.

METHOD

Subjects

Participants were 100 students at the University of Tromsø. Two research assistants recruited subjects at lectures and in small groups.

Material and procedure

The scenario and questionnaire from Study 1 was used. Two excerpts adapted from a Norwegian textbook (Svartdal & Flaten, 1998) were used to manipulate the participants' knowledge of reward on extinction in opposite directions. One, the "Wagner" excerpt, described an experiment with PREE as the outcome (cf. Wagner, 1961), and also stated a generalized inference from research to this effect. The other, the "Nevin" excerpt, described a situation with the reversed PREE as the outcome, and stated a generalized inference in accordance with this effect. Both excerpts were formulated in non-technical language and were sufficiently general to be easily applied to the dog scenario. All participants first read a research excerpt, then read the scenario and answered the persistence questions. Half the subjects read the Wagner information, half the Nevin information. Within each of these groups, half the participants read the CRF scenario, half the PRF scenario.

RESULTS

The dog experience factor, knowledge of psychology, and age factor were non-significant and therefore ignored in the following analyses. The ANOVA indicated a nonsignificant effect of reward manipulation, $F(1,96) = 1,66$, $p > 0.20$, a nonsignificant effect of information (Wagner vs. Nevin), $F(1,96) = 0.33$, and a significant effect of Weeks, $F(9,864) = 145.26$. The interaction effect was not significant. These data are shown in Fig. 5, left panel. The figure indicates a tendency among all participants to judge persistence under the PRF condition as somewhat higher than under the CRF condition, but as noted, the difference was not reliable. These data indicate, therefore, that the participants did not judge persistence in the two described reward regimes in accordance with the information provided prior to judgments.

Analyses of the reversed scenario judgments indicated a different outcome. The reversed judgments were computed in the same manner as in Study 1. Inspection of Fig. 5, right

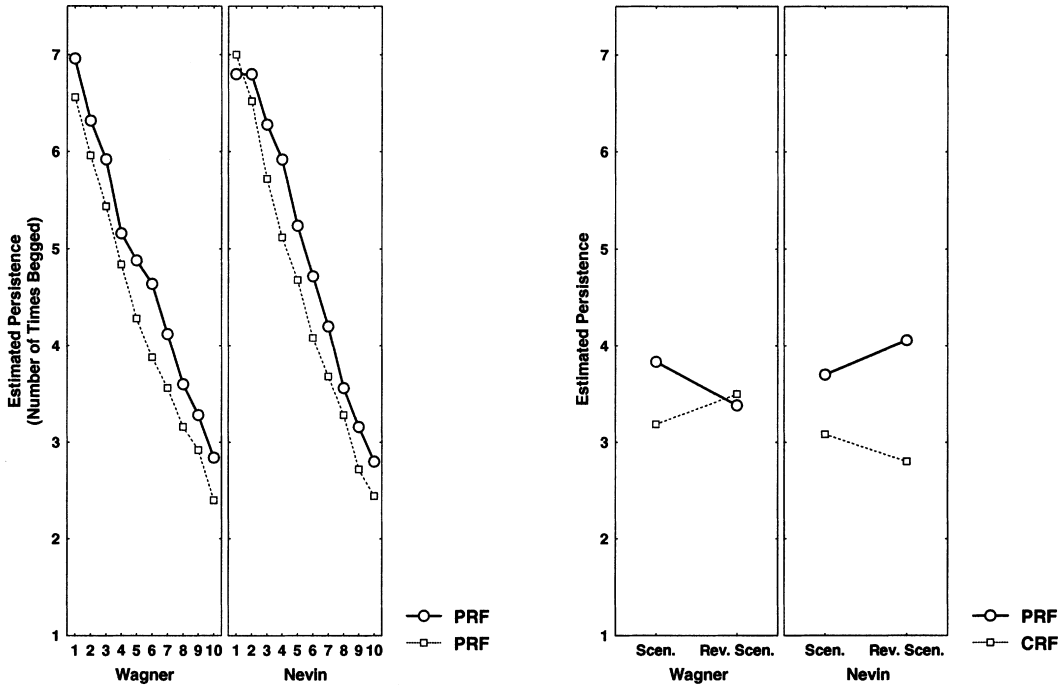

Fig. 5. Estimated persistence under nonreward following reward at every response or only some of the responses (left panel); judged persistence if reversed scenario (right panel).

panel, reveals that participants in the Wagner/CRF group correctly indicated that persistence would have been higher under the reversed PRF conditions, and participants in the Wagner/PRF indicated that persistence would have been lower under the reversed CRF conditions. The reversed pattern was observed in the Nevin groups. ANOVA of this particular interaction revealed a significant effect, $F(1, 93) = 7.63$, $p < 0.01$. Thus, the reversed scenario judgments indicated that the participants were correctly influenced by the information provided.

DISCUSSION

The outcome of this experiment was somewhat surprising. Why were judgments of the scenario unaffected by relevant contingency information read seconds before? Given the simplicity of the information provided, it should be easy to apply in the scenario judgments. The fact that judgments of the reversed scenario conformed to the information provided indicates that participants had confidence in, and remembered the information provided. The most straightforward explanation of these data is that the information received prior to the questionnaire was relatively difficult to translate into quantitative judgments, but easily applied in a judgment involving a dichotomous increase/decrease decision. It is easy to remember information about more or less persistence, but that information may be more difficult to translate into a quantified judgment. It seems fair to conclude, therefore, that the reversed scenario task is more sensitive than the scenario task in judgments of persistence.

It should be noted that the reversed scenario judgment data indirectly support the notion that people possess no accumulated knowledge of the effects on extinction performance of intermittent vs. continuous reward. The fact that subjects changed their reversed judgments equally and according to the information given (see Fig. 5, right panel) indicates no prior conforming or conflicting beliefs about extinction performance. If people had prior beliefs, the information given should activate those beliefs. There is no indication that this was the case for any of the two excerpts provided.

STUDY 4A

If the scenario type task is insensitive as a tool for persistence measurement, the validity of the judgment data presented so far is questioned. One possible explanation of the apparent insensitivity of the dog and playing scenario tasks to reward rate manipulations is that they are familiar to most people. New information is not likely to change strong expectations, hence the rate information may be discounted in the persistence judgments because the scenarios activate specific expectations. One way of assessing this possibility is to present a scenario that cannot be related to specific prior expectations.

Study 4a therefore described an experiment in which a new skill was learned under continuous vs. intermittent reward. No prior expectations should exist about the persistence of such a skill under subsequent extinction conditions. The scenario was distributed among two groups of students, one group with knowledge about the effects of continuous vs. intermittent reward on persistence under extinction, and one group that did not possess such knowledge. In this way, the effect of knowledge on judgments could be assessed. If it is assumed that people in general do not accumulate contingency knowledge, two simple predictions are possible: Subjects in the first group were expected to demonstrate PREE in judgments, not because of their everyday experience with learning contingencies but rather because they applied a principle described in their curriculum. In contrast, students without formal training in psychology do not have such a principle to apply, hence no PREE in judgments should appear. However, if people in fact do accumulate contingency experience, both groups should demonstrate PREE in their judgments.

METHOD

Subjects

Participants were 127 students, 68 students from the introductory course in psychology and 61 non-psychology students, all from the University of Tromsø. The non-psychology students did not have any formal education in psychology. The psychology students had good knowledge of behavioral psychology. Included in the required reading list for their course is the text by Roediger *et al.* (1996). This book contains a discussion of PREE, including a figure from Wagner (1961), and points out some implications of PREE for our understanding of persistence in humans. At the time of testing, this topic had been covered in lectures.

Material and procedure

The scenario described an experiment on learning. The description was formulated in a non-technical language. The task to be learned was said to be quite complex, requiring a great deal of concentration to perform. Good mastery of the task gradually evolved over an acquisition period of 40 minutes and more than 100 trials. Half the participants (high reward rate group) then read the following:

> "During learning, the subject was rewarded for every correct solution, while incorrect responses were ignored. Reward was thus presented every time after the correct solution, never at other times."

The other half read the following instead:

> "During learning, the subject was rewarded occasionally for correct solution, while incorrect attempts were ignored. Reward was thus presented after some of the correct solutions (on about half of all occasions), never at other times."

All students then read the following:

> "After learning had taken place (after 40 minutes and more than 100 trials), reward was discontinued. Now, even if the subject emitted the correct response that had been rewarded during acquisition, reward never occurred."

The participants were then asked to answer the following question:

> "How long do you think that the subject would continue to emit the correct response until he/she quits?"

The participants indicated the expected number of times (0–7) for each of the five consecutive minutes of nonreward. Then, all were asked to judge persistence for the hypothetical case that reward conditions had been the opposite. Thus, for the 100% group, we asked if persistence would have been lower, equal, or greater if reward had been presented only occasionally. For the 50% group, we asked if persistence would have been lower, equal, or greater if reward had been presented following every correct response.

RESULTS AND DISCUSSION

Two of the subjects were excluded from data analysis because they did not answer the critical persistence question. An overall ANOVA showed significant effects of reward condition, $F(1, 123) = 10.40$, of group, $F(1, 123) = 3.99$, $p < 0.05$, and of minutes, $F(4, 492) = 164.06$. Also, the interaction between reward condition and group was significant, $F(1, 123) = 5.44$, $p < 0.025$. None of the other interaction effects were significant.

The data are shown in Fig. 6. It seems that the reward manipulation created a difference in the psychology group, but not in the other group. Separate analyses were run for each group. Within the psychology group there was a significant effect of reward condition, $F(1, 123) = 16.25$. In the other group, the effect of reward condition was not significant, $F(1, 123) = 0.38$.

As a further test of knowledge of differential outcomes from 100% vs. 50% reinforcement history on persistence, participants judged whether persistence would have been reduced, equal, or greater if reinforcement conditions had been opposite during learning. The persistence judgments were computed as in Study 1, but here the reference judgment was computed as the mean score for the final two minutes of the scenario judgment. Within the psychology group, the critical scenario—reversed scenario interaction was highly significant, $F(1, 67) = 47.46$. Among the other students, the interaction was non-significant, $F(1, 57) = 0.35$. These data are shown in Fig. 7. This pattern may be seen as another indication that the reward manipulation affected judgments in the psychology group in accordance with PREE, while the other participants did not reveal any sensitivity to the rate manipulation in persistence judgments.

Since non-psychology students did not show any indication of PREE in their judgments, these data demonstrate that the sensitivity in psychology students to information about learning contingencies is most probably due to their knowledge of learning theory, and that non-psychology students do not possess such knowledge. It should be noted, however, that the complexity of that scenario could potentially obscure sensitivity to the reward rate manipulation. For example, it could be argued that psychology students are more familiar with descriptions of experimental situations than other students, and therefore more easily would process the relevant reward rate information. For the

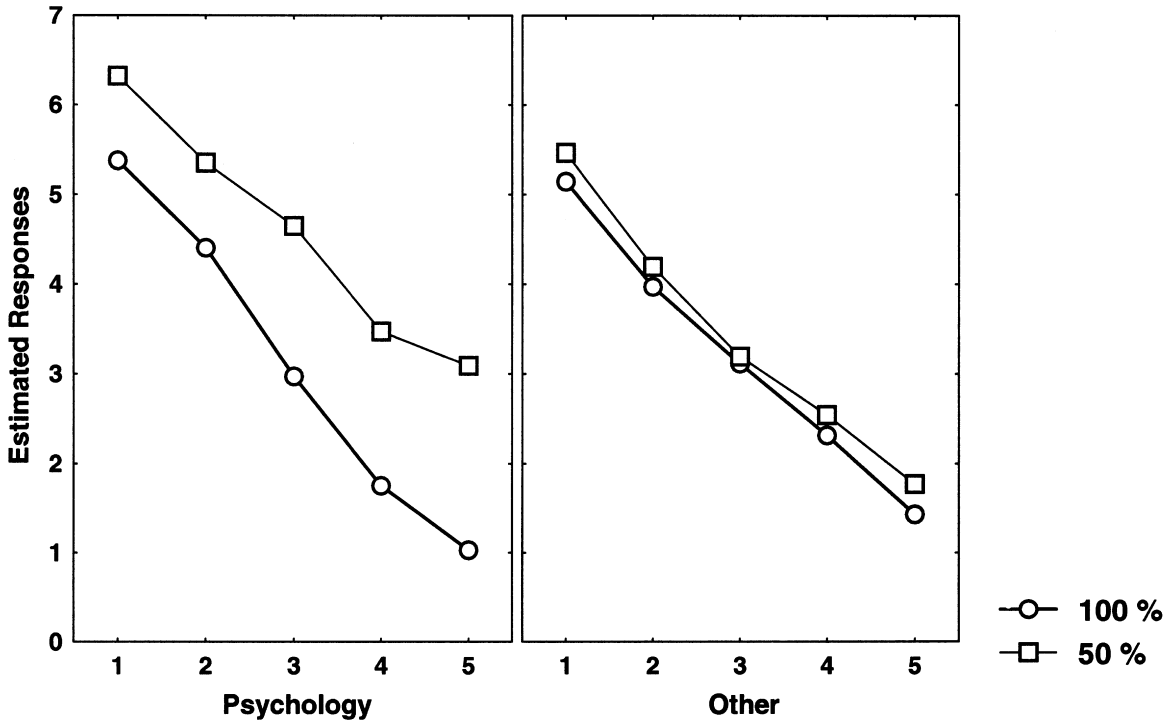

Fig. 6. Judgments of persistence in psychology students (left panel) and other students (right panel) under scenario with 50% vs. 10% reward.

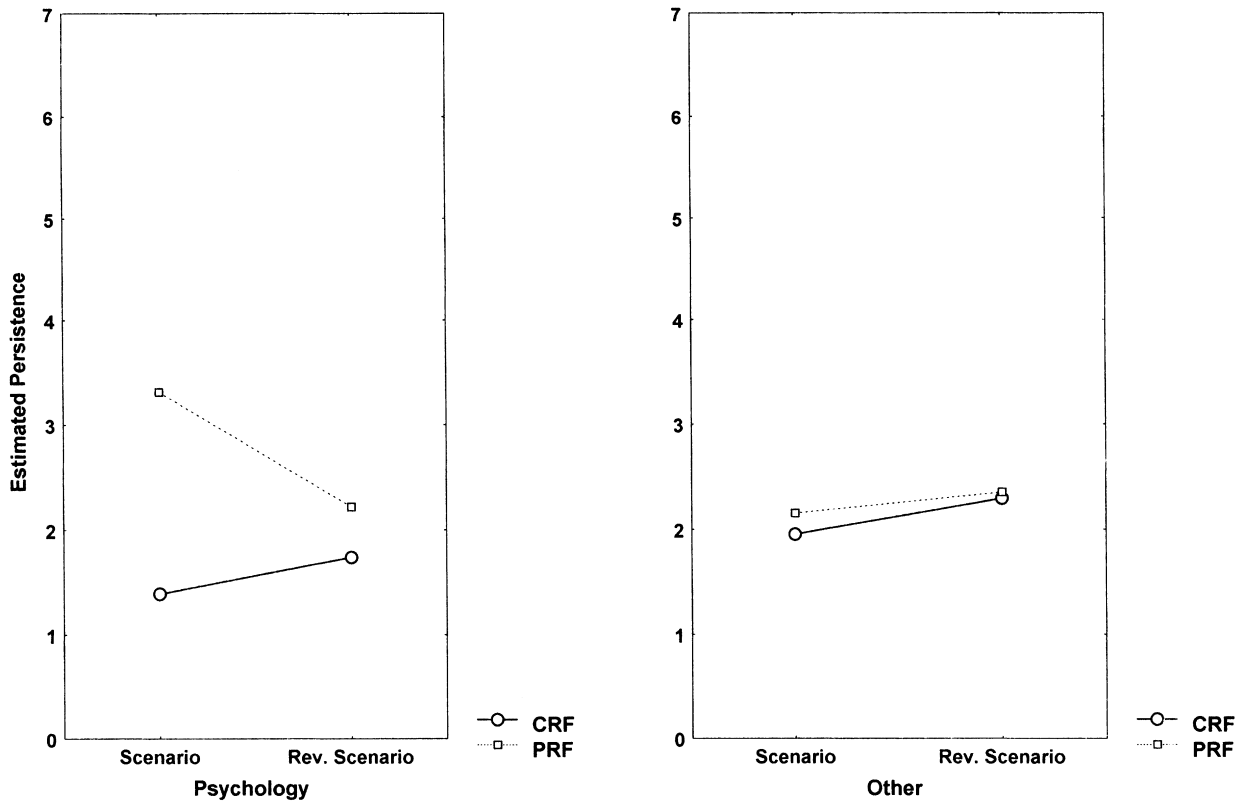

Fig. 7. Estimated persistence of scenario (final two minutes) and reversed scenario in psychology students (left panel) and other students (right panel).

final experiment we therefore returned to the familiar dog scenario.

STUDY 4B

The dog scenario, already tested in more than 250 students with no demonstrable sensitivity to the reward rate manipulation (Study 1), was distributed to students with thorough knowledge of behavioral psychology. Because of their knowledge of the relevant principles, the reward rate manipulation was now expected to create judgment differences according to the well-known PREE.

METHOD

Subjects

Participants were 20 students with extensive knowledge of theoretical and applied behavioral psychology at the College of Akershus.

Material and procedure

The material and procedure was identical to that of Study 1.

RESULTS AND DISCUSSION

ANOVA showed a marginally significant effect of reward manipulation, $F(1, 18) = 4.21$, $p = 0.055$, a significant effect of weeks, $F(9, 162) = 46.26$, and a significant effect of their interaction, $F(9, 162) = 2.44$, $p < 0.025$. The significant interaction effect was due to the fact that subjects in the CRF condition judged persistence to decrease more rapidly over initial weeks than subjects in the PRF condition. Thus, although the sample was small, the reward manipulation had a reliable effect on persistence judgments. The judgments of the reversed scenario supported this. ANOVA of the scenario vs. reversed scenario interaction (see Fig. 8, right panel) was significant, $F(1, 18) = 12.88$, $p < 0.005$.

One characteristic of these data should be noted. Fig. 8, left panel, indicates that all subjects judged persistence at the end of the 10-week period to be complete. This contrasts the judgment data from Study 1, which showed that subjects generally believed that some begging still existed after 10 weeks. This difference may be an effect of a strong belief among behaviorally oriented therapists in extinction as an effective method of eliminating undesirable behaviors. Thus, the extinction curves seen here most probably was a compromise between the two beliefs that (a) PRF increases persistence relative to CRF, and (b) extinction if effective in reducing undesirable behaviors.

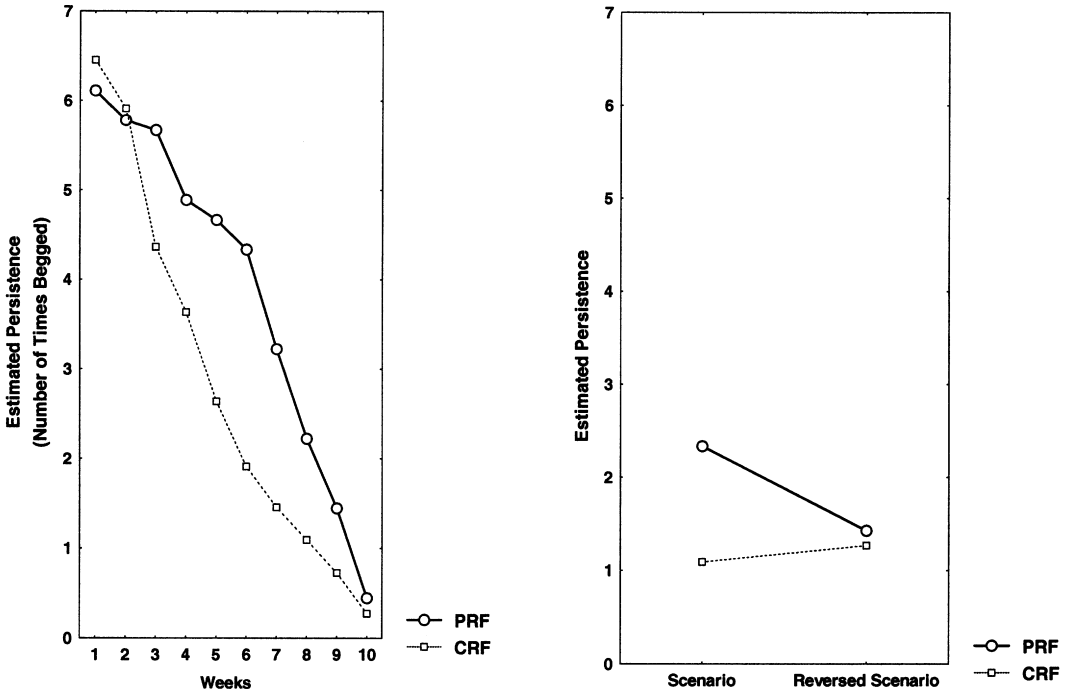

Fig. 8. Estimated persistence under nonreward following CRF or PRF (left panel); judged persistence if reversed scenario (right panel).

Overall, Studies 4a and 4b clearly demonstrated that students with knowledge of the relevant behavioral psychological principles judge persistence in accordance with the PREE in scenario-type tasks. These judgments are clearly related to students' formal knowledge, as students lacking this expert knowledge do not demonstrate persistence judgments according to PREE.

GENERAL DISCUSSION

People (as well as animals) demonstrate increased behavioral persistence under extinction conditions when the response is acquired under intermittent reward conditions. If rewarded continuously rather than intermittently, reduced behavioral persistence results. Although this observation has been challenged as a general principle (e.g., Nevin, 1988; Pittenger & Pavlik, 1988), it is safe to assume that intermittent vs. continuous reward will affect behavioral persistence in this manner in a variety of situations. This is a rational strategy, since persistence is adaptive when desired outcomes are uncertain (e.g., Staddon, 1983). It is reasonable to assume that adults will have experienced a large number of reward-related learning situations, and also that learning from many of these situations is associated with a high degree of cognitive and conscious involvement. This paper then asked whether or not people accumulate and use that knowledge in persistence judgments. Are judgments of extinction affected by information about the reward history that created and maintained a response?

Results from Studies 1 and 2 revealed no support for an assumption that judgments of persistence are sensitive to manipulations of reinforcer rate information in between-group comparisons. Study 3 manipulated information about the effect of CRF and PRF, but judgments were only partially affected by this information. Finally, Study 4 tested judgments in subjects with and without knowledge of behavioral psychology. Students with expert knowledge of behavioral psychology judged persistence to be higher when acquisition conditions involved intermittent reinforcement and lower under continuous reinforcement. In contrast, judgments by participants with no formal knowledge about psychology did not demonstrate sensitivity to this information. The fact that psychology students did is, therefore, most probably not a function of generalized experience with various learning contingencies but rather the (correct) result of application of a principle acquired under academic contingencies.

The present data therefore indicate that people appear to have no accumulated knowledge of increased or decreased persistence after different reinforcement schedules, given everyday experience with reinforcement contingencies. This finding is somewhat surprising. The surprise here is not related to the fact that people are not aware of PREE. After all, it took many years of research for Skinner (1938) and Humphreys (1939) to bring this phenomenon to awareness. Skinner (1956) even reported that his awareness arose by accident. Many cognitive processes are not easily available to explicit report, and PREE may be the outcome of such a mechanism. The surprise is, instead, related to the findings

that judgments of persistence do not seem to be affected by relevant contingency information. Such judgments should be sensitive to contingency effects independently of awareness. Therefore, two interpretations of the present data are possible. One is that people do not generate contingency knowledge from high vs. low-rate reinforcer situations, so that the null effects of reinforcer rate manipulations seen in the present studies are due to lack of knowledge of reinforcer rate effects on persistence. Another interpretation is that people accumulate such knowledge, but that the knowledge is not reflected in judgments.

The former interpretation assumes that people should accumulate general contingency knowledge, implicit or explicit, as a basis for differential judgments of persistence. Is it at all reasonable to expect that people should accumulate knowledge from experience with learning contingencies and their effects on behavior? An affirmative answer is likely, given conclusions from studies that show a close correspondence between contingency judgments and behavioral adaptation to contingencies. For example, Shanks and Dickinson (1991) assumed that performance of an instrumental action is determined by a subject's belief about its causal effectiveness in producing the desired outcome. They found that judgments and free-operant behavior were equivalently affected by varying response-outcome contingencies (in fact, judgments matched actual contingencies even better than behavioral indices). Similar findings have been reported by others (e.g., Chatlosh *et al*., 1985; Svartdal, 2000a). From such findings it appears that behavioral adaptation to learning contingencies is mediated by explicit cognitive sensitivity. Thus, the behavioral effects of learning contingencies are strongly tied to the subject's apprehension of them. We should then expect that people are quite well able to perceive, describe, and remember the most salient properties of different learning contingencies, and also to assess at least some of the effects they have on behavior and cognition.

The fact that our subjects did not may indicate that people do not accumulate experience from reward situations, and therefore have no knowledge to apply when persistence judgments are given. However, before this conclusion is endorsed, two issues should be considered. First, judgment data from subjects trained under real learning contingencies indicate that there is a dissociation between behavior and judgment. Svartdal (2000b) exposed independent groups of subjects to CRF vs. PRF learning contingencies. Previously, these contingencies have been shown to create gradually increasing response rates that correlate well with the reinforcer rates under each condition, and also to create a reliable between-groups conventional PREE (Svartdal, 2000a). In the Svartdal (2000b) study, subjects were asked to predict their own persistence under no-reward conditions immediately following acquisition. The results demonstrated no effect on persistence predictions of the previous CRF vs. PRF contingencies. This indicates that extinction persistence may not be well represented cognitively, even not when contingency exposure is under experimental control and occurred immediately before the persistence predictions were given.

Second, even if the effects of reward contingencies are not well represented cognitively, such effects may nevertheless be reflected in other measures, as in behavioral measures. We know that subjects exposed to CRF conditions during acquisition will quickly abandon a previously functional response under no-reward conditions, while subjects having been exposed to PRF conditions will maintain a relatively high rate of responding also under no-reward (Svartdal, 2000a). If a similar difference should emerge if subjects, after reading stories about CRF vs. PRF reward situations, were to emit their judgment behaviorally rather than by conventional judgments, we certainly would have to reconsider a conclusion that people do not accumulate experience from different reward situations. In general, alternative measures of persistence should be tested before a definitive conclusion about these matters is drawn.

Finally, it is possible that the PREE may not be a state of increased vigor or persistence (e.g., Eisenberger, 1992), but rather a state that affects behavioral adaptation to new contingencies. If extinction is introduced following exposure to PRF vs. CRF contingencies, PREE may be the manifestation of slower adaptation to the extinction condition because of the prior reinforcement history. However, PREE is then not necessarily an outcome of prior learning, but rather the manifestation of slower adaptation to new contingencies. This interpretation implies that PREE cannot readily be measured as an outcome of contingency exposure. The present data are consistent with such an interpretation, but more research is required to determine its validity.

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NOTES

[1] For significant effects, *p*-values not specified were <0.001 or lower.

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