The Psychological Record, 1998, 48, 45-62

SUPERSTITIOUS MATH PERFORMANCE: INTERACTIONS BETWEEN RULES AND SCHEDULED CONTINGENCIES

H. A. CHRIS NINNESS
Stephen F. Austin State University

SHARON K. NINNESS
Nacogdoches Independent School District

Experimental conditions were designed to examine students' sensitivity to scheduled contingencies and accurate or fallacious rules as these variables influence performance during computer-generated math problems. Experimental subjects were provided: scheduled contingencies followed by extinction, follow-up extinction, and a *rules condition* promulgating *accurate* or *fallacious* rules for accessing reinforcement. Control subjects did not have access to rules; however, sensitivity to direct-acting contingencies was measured during response independent reinforcement. Performing with accurate rules and scheduled contingencies, most experimental subjects correctly answered math problems at accelerated rates and extended durations. Also, providing fallacious rules during response independent reinforcement induced high rates and extended durations of superstitious responding. However, for most students response independent reinforcement, without rules, was insufficient to induce such behavior. Evidence from this study suggests that maintenance of high rate superstitious responding requires exposure to a fallacious rule in conjunction with making contact with response independent reinforcement. Implications from this study support the theory that superstitious behavior may become self-sustaining by precluding one's opportunities to contact the null effects of *not* performing in accordance with fallacious rules. Ramifications regarding interactions between verbal fallacies and coincidental reinforcement are discussed.

In common parlance, "superstition" is generally understood as an irrational association between cause and effect. Superstitions in folklore

This investigation was supported in part by a Stephen F. Austin State University Faculty Research Grant 1-14065.

We gratefully acknowledge the helpful comments provided by Cloyd Hyten, Glen McCuller, and Eugene Edgington in the development of this study.

Correspondence concerning this article should be directed to H. A. Chris Ninness, School Psychology/Behavior Analysis Program, PO Box 13019 SFA Station, Stephen F. Austin State University, Nacogdoches, TX 75962 (E-mail: cninness@titan.sfasu.edu).

often forecast ominous connections between seemingly unrelated events. Black cats that cross one's path portend miscellaneous misfortunes; failure to knock on wood may nullify a positive prediction; and so on. Most people would agree that there exists no rational relationship (or real probability) between such unlikely and unfortunate antecedent and consequent events, yet they often feel compelled to act as though there might be. In contrast, superstitions may forecast one's potential for gaining good fortune. Wishing wells are laden with the tokens of superstitious rules for having dreams come true. Either way, humans are renowned for drawing unwarranted inferences and performing unnecessary behaviors based on irrelevant phenomena. Humans appear to be at particularly high risk for developing superstitions in contexts that establish increased probabilities for accidental or response independent reinforcement. For example, because of the game's inherent potential for generating coincidental reinforcement, baseball players have become notorious for developing a wide range of superstitious behaviors—particularly while in the batters' box (Malott, Whaley, & Malott, 1997).

Although the phenomenon has been disputed (e.g., Staddon & Simmelhag, 1971), early laboratory research with pigeons demonstrated that superstition is not the exclusive province of humans. However, unlike humans, nonverbal organisms require no description of environmental contingencies in order to rationalize their ritualistic performances. Their seemingly "pointless" behavior is directly and predictably controlled by salient environmental events, for example, selection by response independent, fixed-time (FT) reinforcement (Skinner, 1948).

Conversely, humans often conduct superstitious performances under the influence of verbal rules. Such rules may be self-generated or socially mediated (Hayes, Zettle, & Rosenfarb, 1989). The term *superstitious rule* has been coined in reference to a verbal statement delineating a performance-consequence relation which is not in effect during programmed contingencies (Heltzer & Vyse, 1994). Accordingly, superstitious rules function as discriminative stimuli, or contingency-specifying stimuli (Schlinger & Blakely, 1987), for the behavior described and may continue to operate that way so long as the advertised negative or positive consequences are not conspicuously disconfirmed. Once a person has learned to respond under the stimulus control of a superstitious rule, compliance may override the effects of scheduled contingencies (cf. Catania, Matthews, & Shimoff, 1982; Ono, 1994).

Conversely, there is evidence that the incremental influence of direct-acting contingencies may interact with the effects of instructions (see Baron, Perone, & Galizio, 1991). For example, Newman, Buffington, & Hemmes (1995) have found that the leaner fixed-ratio (FR) 2 and FR 3 schedules may have compromised subjects' abilities to discriminate accurate from fallacious instructions. Vyse (1991) found that subjects who demonstrated inefficient stereotyped bar-pressing patterns while on random ratio (RR) schedules provided written commentaries that accounted for their superstitious performances. In a replication (Heltzer & Vyse, 1994), subjects who performed under the influence of RR schedules were more likely to generate superstitious rules than subjects operating under FR 2 or continuous reinforcement. Additionally, recent findings suggest that superstitious location preferences on a computer screen may be a function of interacting chaining procedures (Lee, 1996).

Interactions between rules and direct-acting contingencies have also been documented. Rosenfarb, Newland, Brannon, and Howey (1992) demonstrated that college students who were asked to generate rules, or follow rules, regarding scheduled contingencies were more likely to show schedule-typical behavior than those who had been asked *not* to generate or follow rules. During extinction, subjects who had generated, or been furnished rules, were more likely to persist in responding than those who specifically had been told to avoid developing rules. It is important to point out, however, that subjects in the Rosenfarb et al. study were not given a specific opportunity to generate rules during the extinction phase of the experiment as they had during the acquisition phase.

Presently, the functional mechanisms which account for human subjects performing superstitiously remain somewhat elusive. It is not clear whether such behavior is most likely to interact with extinction (Rosenfarb et al., 1992), various schedules of reinforcement (Cerutti, 1991; Heltzer & Vyse, 1994; Newman et al., 1995), interacting chains (Lee, 1996), socially mediated rules (Ono, 1994), or other unexplored variables. Heltzer and Vyse (1994) and Rosenfarb et al. (1992) have reported the need for further research aimed at determining whether various types of schedules interact with the generation and following of accurate and superstitious rules. In the same vein, Hackenberg and Joker (1994) propose that it would be "especially interesting" to contrast outcomes associated with accurate and inaccurate instructions, and noninstructed controls. Following the above recommendations, the present experiment sought to examine the effects of scheduled and response independent reinforcement in conjunction with accurate or fallacious rules during the performance of computer-generated math problems. The experimental preparations were designed to investigate the applied relevance (Hastings, Remington, & Hall, 1995) and interactions of rules and direct-acting contingencies in a computer-interactive environment.

Experiment 1

Method

Participants, setting, and apparatus. Twelve 6th-grade students, ranging from 11 to 12 years of age, from a regular education classroom served. Participants were randomly assigned to one of three groups, with four students assigned to each group. Following informed consent, all experimental sessions were conducted during a regular school day in a vacant classroom adjacent to the students' homeroom. Students performed all aspects of the experiment on a Toshiba notebook computer connected to a Canon laser printer. The software was written by the first author in QBASIC for IBM PC compatible machines.

Data collection and reliability checks. The computer screen presented the student with an opportunity to perform a series of multiplication problems. Each screen displayed the word "Continue?" at the top center followed by the words type "Y" or "N." Immediately below, a single-digit multiplication problem appeared. Students first responded by typing "Y" or "N." If "N" were typed, the program terminated; if "Y" were typed, the multiplication problem below could be performed by typing the number key/s followed by the enter key. Subsequently, a new problem was presented to the student according to the same format. In this context, a unit of measured behavior always entailed a combination of three or four key presses (depending upon whether the answer required one or two digits).

Following each experimental session, all subjects in all groups answered a brief questionnaire regarding why they believed they had performed the problems and why they had stopped doing so. Two independent raters reviewed all responses to all items on all questionnaires for all subjects. Calculation of agreement was obtained by dividing the number of agreements by the number of agreements plus disagreements and multiplying by 100. Agreements were designated as both raters determining that the same response to the same item had been circled by the student participants. Reliability coefficients were at 99% across all sessions for all students.

Experimental design. Experimental conditions were designed to examine students' sensitivity to scheduled reinforcement and accurate or fallacious rules as these variables influence the rate of math performance during the presentation of computer-generated problems. During sessions, students solved multiplication problems by typing answers on the keyboard. Reinforcement (in all conditions) consisted of a brief (.5-s) flashing message on the computer screen indicating the earning of five cents. Points were exchanged for money immediately following each session. In the event that no key strokes occurred over a 7-min period, the computer program self-terminated.

In Experiment 1, Groups 1 and 2 were provided three experimental conditions; the control group was provided one experimental condition. Group 1 (three males and one female) received scheduled reinforcement followed by extinction, a follow-up extinction condition without rules, and a condition that included an accurate rule for obtaining scheduled reinforcement. Group 2 (two males and two females) received scheduled reinforcement followed by extinction, a follow-up extinction condition with a fallacious rule, and a condition that included the presentation of a fallacious rule in conjunction with response-independent reinforcement. A control group (two males and females) did not have access to computer-displayed rules; however, sensitivity to scheduled contingencies was measured during response independent reinforcement only. Following the final session, students in all groups completed brief questionnaires of the form illustrated on Table 1.

Table 1

Post-Session Questions: Experiment 1 and Experiment 2 Students

Please put a circle around the correct number below, or write your answer in the space provided.

I did the math problems on the computer because:

1. I like doing math problems on the computer.
2. The computer gave me money for doing math problems.
3. ______________________________.

I stopped doing math problems on the computer because:

1. I got tired of doing them.
2. The computer stopped giving me money for doing them.
3. The computer gave me money even when I did nothing.
4. The computer program stopped.
5. ______________________________.

Post-Session Questions: Experiment 2 Students

Please put a circle around the correct number below, or write your answer in the space provided.

I did the math problems on the computer because:

1. I like doing math problems on the computer.
2. The computer let me keep money as long as I was doing math problems.
3. ______________________________.

I stopped doing math problems on the computer because:

1. I got tired of doing them.
2. The computer stopped telling me that I was not losing money.
3. The computer let me keep money even when I did nothing.
4. The computer program stopped.
5. ______________________________.

Procedure. During acquisition, four subjects in Group 1 were provided reinforcement according to a VR 6 schedule. Subjects' performance during the computer-generated multiplication problems was reinforced according to this schedule for the first 8 min of the first session. Following 8 min of reinforced performance, extinction procedures were inserted. At this time no further point acquisition (or other feedback) was possible; however, math problems continued to become available on the computer screen so long as the student responded by typing "Y" subsequent to the prompt, "Continue?." The session ended when students aborted the program by typing "N." Approximately 1 week following this initial session, subjects in Group 1 were given a second opportunity to perform math problems on the computer according to the same extinction format established at the end of the prior session. This follow-up extinction condition was not preceded by any form of scheduled reinforcement or verbal instructions. At the beginning of the third and final session of the experiment, all subjects in Group 1 viewed the following *accurate rule* for maximizing reinforcement during the VR 6 schedule: "The faster you work, the more money you make. Type enter if you understand." Subsequently, VR 6 contingencies went into effect.

During acquisition, four students in Group 2 were provided reinforcement according to a VR 6 schedule. Following 8 min of scheduled contingencies, extinction was introduced, and no further monetary gain was possible. One week later, subjects in Group 2 received a second opportunity to perform multiplication problems according to the same extinction format established at the end of the previous session. However, this extinction condition was introduced by a *fallacious rule*: "The faster you work, the more money you make. Type enter if you understand." The rule in this context *did not* correctly describe the response-consequence relationship. Performing math problems *did not result* in any form of monetary gain during this follow-up extinction condition. One week later Group 2 had a third and final opportunity to observe the same rule on the computer screen. The rule in this last condition was again *fallacious*; reinforcement was provided approximately every 60 sec independent of responding. During this session, a fixed-time (FT) 60-s schedule of reinforcement was provided *with a delay component* (WDC). That is, in the event that a FT 60-s WDC interval elapsed during the brief time between the pressing of a number key and the enter key, reinforcement was not delivered until after the enter key had been pressed. Otherwise, when FT 60-s WDC intervals elapsed previous to a response, or subsequent to a response, reinforcement was immediately presented on the computer screen. This delay component was arranged so as to preclude interruption of a given response sequence. Performing a math problem, correctly or incorrectly, quickly, or not at all, had no bearing on reinforcement delivery. At the conclusion of the session, students in Group 2 completed questionnaires of the same type as those in Group 1.

Four students in the control group did not come into contact with computer-displayed rules; however sensitivity to response independent reinforcement contingencies was measured during a FT 60-s WDC schedule. At the conclusion of the above session, students in the control group also completed questionnaires as described above.

Results: Molar and Molecular

Outcomes from Experiment 1 are describable at both the molar (group) and molecular (individual) level of analysis (Fisher, Piazza, Zarcone, O'Conner, & Ninness, 1995).

Molar results and discussion. The molar data were summarized by obtaining the mean number of correct answers for subjects in each of the three groups during selected conditions. Using a randomization test (Edgington, 1995), systematic permutation procedures for family-wise and planned comparisons were conducted.

Test statistics for planned comparisons between selected conditions preclude the necessity for the computation of all post hoc possibilities (E. S. Edgington, personal communication, October 20, 1996); accordingly, analysis of variance was computed for the final condition of all groups. This analysis compared Group 1 (*accurate rules plus VR 6 contingencies*), Group 2 (*false rules plus response independent reinforcement*), and the control group (*no rules but response independent reinforcement*). Figure 1 contrasts the total number of correct answers for each subject in each group across these three conditions. The probability for determining F as

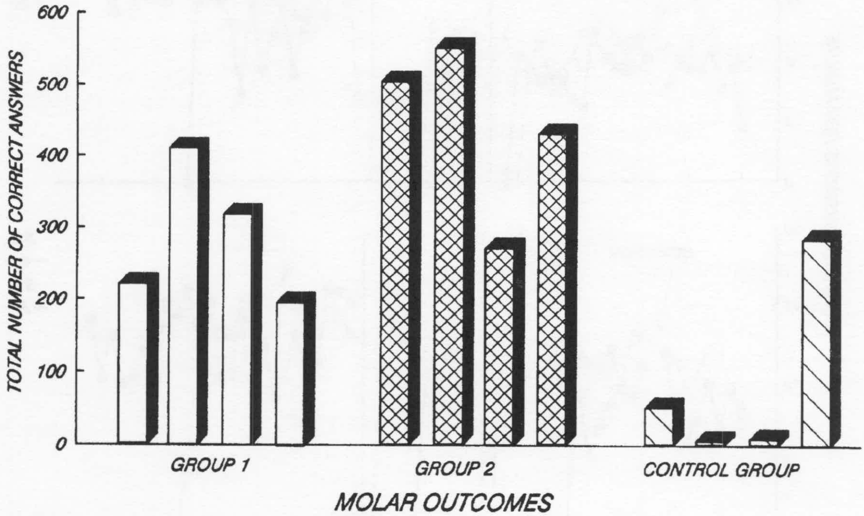

Figure 1. Total number of correct answers for subjects in each group during planned comparisons in Experiment 1. Comparisons include accurate rules plus VR 6 contingencies, false rules plus response independent contingencies, and no rules but response independent reinforcement.

the proportion of permutations revealed a significant effect, $p < .02$. Subsequently, one-tailed probabilities for specific planned comparisons were computed by determining the proportion of permutations that provide a statistic for P-values. This analysis revealed that the control group students who received no rules, but, nevertheless, obtained response independent reinforcement (FT 60-s WDC) performed a significantly fewer number of correct answers than Group 2 students ($p < .03$) who were provided *false rules* and response independent reinforcement (FT 60-s WDC). The control group also performed a significantly fewer number of correct answers than Group 1 students ($p < .05$) who were provided *accurate rules* for acquiring reinforcement in conjunction with VR 6 contingencies. Because students in Group 1 and Group 2 had been on extinction prior to this final condition, it seems unlikely that their experimental histories would have contributed to their enhanced performances over that of the control group.

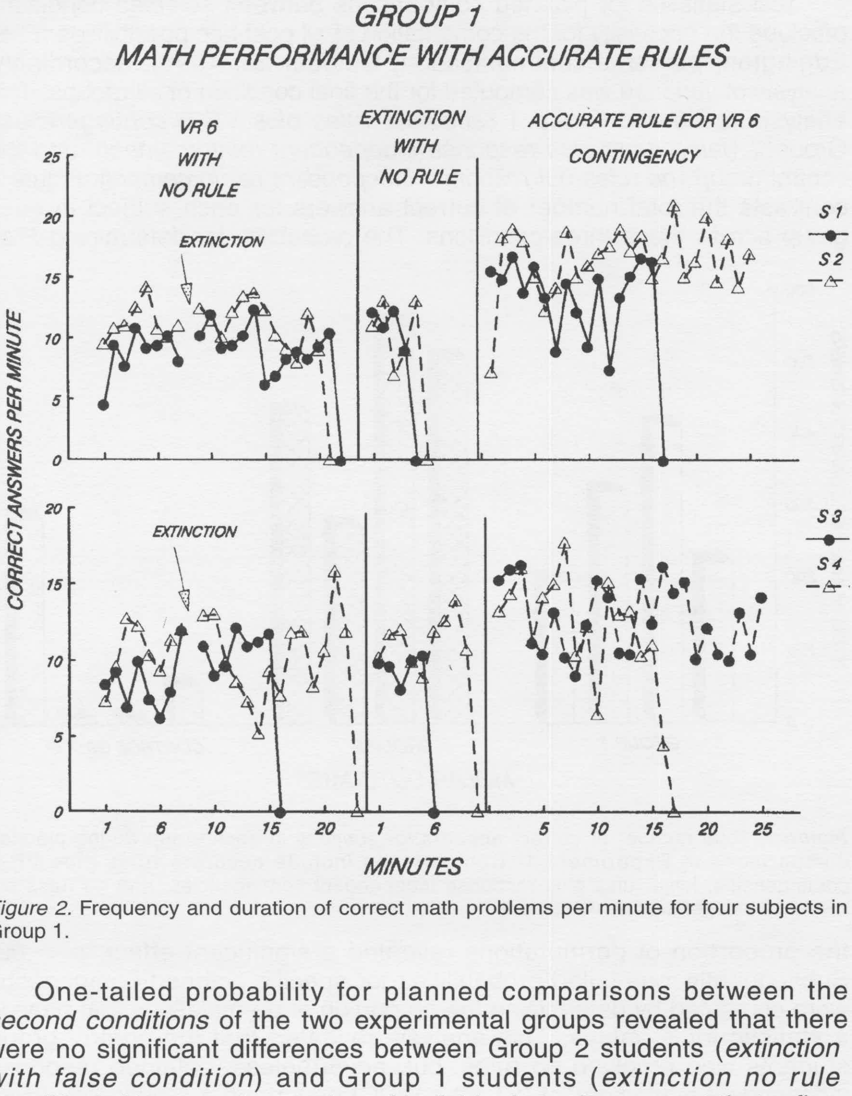

Figure 2. Frequency and duration of correct math problems per minute for four subjects in Group 1.

One-tailed probability for planned comparisons between the *second conditions* of the two experimental groups revealed that there were no significant differences between Group 2 students (*extinction with false condition*) and Group 1 students (*extinction no rule condition*). However, inspection of individual results suggest that a finer grain analysis may be warranted.

Molecular results and discussion. Molecular results were assessed in terms of single subject rate and duration within each condition of the study. Figure 2 reveals that during the acquisition phase of the experiment, students in Group 1 exhibited moderate rates of problem solving which accelerated slightly during the first 3 or 4 min and became relatively stable by the 5th min of the first session. Prior to initiating extinction, Subjects 1 through 4 averaged 8.76, 11.25, 8.57, and 10.78

correct problems/min, respectively. During the second (*extinction with no rule*) session, these subjects were reexposed to the same extinction format they had encountered at the end of the previous condition. Data suggests that for all students, performances were reinitiated at approximately the same rate as that maintained during the previous session (*M* = 8.92, 8.83, 8.05, 10.18, for Subjects 1 through 4, respectively); however, in the absence of reinforcement or prompts to continue responding, all four students aborted the program within 10 min. With the presentation of an accurate rule for accessing reinforcement on the computer screen, three of the four students in Group 1 exhibited almost immediate performance elevations of problems per/min relative to their previous sessions (*M* = 12.93, 16.42, 12.70, and 11.62 for Subjects 1 through 4, respectively). Subjects 1 and 4 initially manifested high rates of responding, but each terminated the program after 16 min of problem solving. Subjects 2 and 3 sustained high rates of correct problem solving throughout the duration of the final session and stopped responding only when the computer terminated the program after 25 min of the session. Answers to written questions following the session indicated that, during this final session, students all "believed" they had performed math problems because the computer gave them money for doing so. Subjects 1 and 4 indicated that they stopped working because they had become tired. Subject 2 and 3 indicated that they stopped because the computer program terminated.

During the acquisition phase of the experiment, students in Group 2 all evidenced moderate rates of problems solving/min which stabilized by the 4th min of the first session (see Figure 2). Prior to the initiation of extinction during this condition, Subjects 5 through 8 averaged 11.70, 11.00, 8.93, 7.73, respectively.

During the following (*extinction with false rule*) condition, all four students evidenced an immediate elevation in their rates of problem solving/min (*M* = 16.45, 21.38, 10.96, and 10.12 for Subjects 5 through 8, respectively) and exceeded their previous performance rates during their exposure to VR 6 schedules. Furthermore, responding persisted in the face of extinction beyond that which had occurred during the previous session, which had included actual contact with scheduled reinforcement prior to extinction. One week later, all four students were given a third opportunity to perform math problems at the computer. This session was introduced with the same message indicating that fast problem solving would provide access to more money; however, in this session, the computer delivered response independent reinforcement according to a FT 60-s WDC schedule. Figure 2 suggests that students were initially reluctant to perform high rates of problem solving. However, by the end of the first minute, all students made contact with response independent reinforcement while performing and concurrently began to exhibit accelerated rates of correct problem solving. Subsequently, all four students in this group maintained elevated rates (*M* = 20.16, 22.04, 10.89, and 17.24 for Subjects 5 through 8, respectively) well above those

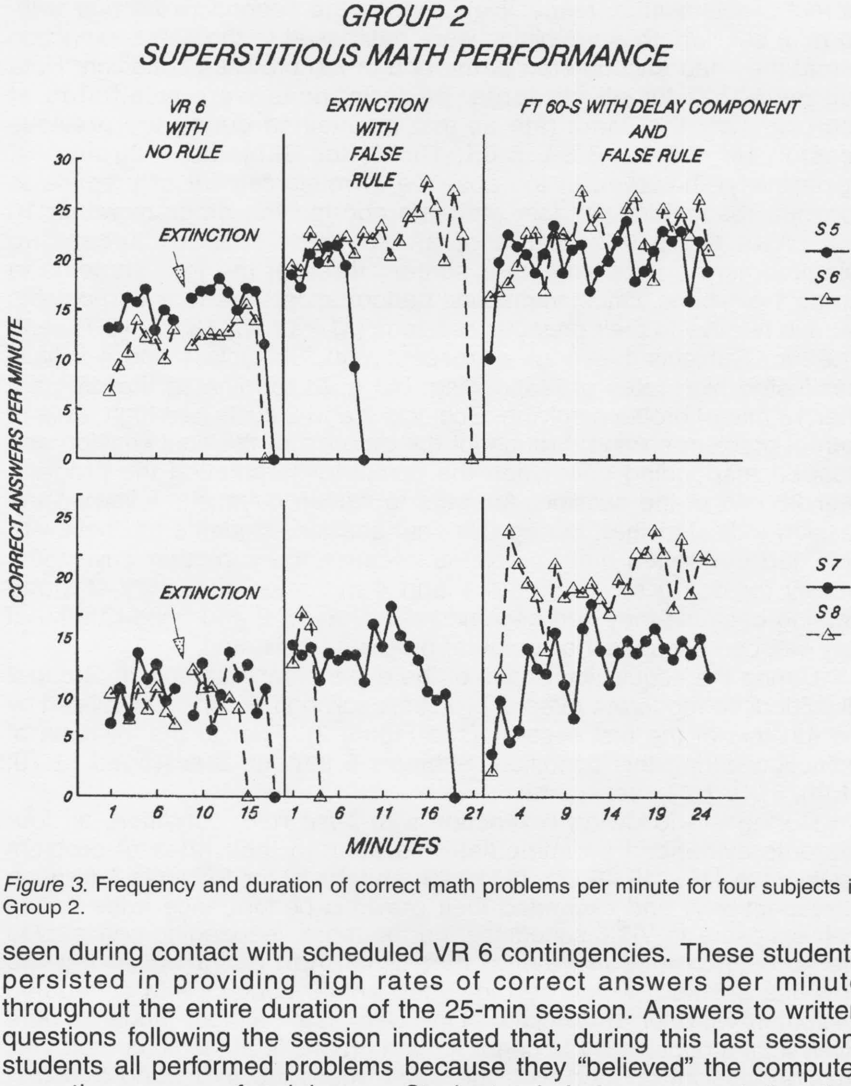

Figure 3. Frequency and duration of correct math problems per minute for four subjects in Group 2.

seen during contact with scheduled VR 6 contingencies. These students persisted in providing high rates of correct answers per minute throughout the entire duration of the 25-min session. Answers to written questions following the session indicated that, during this last session, students all performed problems because they "believed" the computer gave them money for doing so. Students circled answers stating that they stopped because the computer program terminated.

Figure 3 illustrates that two of the four control subjects receiving response independent reinforcement (FT 60-s WDC) *without rules* chose to abort the program within the first minute. Means for subjects within this group were extremely dissimilar (M = 4.24, 2.65, 4.10, and 11.41 problems/min for Subjects 9 through 12, respectively). Responding to the first question regarding why they had performed math problems, Subjects 10 and 11 wrote, "I don't know" and "Not," respectively. In

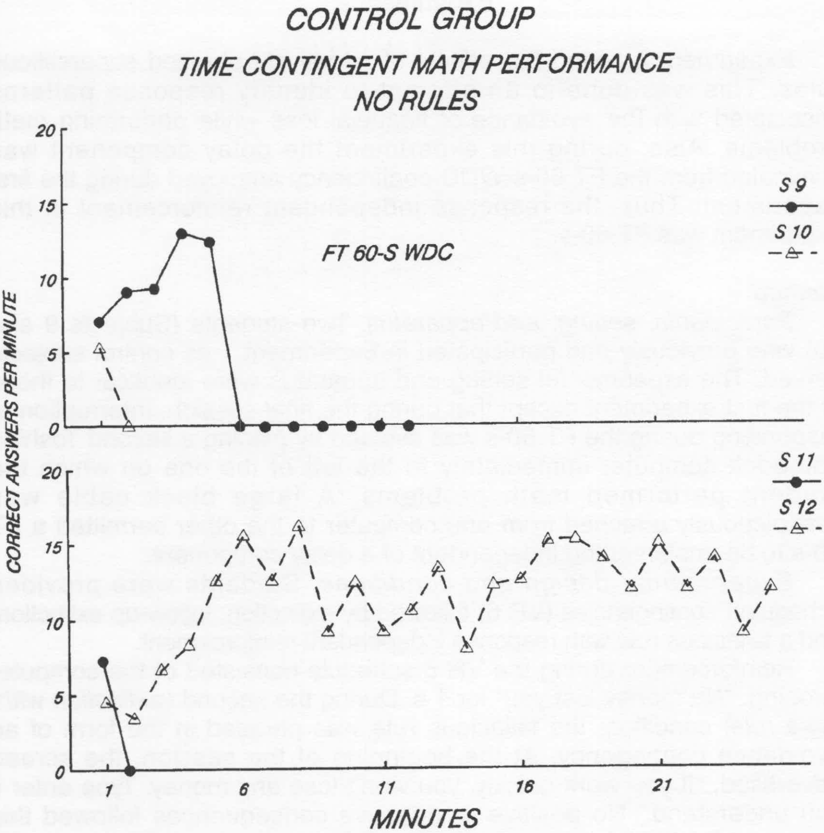

Figure 4. Frequency and duration of correct math problems per minute for four subjects in the control group.

response to the second question regarding why they stopped performing, they both circled, "I got tired of doing them." Subject 9 initially showed moderate rates of problems solving/min; however, he suddenly stopped performing and began to simply observe the screen without aborting the program. After 7 min of response independent reinforcement, the program self-terminated. In response to the first question, he circled the item asserting that the computer gave him money for doing math problems. In response to the second question, he circled the item asserting that the computer gave him money when he did nothing. Subject 12 exhibited an erratic but sustained series of correct answers/min throughout the duration of the 25-min session. Following the session, he indicated that he had performed because the computer gave him money for doing so and that he stopped performing because the computer program terminated.

Experiment 2

Experiment 2 tested the effects of negatively phrased superstitious rules. This was done in an attempt to identify response patterns associated with the *avoidance* of financial loss while performing math problems. Also, during this experiment the delay component was eliminated from the FT 60-s WDC contingency employed during the first experiment. Thus, the response independent reinforcement in this experiment was FT 60-s.

Method

Participants, setting, and apparatus. Two students (Subjects 9 and 10) who previously had participated in Experiment 1 as control subjects served. The experimental setting and apparatus were identical to those of the first experiment except that during the final session, interruption of responding during the FT 60-s was avoided by placing a second Toshiba notebook computer immediately to the left of the one on which the student performed math problems. A large black cable was conspicuously attached from one computer to the other permitted a FT 60-s to be implemented independent of a delay component.

Experimental design and conditions. Students were provided scheduled contingencies (VR 6) followed by extinction, follow-up extinction, and a fallacious rule with response independent reinforcement.

Reinforcement during the VR 6 schedule consisted of the computer strobing: "No money lost yet!" for 1 s. During the second (*extinction with false rule*) condition, the fallacious rule was phrased in the form of an avoidance contingency. At the beginning of the session, the screen advertised, "If you work quickly, you won't lose any money. Type enter if you understand." No positive or negative consequences followed this message. During the final session, the computer posted a fallacious rule, "If you work quickly, you won't lose any money. The computer on your left will let you know if you have lost any money. Type enter if you understand." Every 60 s, this second computer provided reinforcement by strobing the following message for 1 s: "No money lost yet!" This time-based reinforcement was delivered by the second notebook computer every 60 s completely independent of any operations performed on the primary computer. Students were given an opportunity to complete questionnaires following the session; however, phrasing of the items were adjusted so as to take into consideration the avoidance contingency reflected in the fallacious rule (see Table 1).

Results and Discussion

Figure 4 illustrates that during acquisition Subjects 9 and 10 averaged 6.20, 8.00 correct answers/min, respectively (see Figure 5). During the second (extinction) session, prefaced by a fallacious rule specifying an avoidance contingency, these subjects accelerated responding for 13 and 19 min. respectively (M = 10.85 for Subject 9 and

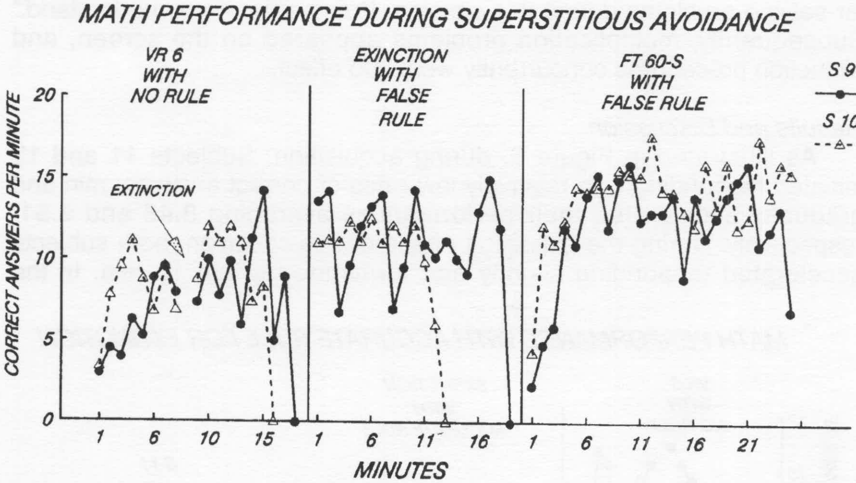

Figure 5. Frequency and duration of correct math problems per minute for two subjects in Experiment 2.

10.10 for Subject 10). In the final session, both subjects reinintiated responding at relatively low rates; however, by the third minute of this session, rates of correct problem solving accelerated and maintained throughout the duration of the FT 60-s response independent reinforcement condition (*M* = 11.84 and 13.90 for Subjects 9 and 10). Answers to questions following the test suggest that they performed in compliance with the fallacious rule specifying high rates of math performance in order to avoid the financial loss. Outcomes for these subjects correspond to those of Group 2 of Experiment 1 in which students had been provided *positively phrased* consequences according to a *FT 60-s WDC.*

Experiment 3

Experiment 3 analyzed the effects of accurate rules during extinction procedures.

Method

Participants, setting, and apparatus. Two students (Subject 11 and Subject 12) who had participated in Experiment 1 as control subjects served. The experimental setting and apparatus were identical to those of the first experiment.

Experimental design and conditions. Following scheduled (VR 6) reinforcement and extinction, a follow-up extinction session was instated. This extinction session was initiated with the presentation of an *accurate rule* regarding extinction. At the beginning of the session, the computer screen posted the following bulletin: "No money can be earned for solving problems during this session. Press enter if you understand." Subsequently, multiplication problems appeared on the screen, and extinction procedures concurrently went into effect.

Results and Discussion

As illustrated in Figure 6, during acquisition, Subjects 11 and 12 initiated responding with relatively low rates of correct answers/ min and gradually accelerated their performances averaging 8.48 and 6.51, respectively. During the extinction phase of this condition, both subjects accelerated responding slightly and terminated within 10 min. In the

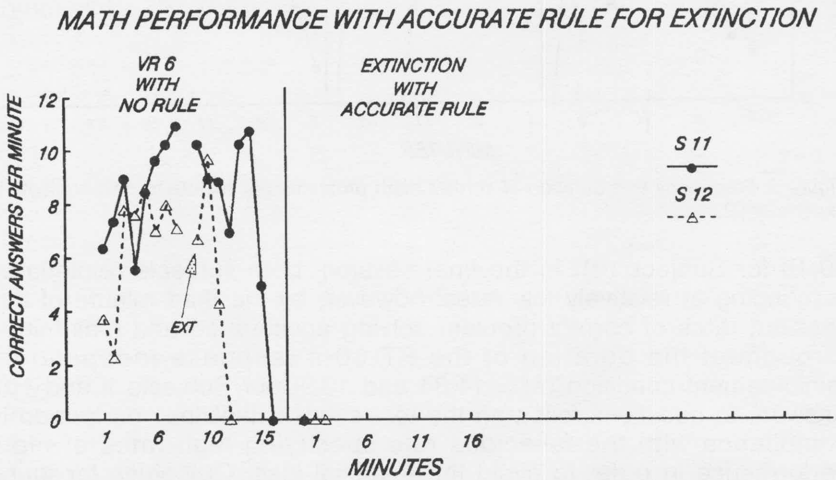

Figure 6. Frequency and duration of correct math problems per minute for two subjects in Experiment 3.

following session, when these students were given an accurate rule regarding the forthcoming *extinction contingency*, they both aborted the program directly. Their answers reflect their belief in the rule. In response to the first question regarding why they had performed math problems on the computer, Subject 11 wrote, "I didn't." The other student did not respond to that item. Additionally, both circled the item stating that they stopped because the computer quit giving them money for doing math.

General Discussion

Rosenfarb et al. (1992) found that self-generated rules and instructions to follow rules proposed by others appeared to promote the acquisition of schedule-appropriate behavior; however, their results also suggested that rules may have impeded subjects' sensitivity to extinction. In part, our results seem to confirm this observation. Students in Experiment 1 (Group 1) whose performances were reinforced on VR 6 schedules, elevated their rates after contacting a rule that correctly described the reinforcement contingencies. Also, consistent with findings by Rosenfarb et al. is the finding that inaccurate instructions impeded extinction. When Group 2 (Experiment 1) students were placed on extinction in the second session, but were fallaciously advised via the computer that fast problem solving would lead to increased earnings, their problem solving behavior accelerated. However, subjects in the above condition, as well as those described by Rosenfarb et al., were not provided specific opportunities to generate or access new rules consistent with changing contingencies. Conversely, in Experiment 3, two subjects were provided *accurate* computer-displayed rules regarding the forthcoming extinction contingency, and these subjects terminated responding immediately. These results seem to suggest that had Rosenfarb et al.'s subjects been given a specific opportunity to generate or receive new rules previous to extinction, it might well have been found that rules facilitate (or impede) a wide range of experimental contingencies—not the least of which is extinction.

Superstitious interactions. It appears that in the world of computer interactive behavior, a myth may function as well as an accurate rule provided that the myth establishes *and maintains* the "occasional appearance" of a response-consequence relationship. This seems to be true even when exposure to the superstitious rule has been preceded by substantial evidence to the contrary and even when the relevant behavior includes "labor intensive" academic performance.

Of particular interest in this study is the behavioral transition demonstrated by Group 2 students. Following an extinction session introduced by the computer posting a fallacious rule, subjects were reexposed to the same *fallacious rule plus a FT 60-s WDC response independent contingency*. Within 2 to 3 min, all students in this group were performing math problems at accelerated rates *as if* the consequences implied in the rule were forthcoming exactly as advertised. Once these students initiated a minimal level of compliance and came into contact with response-independent reinforcement, none of them attempted to test the veracity of this rule by slowing their rate of problem solving or simply watching the screen to see if money would be delivered independent of their math performance. Here, in the presence of a computer-displayed fallacious rule followed by response independent reinforcement, all four students demonstrated conspicuously higher rates of calculating than they had during actual contact with scheduled contingencies.

It may be reasonable to infer that during response independent reinforcement, a student's "belief" in a response-consequence relationship initially requires some minimal number of coincidently reinforced behaviors. Otherwise, a time-based contingency may function as an extinction procedure (e.g., Hagopian, Fisher, & Legacy, 1994; Fisher, Ninness, Piazza, & Owen-DeSchryver, 1996). But a rule that sufficiently prompts some minimal target behavior may preclude this possibility. For example, following their second extinction session at the beginning of the third session, students appeared reluctant to reestablish their previous high rates of calculating; however, some level of reinitiated problem solving apparently was prompted by the presentation of the computer-posted fallacious rule. And, even though their previous experience with the computer had demonstrated that the computer was quite capable of posting a "bold faced lie," students all initiated a few math problems which noncontingently coincided with the delivery of reinforcement. One might infer that it was this event which "triggered" their "belief" in the veracity of the fallacious rule. It seems that once target behavior comes into contact with reinforcement coincident with some minimal amount of compliance with a rule, such behavior may become self-sustaining by precluding the students' opportunities to contact the effects of *not* performing. As stated by Cerutti (1991), once compliance begins it "may engender itself by precluding opportunities to discriminate the null effects of noncompliance" (p. 63).

Conversely, three of four students in the control group, who received response independent reinforcement according to the same FT 60-s WDC, but who *were not* provided exposure to computer-posted rules, demonstrated very little superstitious responding. In the absence of computer-displayed rules, two students aborted the program almost immediately. One student performed briefly and then chose to simply watch the computer screen. Subject 20 performed high to moderate rates of correct multiplication throughout the duration of the 25-min period. Interestingly, his answers to multiple choice questions following the session revealed that he had *self-generated* a rule describing the "imagined" relationship between solving problems correctly and gaining access to earned reinforcement.

Data from Experiment 2 seems to verify that such superstitious behavior is not related to the phrasing of the fallacious rule. Positively phrased contingencies (Experiment 1, Group 2) and negative phrasing as an avoidance contingency (Experiment 2) showed similar superstitious effects. Moreover, data from Experiment 2 suggest that the delay component (WDC) within time-based contingencies did not appear to differentially affect the acquisition of superstitious behavior.

Evidence from this study indicates that exposure to a computer-transmitted rule, that is only superficially consistent with a contingency, is sufficient to persuade many students that a response-consequence relationship is in effect. Under such conditions, even students who have had a recent history of coming into contact with a computer-generated fallacy appear likely to conform their behavior to the dictates of that fallacy, provided they are given some minimal and superficial evidence that suggests the rule's potential veracity. Had any of the students in Experiment 1 (Group 2) or those in Experiment 2, briefly tested the experimental contingencies by *reversing* their behavior, they might well have concluded that they were in the midst of performing a great deal of unnecessary work. So it may be with some of our day-to-day interaction with the world. An unknown portion of what we do "customarily" may be initiated by fallacious rules and sustained by spurious correlations between our behavior and its irrelevant consequences.

The question arises as to what type of repertoire might enable students to perform more efficiently and less superstitiously in a wide range of academic and social environments. Our theoretical orientation leads us to advise that a form of training which readies students to "question their own belief systems" and to functionally assess their own ongoing behavior might be of some value (Ninness, Glenn, & Ellis, 1993). The experimental analysis of human behavior may be one means of engendering such a repertoire. Indeed, it has been demonstrated that trained behavior analysts are well positioned to "recognize" and differentially respond to ongoing experimental contingencies (Catania Shimoff, & Matthews, 1989).

Although the present study penetrates some of the mystery associated with superstitious behavior among verbal humans, our immediate results are confined to the sequestered conditions which address superstitious rule-following during computer interactive behavior by intermediate school students. More research is needed to account for the conditions whereby humans generate and follow superstitious rules in a wide range of academic and social contexts.

References

BARON, A., PERONE, M., & GALIZIO, M. (1991). Analyzing the reinforcement process at the human level: Can application and behavioristic interpretation replace laboratory research? *The Behavior Analyst,* 14, 95-105.

CATANIA, A. C., MATTHEWS, B. A., & SHIMOFF, E. (1982). Instructed versus shaped human behavior: Interactions with nonverbal responding. *Journal of the Experimental Analysis of Behavior*, 38, 233-248.

CATANIA, A. C., SHIMOFF, E., & MATTHEWS, B. (1989). An experimental analysis of rule-governed behavior. In S. C. Hayes (Ed.), *Rule-governed behavior: Cognition, contingencies, and instructional control* (pp. 119-150). New York: Plenum Press.

CERUTTI, D. T. (1991). Discriminative versus reinforcing properties of schedules as determinants of schedule insensitivity in humans. *The Psychological Record*, 41, 51-67.

EDGINGTON, EUGENE S. (1995). *Randomization tests*. New York, NY: Marcel Dekker, Inc.

FISHER, W. W., NINNESS, H. A. C., PIAZZA, C. C., & OWEN-DESCHRYVER, J. S. (1996). On the reinforcing effects of the content of verbal attention. *Journal of Applied Behavior Analysis*, 29, 235-238.

FISHER, W. W., PIAZZA, C. C., ZARCONE, J. R., O'CONNER, J., & NINNESS, H. A. C. (1995, May). *On the clinical and theoretical implications of molar and molecular functional assessment.* Paper presented at the 21st Annual Convention of the Association for Behavior Analysis International, Washington, DC.

HACKENBERG, T. D., & JOKER, V. R. (1994). Instructional versus schedule control of human choices in situations of diminishing returns. *Journal of the Experimental Analysis of Behavior*, 62, 367-383.

HAGOPIAN, L. P., FISHER, W. W., & LEGACY, S. M. (1994). Schedule effects of noncontingent reinforcement on attention-maintained destructive behavior in identical quadruplets. *Journal of Applied Behavior Analysis,* 27, 317-325.

HASTINGS, R. P., REMINGTON, B., & HALL, M. (1995). Adults' responses to self-injurious behavior. *Behavior Modification*, 19, 425-450.

HAYES, S. C., ZETTLE, R. D., & ROSENFARB, I. (1989). Rule following. In S. C. Hayes (Ed.), *Rule-governed behavior: Cognition, contingencies and instructional control* (pp. 191-220). New York: Plenum.

HELTZER, R. A., & VYSE, S. A. (1994). Intermittent consequences and problem solving: The experimental control of "superstitious" beliefs. *The Psychological Record*, 44, 155-169.

LEE, V. L. (1996). Superstitious location chances by human beings. *The Psychological Record*, 46, 71-86.

MALOTT, R. W., WHALEY, D. L., & MALOTT, M. E. (1997). *Elementary principles of behavior: Third edition.* Upper Saddle River, NJ: Prentice Hall.

NEWMAN, B., BUFFINGTON, D. M., & HEMMES, N. S. (1995). The effects of schedules of reinforcement on instruction following. *The Psychological Record*, 45, 463-476.

NINNESS, H. A. C., GLENN, S. S., & ELLIS, J. (1993). *Assessment and treatment of emotional or behavioral disorders.* Westport, CT: Praeger.

ONO, K. (1994). Verbal control of superstitious behavior: Superstitions as false rules. In S. C. Hayes, L. J. Hayes, M. Sato, & K. Ono (Eds.), *Behavior analysis of language and cognition* (pp. 181-196). Reno, NV: Context Press.

ROSENFARB, I. S., NEWLAND, M. C., BRANNON, S. E., & HOWEY, D. S. (1992). Effects of self-generated rules on the development of schedule-controlled behavior. *Journal of the Experimental Analysis of Behavior*, 58, 107-121.

SCHLINGER, H., & BLAKELY, E. (1987). Function altering effects of contingency-specifying stimuli. *The Behavior Analyst*, 10, 41-45.

SKINNER, B. F. (1948). "Superstition" in the pigeon. *Journal of Experimental Psychology*, 38, 168-172.

STADDON, J. E. R., & SIMMELHAG, V. L. (1971). The "superstition" experiment: A reexamination of its implications for the principles of adaptive behavior. *Psychological Review*, 78, 3-43.

VYSE, S. A. (1991). Behavioral variability and rule generation: General, restricted, and superstitious contingency statements. *The Psychological Record*, 41, 487-506.