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Resurgence of inaccurately instructed behavior

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RESURGENCE OF INACCURATELY INSTRUCTED BEHAVIOR

Carolina Aguilera

Dissertation submitted to the
Eberly College of Arts and Sciences
at West Virginia University
in partial fulfillment of the requirements
for the degree of

Doctor of Philosophy
in
Psychology

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ABSTRACT

Resurgence of Inaccurately Instructed Behavior

Carolina Aguilera

The current experiments examined the relation between resurgence and the sensitivity of instructed behavior to contingency changes. Although previous investigations have examined resurgence with directly reinforced responses, no studies had examined situations where the responses that recurred during extinction belonged to the class of rule-governed behavior and where the specific responses had not been reinforced directly within the experiment. To address this issue, the current experiments examined the effect of a history of instructing responding at different rates without directly reinforcing these specific rates. Both resurgence and sensitivity to environmental changes were measured to determine whether the instructed responses would recur and whether they would affect the sensitivity of responding to novel contingencies. Instructed behavior resurged and two factors affected the sensitivity of rule-governed behavior to environmental changes: (a) the recurrence of both directly reinforced responses and responses under instructional control, and (b) subjects' history of reinforcement for responding variably.

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Resurgence of Inaccurately Instructed Behavior

Several studies have examined the apparent insensitivity of behavior acquired through the verbal specifications of environmental contingencies (*rule-governed behavior*) to changes in the environment. Although some researchers have concluded that this insensitivity may be a defining feature of rule-governed behavior (e.g., Catania, Shimoff, & Matthews, 1989), various studies have shown that variables other than rules may account for insensitivity. For example, variables such as the variety of training instructions used (LeFrancois, Chase, & Joyce, 1988), the response variability present at the time of the contingency change (Joyce & Chase, 1990), and whether the changing contingencies were contacted (Galizio, 1979), all have been shown to increase the probability that rule-governed behavior will be sensitive in the presence of new contingencies.

Another variable that has been examined as it relates to sensitivity is the effect of a history of reinforcement for following or not following rules. For example, Wulfert, Greenway, Farkas, Hayes, and Dougher (1994) suggested that a clinical assessment of rigidity may indicate the extent to which individuals historically have adhered to rules. Furthermore, they argued that an assessment of rigidity may predict whether behavior will be sensitive to environmental changes. To test this suggestion, these authors examined the relation between subjects' self-reported rigidity and their performance on various experimental tasks. Rigidity was quantified based on the answers subjects gave to a questionnaire that purportedly assessed their adherence to rules outside the laboratory. In Experiment 1, subjects were separated into 2 groups: high and low rigidity. Subjects were then further subdivided so that

half of them received accurate instructions about the experimental tasks and half of them received minimal instructions. After a predetermined number of sessions were conducted, the schedule of reinforcement for the experimental tasks switched to extinction. Subjects in the high rigidity group, regardless of whether they had received accurate or minimal instructions, were more likely than the subjects in the low rigidity group to continue responding although extinction was in effect.

Although historical variables were not experimentally manipulated in Wulfert et al. (1994), Aguilera and Chase (2003) found that a history of reinforcement for not following rules led to sensitivity to contingency changes. Aguilera and Chase adopted Madden, Chase, and Joyce's (1998) view of the different ways in which sensitivity can be examined. Tests for sensitivity assessed whether responding changed following an unsignaled manipulation of the contingencies of reinforcement *and* whether these changes resulted in earning reinforcers during the new contingencies. Aguilera and Chase found that the assessment that differentiates more clearly among the variables that affect behavior in the presence of novel contingencies is the latter: whether the behavior results in earning reinforcers. This dissertation will also use this test to examine sensitivity.

One group of subjects in Aguilera and Chase (2003) was provided with a history of reinforcement for following accurate instructions on four tasks (AC subjects): This group's behavior was rule governed. A second group was presented with inaccurate instructions on these same tasks (IN subjects). For this group, following instructions was not reinforced and the behavior eventually emitted during training was shaped by the scheduled contingencies.

Once subjects met stability criteria that ensured similar responding among subjects by the end of the initial condition, the scheduled contingencies for one of the four tasks changed. Instead of providing reinforcers on a differential-reinforcement-of-low rates (DRL; see Catania, 1997, for definition) 10-s schedule of reinforcement as during the earlier condition, unsignaled changes to three different types of mixed (mix) schedules were presented sequentially: DRL 10-s/DRL 4-s, DRL 10-s/DRL 4-s Limited Hold (LH: restriction placed on a schedule requiring that a response occur within a particular time limit following an interval of time to be eligible for reinforcement, or the reinforcer is lost) 4-s, and DRL 10-s/DRL 4-s LH 4-s with a point loss contingency. Although the responding of all subjects changed following the experimental manipulations, the IN subjects were more likely to earn reinforcers during both components of the three mixed schedules and AC subjects were more likely to earn points only during the initial (10-s) components of testing. The authors concluded that it was likely that IN subjects' history of reinforcement for not following rules affected the probability that their changes in responding resulted in earning reinforcers under new contingencies.

Analyses by Aguilera and Chase (2003) of the specific effects instructions had on the initial training responses, however, suggested an alternative explanation that warrants further research. The IN subjects received inaccurate instructions during the DRL 10-s task that stated that reinforcers would be provided for producing higher response rates than were actually required: "wait 2-s before pressing the 'EARN' button." All IN subjects subsequently had a high number of short interresponse times (IRTs; see Catania, 1997, for definition) < 8 s during their first few sessions. On the other hand, most of the AC subjects, who were

instructed to respond every 10 s, did not engage in short IRTs, but, instead, engaged in IRTs approximately equal to 10 s. When the contingencies changed during testing so that responding at least every 10 s was no longer reinforced (during the DRL 4-s LH 4-s and the DRL 4-s LH 4-s with a point loss contingency components), most IN subjects reliably engaged in short IRTs, something they had done initially during training, while most AC subjects engaged in IRTs ≥ 10 s. In other words, when responding at least every 10 s was extinguished, short IRTs recurred for most IN subjects, but not for the AC subjects. Thus, the high-rate responding by the IN subjects during training may have contributed to the sensitivity of their behavior to contingencies that changed from low to high rates.

One way of describing the results obtained by Aguilera and Chase (2003) is in terms of extinction-induced resurgence (hereafter referred to as “resurgence”). Although consensus on the definition of this phenomenon has not been reached (see Cleland, Guerin, Foster, & Temple, 2001), the concept of resurgence is frequently applied to situations where a previously reinforced response recurs when a recently reinforced response is under extinction. For example, in the first phase of Epstein (1983), 6 pigeons pecked one of two keys under a variable interval (VI) 1-min schedule. Reinforcement subsequently was withheld in the second phase until pecking extinguished, at which time emitting one of five possible alternative responses (determined randomly for each pigeon) was reinforced 20 times. Reinforcement was withheld for these responses in the third phase, and results showed that pecking resumed only on the key previously correlated with the VI schedule of reinforcement. Similarly, in Lieving and Lattal (2003, Experiment 1), 4 pigeons pecked a key under a VI 30-

s schedule. Reinforcement for pecking was withheld in the second phase while treadle presses were reinforced on a VI 30-s schedule. Reinforcement was withheld for treadle presses in the third phase, and results showed that pecking resurged for 3 of the 4 pigeons. These conditions were replicated and results showed that key pecking resurged for all pigeons in the replication condition.

Analyses of studies on resurgence such as Epstein (1983) and Lieving and Lattal (2003) suggest that the behavior of most IN subjects in Aguilera and Chase (2003) may have been sensitive during testing in part because of the effect of resurgence: Short IRTs recurred during testing when the previously reinforced responses ($IRTs \geq 10$ s) were no longer reinforced. For the IN group, the short IRTs during training can be seen as specific instances of rule-governed behavior because these IRTs followed the presentation of instructions that told subjects to wait 2 s before responding.

It should be noted that to interpret those results as the resurgence of short IRTs, a modification of the procedure commonly used to study resurgence is required because short IRTs never were reinforced *directly* in the training condition of the experiment. Studies that have demonstrated resurgence, with few exceptions, have involved: (a) reinforcing a response (e.g., Response A), (b) extinguishing Response A while concurrently reinforcing an alternative response (e.g., Response B), and (c) extinguishing Response B.

At least one study, however, investigated resurgence *without* explicitly reinforcing the response that recurred within the experiment (Wilson & Hayes, 1996). Twenty-three subjects were trained to make conditional discriminations among 12 stimuli in a three-choice

matching-to-sample procedure (initial training condition). Unreinforced tests of stimulus equivalence were presented and these showed that subjects responded to trials testing symmetric and equivalence relations consistent with the initial training, thus indicating that three classes of stimuli had been established. During the next phase, subjects were trained to make different conditional discriminations with these same 12 stimuli (altered training condition). Unreinforced tests for symmetry and equivalence at this stage showed that most subjects' response patterns were consistent with altered training. Responding consistently with the altered training on symmetric and equivalence trials then was punished. Under these circumstances, some subjects showed a recurrence of responding consistent with the initial training. Although at no point during this study was responding consistently with the original class of stimuli directly reinforced, this type of responding recurred once the alternative responses were eliminated. Wilson and Hayes described these results as the resurgence of relational responding (i.e., resurgence of behavior under the control of a class of stimuli).

Just as Wilson and Hayes (1996) obtained resurgence of relational responding, it seems reasonable to assume that resurgence also may occur with rule following. It was clear in Aguilera and Chase (2003) that subjects' initial responding was rule governed. It is reasonable to assume, therefore, that responses under the control of rules had been reinforced in the past. Then, although rule following was extinguished within the experiment, rule following may have resurged when the alternative response was extinguished. Specifically, the sensitivity found in Aguilera and Chase may have occurred for the IN subjects because short IRTs were initially under the control of rules that had a preexperimental history of

socially mediated reinforcement (see Hayes, Brownstein, Zettle, Rosenfarb, & Korn, 1986). This pre-experimental history would take the place of the first condition typically provided in studies of resurgence to establish an operant. The short IRTs may have resurged subsequently as an instance of rule following when reinforcement was no longer available for responding as trained in the experiment.

Statement of Problem

The main goal of the current experiments was to examine the relation between resurgence and the sensitivity of instructed behavior to contingency changes. Although previous investigations have examined resurgence with directly reinforced responses, no studies have examined situations where the responses that recur during extinction belong to the class of rule-governed behavior and where the specific responses have not been reinforced directly within the experiment. To address this issue, the current experiments examined the effect of a history of instructing responding at different rates without directly reinforcing these specific rates. Both resurgence and sensitivity to environmental changes were measured to determine whether the instructed responses would recur and whether they would affect the sensitivity of responding to novel contingencies. Specifically, it was predicted that responding instructed at different rates would recur when previously reinforced responding was extinguished and that such responding would either lead to reinforcement (sensitivity) or lack of reinforcement (insensitivity).

The results from the current experiments were expected to support the argument that sensitivity to contingency changes is influenced by the *specific* instances of rule following

emitted prior to the environmental change, even if there are no programmed consequences within the experiment for those responses. Furthermore, the anticipated results were expected to aid in our understanding of how resurgence could be applied to situations where responding is under instructional control. This understanding would support further the idea that basic studies on resurgence (e.g., Epstein, 1985; Epstein & Skinner, 1980; Lieving & Lattal, 2003; Rawson, Leitenberg, Mulick, & Lefebvre, 1977) may offer new perspectives on the mechanisms responsible for instances of instructed sensitivity and insensitivity to changing contingencies (see Otto, Torgrud, & Holborn, 1999).

Experiment 1

Experiment 1 examined the relation between responding in the presence of inaccurate instructions and subsequent responding during two unsignaled contingency changes. If the resurgence of rule-governed behavior influenced changes in behavior during these contingency changes, then subjects who had been instructed to respond quickly would be more likely to engage in responding that met the scheduled contingencies during the initial unsignaled change and those who were instructed to respond slowly would be more likely to engage in responding that met the scheduled contingencies during the second unsignaled change.

Method

Subjects

Eighteen female West Virginia University undergraduate students between the ages of 17 and 22 (mean age = 19.14) participated in this experiment. Students were paid for their performance in the experiment and for their attendance.

Apparatus

Schedules were programmed on two computers (an IBM-compatible Pentium I and an IBM-compatible Pentium II). Sessions were conducted in rooms measuring approximately 2 m square. The workspace consisted of a chair, a table, and a computer placed on the table. Half of the subjects received information on a 14-in. monitor and the other half received information on a 17-in. monitor. An IBM style 101-key keyboard and a Microsoft mouse were placed within subjects' reach.

Procedure

Subjects were assigned randomly to 1 of 2 groups, "Short Instructions" (SH) or "Long Instructions" (LO). Two sessions were conducted daily six or seven days a week. Each session lasted 16 min, with a 5-min break between sessions. Reinforcers for all sessions were points exchangeable for money and each point was worth .0354. Subjects were required to read and sign a copy of an Informed Consent Form approved by the West Virginia University Institutional Review Board (Appendix A). Subjects received a slip of paper indicating how much money they had earned daily. Daily earnings receipts included a \$1.00 bonus paid

contingent on the completion of the experiment. Subjects were paid upon completing the experiment and were debriefed once all data were collected.

Subjects who were wearing a watch were asked to give their watch to the experimenter for the length of the session. Subjects were escorted subsequently into an experimental room and, during the first session, were read a set of introductory instructions (see Appendix B). Any questions were answered by repeating the relevant part of the instructions. The experimenter subsequently left the room after asking the subject to read the instructions on the screen. Only during the first session of the experiment were the following general instructions presented:

Welcome to the human behavior lab!

Get comfortable and when you are ready to read the general instructions, press the “CONTINUE” button.

In order to earn points, you will work on various computer tasks. Before you begin, you will be presented with instructions.

During the tasks, a beep will signal that you have earned a point. In order to have the point registered, press the “REGISTER” button. After you have registered your points, you will hear another beep, a stack of coins will briefly appear on the screen and the point counter will increment. So, as soon as you have earned a point, register it!

Accurate Instructions. Subjects were presented with the Accurate (AC) Instructions condition at the beginning of the experiment. Figure 1 diagrams the sequence of experimental

Figure 1. Sequence of conditions in Experiment 1 for Short Instructions (SH) and Long Instructions (LO) Subjects.

conditions. A DRL 10-s LH 8-s schedule was in effect during the AC Instructions condition. Figure 2 shows the screen containing instructions about the experimental task presented to all subjects. Pressing the “CONTINUE” button shown on Figure 2 resulted in the presentation of the following instructions:

Now you are ready to begin the session. Remember to earn and register your points. Each point will be worth .035 cents.

Press the “START” button to begin the session.

Throughout the rest of the AC Instructions session, subjects saw the screen containing the experimental task (Figure 3). This task was labeled “Dragging” and it required subjects to drag and drop an icon of a match into the icon of a trash can. If the contingency was met, a puff of smoke appeared from the trash can, a 0.5-s beep was presented, and a button labeled “REGISTER” appeared on the screen. Pressing the “REGISTER” button (“register response”) incremented the point counter by one, resulted in the presentation of another 0.5-s beep, and started the next trial. A new trial started only after the available point was registered. If the response did not meet the scheduled contingency (i.e., the IRT was < 10 s or > 18 s), the screen remained unchanged. The computer recorded IRTs and every response reset the IRT timer. *Accuracy* during the AC Instructions condition and all other nontesting conditions was defined as the result of dividing the number of IRTs between 10 and 18 s by the total number of IRTs in a session. Interresponse times were used as the main dependent variable because a sequential analysis of how long subjects waited between responses allowed the assessment of

This game involves putting objects in a trash can. You will be presented with the following screen:

You will only earn points if you wait APPROXIMATELY t seconds before dragging the match into the trash can. You will hear a beep when you have earned a point. In order to register the point, press the "REGISTER" button that will appear on the screen. You have 16 minutes to play this game. Press "CONTINUE."

Figure 2. Screen containing instructions about the experimental task. During the Accurate Instructions condition, $t = 14$ s. During the Inaccurate Instructions condition, $t = 2$ s for the Short Instructions Subjects and $t = 28$ s for the Long Instructions Subjects.

Figure 3. Screen containing the experimental task. During the Accurate Instructions condition, $t = 14$ s. During the Inaccurate Instructions condition, $t = 2$ s for the Short Instructions Subjects and $t = 28$ s for the Long Instructions Subjects.

whether responding during unsignaled changes could be considered the resurgence of earlier responding.

Once accuracy within a session was 80% or above, the Inaccurate (IN) Instructions condition was presented.

Inaccurate Instructions. During the one IN Instructions session, inaccurate instructions were presented (see Figure 1) while a DRL 10-s LH 8-s schedule continued to be in effect. SH subjects were told to wait approximately 2 s before dragging the match and the LO subjects were told to wait approximately 28 s, although only waiting between 10 and 18 s before dragging the match into the trash earned points.

No Instructions. After the IN Instructions session, the No Instructions condition was presented. All instructions were removed from the screen for the remainder of the experiment, thus allowing for the screen to remain unchanged throughout all subsequent sessions, and a DRL 10-s LH 8-s schedule continued to be in effect (see Figure 1). The stability criteria, which applied to the last three (“stable”) No Instructions sessions, were as follows: (a) subjects had to earn at least \$1.75 per session, (b) subjects could not have any IRTs < 8 or IRTs > 20 s, (c) less than 10% of all IRTs could be between 8 and 10 s and between 18 and 20 s, (d) mean rate of responding for each of the last three sessions had to be within 15% of the mean rate of responding for the last three sessions, and (e) visual inspection of the IRTs distributions had to show little response variability. Analyzing response variability involved examining the IRTs distributions and visually assessing whether there were systematic changes in the peaked gradient and overall response distribution. For example, an IRT

distribution presented in 2-s bins that showed changes in the peaked gradient of ± 1 IRT bin would have been consistent with stability, especially if the dispersion of the overall IRT distribution did not change. Changes in the peaked gradient of ± 2 or more IRTs bins were not consistent with stability, especially if the dispersion of the overall IRT distribution had changed.

Once subjects met these stability criteria, an analysis of their IRT history dictated whether they were presented with SHORT Testing or whether they were dismissed from the experiment. The eligibility criteria were as follows:

1. No IRTs > 20 s during any of the IN or No Instructions sessions for the SH subjects.
2. No IRTs < 8 s during any of the IN or No Instructions sessions for the LO subjects.

The use of these eligibility criteria made it feasible to analyze the relation between the IRTs during the IN and No Instructions sessions and the IRTs during testing. Without these criteria, subjects could have had a history of both < 8 s (short) IRTs and > 20 s (long) IRTs, and either might have recurred during testing.

SHORT Testing. The first (SHORT) testing condition began once stability and eligibility criteria were met during the No Instructions condition. The schedules in effect changed in testing (see Figure 1) although the computer screens presented during testing were identical to the computer screens presented during the No Instructions condition. During SHORT Testing, a mix DRL 10-s LH 8-s/DRL 4-s LH 4-s schedule was in effect. These changes were implemented to assess the sensitivity of behavior to changes in the

environment. Mixed schedules were used throughout testing because previous research (e.g., Aguilera & Chase, 2003; Lamons & Chase, 1992) showed that sensitivity to these schedules could be manipulated experimentally.

In the DRL 10-s LH 8-s component of the SHORT Testing schedule (hereafter referred to as the “10-s component”), IRTs between 10 and 18 s were reinforced as in the previous conditions. In the DRL 4-s LH 4-s component (hereafter referred to as the “4-s component”), only IRTs between 4 and 8 s were reinforced. To assure that subjects would continue to receive some reinforcers during testing, all testing sessions began with the presentation of the 10-s component. The individual components of the mixed schedule then alternated every 3 or 5 min. This was an attempt at decreasing the stimulus control problems associated with simply alternating the components in a fixed sequence (see Lattal, 1991). During the even-numbered sessions, the 10-s components lasted 5 min and the 4-s components lasted 3 min. During the odd-numbered sessions, the 10-s components lasted 3 min and the 4-s components lasted 5 min. This testing condition ended once visual inspection of the IRTs showed little response variability (as defined earlier under the No Instructions condition) for three successive sessions, at which point the No Instructions condition was reinstated.

Sessions during the second No Instructions condition continued until the stability criteria were met. Response stability during this condition was obtained if during three successive sessions: (a) no IRTs < 8 s or > 20 s were recorded, and (b) visual inspection of the IRTs distributions showed little response variability (as defined earlier under the description

of the initial No Instructions condition). After the second No Instructions condition, the second testing condition (LONG Testing) was introduced.

LONG Testing. In this testing condition, a mix DRL 10-s LH 8-s/DRL 20-s LH 6-s schedule was in effect. In the DRL 10-s LH 8-s component (“10-s component”), responses with IRTs between 10 and 18 s were reinforced as in the AC, IN, and No Instructions conditions and as in the 10-s component of SHORT testing. In the DRL 20-s LH 6-s component (hereafter referred to as the “20-s component”), only responses with IRTs between 20 and 26 s were reinforced (see Figure 1).

As in SHORT Testing, all testing sessions began with the presentation of the 10-s component. The individual components of the mixed schedule then alternated every 3 or 5 min. During the even-numbered sessions, the 10-s components lasted 5 min and the 20-s components lasted 3 min. During the odd-numbered sessions, the 10-s components lasted 3 min and the 20-s components lasted 5 min. This testing condition ended once little response variability (as defined earlier under the No Instructions condition) was observed, at which point the Extinction condition was presented.

Extinction. This condition consisted of one session where reinforcement was removed although the computer screens presented were identical to the computer screens presented during the No Instructions, SHORT, and LONG conditions (see Figure 1). During Extinction, no reinforcers could be earned throughout the session.

Extra-experimental Game. After the first daily session and before subjects took a 5-min break, subjects were presented with an arcade-like “extra-experimental” game that in

pilot studies decreased subject attrition. The reason for this effect is unknown, although various pilot subjects stated during debriefing that this game was, “more fun than the other [experimental] task.”

This game lasted 5 min and general instructions about it were presented after the first session of the study (Appendix C). These instructions did not specify how to earn points. Appendix C also shows the instructions presented after the first time subjects came back from the 5-min break and at the end of the first day’s sessions. Subjects were told that although the points earned in this extra-experimental game were not exchangeable for money, it was to their advantage to earn as many points as possible because the 2 individuals with the highest overall scores at the end of the study would receive a \$50.00 and a \$25.00 bonus check for first and second place, respectively.

The extra-experimental game was called “Crackanoid” and it required subjects to destroy all bricks presented on the screen by hitting them with a bouncing ball. Records of the points earned in this game were kept and the subjects with the two highest scores at the end of the study received the bonus money.

Results and Discussion

Subject Attrition

Eight of eighteen subjects completed the experiment. Three SH subjects were excluded from the study because they had IRTs > 20 s and 5 LO subjects were excluded from the study because they had IRTs < 8 s during the IN or initial No Instructions conditions. One

LO subject withdrew from the experiment because of personal reasons and 1 subject did not come back to the lab after the first day of the experiment for unknown reasons.

Accurate, Inaccurate, and No Instructions Conditions

Table 1 shows the number of AC, No Instructions, SHORT, and LONG sessions the 8 subjects needed to meet accuracy or stability criteria. This table also shows subjects' total money earned and the mean amount of money earned per session. The only difference between groups shown in this table is that more SH subjects took fewer sessions than the LO subjects to meet the accuracy criterion during the AC Instructions condition. Although there were some differences among subjects on the other variables, none of these differences appear related to the kind of inaccurate instructions presented. The range of total money earned and the range of money earned per session were also similar between groups.

Figure 4 shows the percentage of reinforced (those between 10 and 18 s) and unreinforced (all others) IRTs during the AC Instructions condition. The unreinforced IRTs are divided further into those that were short, long, or within ± 2 s of the scheduled contingencies. The upper panel shows these data for all SH subjects and the lower panel shows data for all LO subjects. Three of the four SH subjects met the accuracy criterion in one AC Instructions session with few IRTs outside the reinforceable range. The one exception, SH 4, met the criterion in two sessions. The bottom panel in Figure 4 shows that LO 2 was the only LO subject who met the accuracy criterion in one session. Nonetheless, by the second session, all LO subjects had met the accuracy criterion (i.e., $\geq 80\%$ of the IRTs were between 10 and 18 s).

Table 1

Number of Sessions until Accuracy or Stability Criteria Were Met, Money Earned, and Mean Amount of Money Earned per Session for Short Instructions (SH) and Long Instructions (LO) Subjects in Experiment 1

Group	Subject	Accurate Instructions Sessions	No Instructions Sessions - 1 ^a	No Instructions Sessions - 2 ^b	SHORT Sessions	LONG Sessions	Money Earned	Mean Amount Earned per Session
SH	SH 1	1	3	3	3	3	\$34.04	\$2.27
	SH 2	1	6	7	3	3	62.77	2.85
	SH 3	1	5	6	3	3	56.87	2.84
	SH 4	2	3	3	3	3	48.91	3.06
	Mean	1.25	4.25	4.75	3	3	50.65	2.76
	Standard Deviation	0.50	1.50	2.06	0	0	12.44	0.34
LO	LO 1	2	3	3	3	3	37.91	2.23
	LO 2	1	5	10	5	3	62.56	2.41
	LO 3	2	4	7	3	3	48.66	2.32
	LO 4	2	3	3	3	3	37.62	2.35
	Mean	1.75	3.75	5.75	3.5	3	46.69	2.33
	Standard Deviation	0.50	0.96	3.40	1	0	11.76	0.08

^aFirst time the No Instructions condition was presented. ^bSecond time the No Instructions condition was presented.

Figure 4. Percentage of reinforced (black bars) and unreinforced (other bars) interresponse times (IRTs) during the Accurate Instructions condition in Experiment 1.

The number of sessions required by many of the subjects to follow the rule provided in the AC Instructions condition verified the need to provide subjects with an experimental history of reinforced rule following. Although most studies that have presented accurate instructions have shown high accuracy in their presence (e.g., Hayes, Brownstein, Haas, & Greenway, 1986; LeFrancois et al., 1988), the current results suggest that such accuracy is not guaranteed. Only 4 of the 8 subjects (3 SH and 1 LO) followed the accurate instructions from the onset of the experiment. The difficulty subjects had following the instructions in the current study may have been due to the use of a DRL schedule with a LH contingency. This reinforcement arrangement is generally more restrictive than other schedules of reinforcement because only responses separated from other responses by a specific amount of time are reinforced. Most studies that have involved accurate instructions have had less restrictive schedules such as fixed, variable, random ratio, interval schedules, or simple DRL schedules (e.g., Hayes, Brownstein, Haas, et al. used fixed ratio and DRL schedules without a LH contingency). Other researchers have speculated that DRLs are difficult for humans because humans have a long history of responding quickly to buttons or button-like stimuli (Baron & Galizio, 1983). Nonetheless, all the subjects in the current experiment responded most of the time to the contingency and the instructions by the second AC Instructions session and, therefore, had an experimental history of reinforced rule following.

Figure 5 shows the mean IRT, with its corresponding standard deviation, during all AC and IN Instructions sessions and during the initial No Instructions condition for all subjects. Note that the y-axes are different between groups. The upper four panels show that

Figure 5. Mean interresponse time (IRT) during all Accurate (AC), Inaccurate (IN), and initial No Instructions conditions for Short Instructions (SH) and Long Instructions (LO) Subjects in Experiment 1. Range bars represent one standard deviation. Note that the y-axes are different between groups

the mean IRT for *all* SH subjects during the IN Instructions session was always *lower* and had a *larger* standard deviation than the mean IRT from the previous AC Instructions session. The bottom four panels show that the mean IRT during the IN Instructions session was always *higher* and had a *larger* standard deviation than the mean IRT from the previous AC Instructions session for all LO subjects except LO 1.

These data show that all the subjects who met the criteria for continuing in the study emitted responses indicating control by the inaccurate instructions presented during the IN Instructions session except LO 1: For most subjects, the mean IRT during the IN Instructions session changed according to the inaccurate instruction presented, and responding was much more variable as can be seen by the larger standard deviation. It is not clear why LO 1's behavior was different. Nonetheless, LO 1 did engage in *one* long IRT during the IN Instructions session. The data from Figure 5 also show that after some initial instability in responding during the No Instructions condition, all subjects returned to stable IRTs between 10 and 18 s.

Figure 6 shows the percentage of points earned out of the maximum available during the AC, IN, and initial No Instructions conditions. During a DRL 10-s LH 8-s schedule of reinforcement, points can be maximized by responding every 10 s (i.e., six times per minute). Because a register response was required before the IRT timer was reset, however, it was necessary to factor in the latency to make this register response when assessing the most efficient rate of responding during the DRL 10-s LH 8-s schedule. To do this, the median and mean register response latencies were calculated. For Experiment 1, the median latency was

Figure 6. Percentage of points earned out of the maximum available during the Accurate (AC), Inaccurate (IN), and initial No Instructions conditions for Short Instructions (SH) and Long Instructions (LO) Subjects in Experiment 1.

.61, the mean latency was .65, and the standard deviation was $\pm .22$. The median latency was chosen over the mean latency because there were some outlier latencies. It was concluded, then, that the shortest amount of time it would take subjects to earn a point was 10.61 s (10 s for the dragging response plus .61 s for the register response). The most efficient responding during a DRL 10-s LH 8-s schedule of reinforcement, therefore, would lead to earnings of 5.66 points per minute or 90.56 points per session.

To calculate the percentage of available points earned, total points obtained during each AC and IN session and during all sessions of the initial No Instructions condition were divided by 90.56 and converted to a percentage for each subject. Figure 6 shows this information for all subjects. With the exception of LO 1, subjects in both groups earned *fewer* of the maximum available points during the IN Instructions session than during the preceding AC Instructions session. These data show that following the inaccurate instructions decreased the percentage of available points earned. Data from Figure 6 also show that all subjects were earning at least 75% of the available points by the end of the initial No Instructions condition.

In summary, subjects who completed the experiment received a history of reinforcement for following rules in the AC Instructions Condition. In addition, all but 1 subject responded in ways during the IN Instructions condition that suggested initial control by the inaccurate instruction, and even this one subject followed the inaccurate instructions one time. This control was extinguished within a few sessions of the initial No Instructions condition and control by the contingencies of reinforcement occurred. The control by the inaccurate instructions provided SH and LO Subjects with differential response histories:

During the IN Instructions condition, SH subjects responded at high rates and all but one of the LO subjects responded at low rates.

Testing Conditions

SHORT Testing. The initial data analysis during SHORT Testing involved examining the responses emitted immediately after the unsignaled changes in the contingencies were introduced. Figures 7 and 8 show successive IRTs during the initial SHORT Testing session for all subjects. Successive IRTs are plotted on the y-axis. Each point represents a single response and its horizontal position shows the time that elapsed between that response and the previous response (except for the first point, which shows the time that elapsed between the onset of the session and the first response). The dashed lines separate the components (10- or 4-s). Because the last three No Instructions sessions required that all IRTs be between 8 and 20 s, the horizontal solid lines in these figures were set at 8 and at 20 s to allow a comparison between responding during SHORT Testing and responding during the No Instructions condition.

Figures 7 and 8 show that when IRTs reinforced throughout the experiment were no longer reinforced during the 4-s components of SHORT Testing, previously instructed responses under similar conditions recurred. Without exception, at least the first IRT outside the previously reinforced range was related to the type of inaccurate instruction subjects received. Figure 7 shows that all SH subjects had, within a few responses, IRTs < 8 s during the initial 4-s component. Furthermore, these short IRTs fell within the range of IRTs observed during the IN Instructions session. Analyses of the rest of the IRTs recorded during

Figure 7. Successive interresponse times (IRTs) during the initial SHORT session for Short Instructions (SH) Subjects in Experiment 1. IRTs are plotted on the y-axes and successive responses are plotted on the x-axes. The dashed lines separate the components within the SHORT Testing session. The horizontal solid lines allow the comparison of responding between the previous condition, where all IRTs were between 8 and 20 s, and the current condition.

Successive Responses

Figure 8. Successive interresponse times (IRTs) during the initial SHORT session for Long Instructions (LO) Subjects in Experiment 1. IRTs are plotted on the y-axes and successive responses are plotted on the x-axes. The dashed lines separate the components within the SHORT Testing session. The horizontal solid lines allow the comparison of responding between the previous condition, where all IRTs were between 8 and 20 s, and the current condition.

this initial SHORT session showed that 3 of the 4 SH subjects (SH 2, SH 3, and SH 4) reliably engaged in IRTs between 4 and 8 s during the 4-s components and IRTs between 10 and 18 s during the 10-s components. SH 1's data show that although her only IRTs outside the 8 to 20 s range during the first 4-s component were short, she did not engage in short IRTs during the second 4-s component. It is not clear why SH 1 did not reliably engage in IRTs between 4 and 8 s during the 4-s components as the other SH subjects. It should be noted, though, that her two short IRTs went unreinforced because they were < 4 s. Nonetheless, this is not an adequate explanation because some of the other SH subjects also initially had IRTs outside the reinforceable range, yet they continued responding at high rates until the scheduled contingencies were met.

Figure 8 shows that at least the first IRT outside the previously reinforced range during the initial 4-component of SHORT Testing for all LO subjects was > 20 s. These long IRTs also fell within the range of IRTs recorded during these subjects' IN Instructions session. An analysis of responding during the rest of this SHORT session showed that only LO 4 engaged in IRTs between 4 and 8 s during the 4-s components. The other 3 subjects engaged in variable responding between 8 and 20 s, or engaged in variable responding similar to the responding found during their IN Instructions session (where long IRTs were observed). A possible explanation for LO 4's anomalous responding may involve the range of responding in which she engaged during the AC Instructions condition (see Figure 4). LO 4 was the only LO subject who reliably engaged in short IRTs during the AC Instructions

condition, and, because of this history, short IRTs may have recurred when her one long IRT during the 4-s component of SHORT Testing was not reinforced.

Figure 9 compares the percentage of points earned out of the maximum available during the first SHORT Testing session. The most efficient way of responding during the 10-s component of a mix DRL 10-s LH 8-s/DRL 4-s LH 4-s was calculated earlier (see description of Figure 6). The most efficient way of responding during the second component of this schedule of reinforcement, where responding every 4 s maximizes reinforcers, also was calculated. As described for Figure 6, the median latency to register a point in this experiment was .61 s. The most efficient responding during the 4-s component, therefore, would lead to earnings of 13.02 points per minute or 104.16 points per testing session (4.61 s—the most efficient latency to respond during the 4-s component—divided into 60 s). The upper panel in Figure 9 shows that 3 of the 4 SH subjects earned reinforcers during both testing components. Specifically, they earned a mean of 56% ($SD = \pm 11.62$) of the available reinforcers during the 4-s components. The lower panel shows that 3 of the 4 LO subjects did not earn any of the available reinforcers during the 4-s components. The one exception, LO 4, earned only 27% of the available reinforcers during the 4-s components.

Data from Figures 7 through 9 show that although all subjects' responding changed upon contacting the unsignaled contingency changes, 3 of the 4 subjects who earned points when the contingencies changed were in the SH group. All 4 subjects who earned points during both components of the initial SHORT session (SH 2, SH 3, SH 4, and LO 4)

Figure 9. Percentage of points earned out of the maximum available during the first SHORT session for subjects in Experiment 1. Black bars show this information for the 10-s components and striped bars show this information for the 4-s components.

continued earning points throughout both components of all subsequent SHORT Testing sessions.

Figure 10 shows successive IRTs during the last SHORT Testing session for subjects whose behavior was not sensitive to the initial SHORT Testing session (SH 1, LO 3, LO 1, and LO 2). These data showed whether these subjects' behavior eventually became sensitive to the changes. IRTs are plotted on the y-axes and successive responses are plotted on the x-axes. Responding was more variable during the 4-s components than during the 10-s components, but only LO 2 reliably engaged in short IRTs during the 4-s components, while responding between 8 and 20 s during the 10-s components.

Although the effects of differential inaccurate instructions affected the recurrence of instructed responses in all cases during the initial exposure to SHORT Testing, the effect of inaccurate instructions on long-term sensitivity to the schedules was less clear. Although sensitivity during the first SHORT session was observed for the behavior of 3 SH subjects (SH 2, SH 3, SH 4) and only 1 LO subject (LO 4), by the last session of SHORT testing, the behavior of one other LO subject had become sensitive. Nonetheless, the results still show that sensitivity was achieved sooner and by more SH subjects than by LO subjects.

A possible explanation for the sensitivity of LO 4's behavior to the SHORT contingencies was suggested earlier. Although it is not clear why LO 2's behavior eventually was sensitive during SHORT Testing, one aspect of her responding during the No Instructions condition that is different from that of the other LO subjects is that she was the only subject

Successive Responses

Figure 10. Successive interresponse times (IRTs) during the last SHORT session for subjects in Experiment 1 whose behavior was not sensitive during the initial SHORT session. IRTs are plotted on the y-axes and successive responses are plotted on the x-axes. The dashed lines separate the components within the SHORT Testing session. The horizontal solid lines allow the comparison of responding between the previous condition, where all IRTs were between 8 and 20 s, and the current condition.

who did not reliably earn a reinforcer until the third session in that condition. During the IN Instructions condition and the initial two No Instructions sessions, LO 2 only had *one* IRT within the reinforceable range while the other 3 LO subjects were earning points reliably by the first No Instructions session. Generally, it may be said that LO 2 had a history of engaging in variable responding even after long periods (three sessions) of extinction—a factor outside experimental control. Although initially she did not earn reinforcers during the 4-s components of SHORT Testing, LO 2 continued to respond and her behavior eventually contacted the 4- to 8-s contingency.

Data from the first SHORT Testing session lend support to the suggestion that responses instructed, although not reinforced, during the IN Instructions condition were likely to recur during tests (i.e., 4-s components) involving a contingency change. In addition, the behavior of the subjects who were instructed to respond quickly became sensitive to the changes in the SHORT Testing contingencies sooner than most subjects instructed to respond slowly. These findings suggest that simply providing a history of reinforcement for not following instructions, as found in Aguilera and Chase (2003), was not sufficient to influence whether responding would come under the control of the contingencies in effect during SHORT Testing. These differences between studies were consistent with the rationale for conducting this study: to determine whether sensitivity to contingency changes was influenced by the *specific* instances of rule following emitted prior to the environmental change, even if there were no programmed consequences within the experiment for those responses.

After the end of SHORT Testing, the No Instructions condition was reintroduced. All subjects engaged only in IRTs between 8 and 20 s before the presentation of LONG Testing. The only exception was SH 2: A computer error resulted in the presentation of the LONG Testing condition for this subject before the stability criteria had been met.

LONG Testing. During LONG Testing, the contingencies changed from the DRL 10-s LH 8-s schedule of reinforcement used during the previous condition (No Instructions) to a mix DRL 10-s LH 8-s/DRL 20-s LH 6-s schedule. Figures 11 and 12 show successive IRTs during the initial LONG Testing session for all subjects. Successive IRTs are plotted on the y-axis. Each point represents a single response and its horizontal position shows the time that elapsed between that response and the previous response (except for the first point, which shows the time that elapsed between the onset of the session and the first response). The dashed lines separate the components (10- or 20-s). Because the last three No Instructions sessions required that all IRTs (with the exception of SH 2's) be between 8 and 20 s, the horizontal solid lines in these figures were set at 8 and at 20 s to allow a comparison between responding during LONG Testing and responding during the No Instructions condition.

Figure 11 shows that responding for 3 of the 4 SH subjects (SH 2, SH 3, and SH 4) changed in the 20-s component and the first IRTs outside the 8- to 20-s range were between 4 and 8 s in duration as related to the type of inaccurate instructions to which they were exposed and the range of IRTs reinforced during SHORT Testing. The upper left hand panel shows data for SH 1, the only SH subject whose behavior was insensitive to the changes. SH 1 continued responding as she had during the previous conditions: by engaging in IRTs

Successive Responses

Figure 11. Successive interresponse times (IRTs) during the initial LONG session for Short Instructions (SH) Subjects in Experiment 1. IRTs are plotted on the y-axes and successive responses are plotted on the x-axes. The dashed lines separate the components within the LONG Testing session. The horizontal solid lines allow the comparison of responding between the previous condition, where all IRTs were between 8 and 20 s, and the current condition.

Figure 12. Successive interresponse times (IRTs) during the initial LONG session for Long Instructions (LO) Subjects in Experiment 1. IRTs are plotted on the y-axes and successive responses are plotted on the x-axes. The dashed lines separate the components within the LONG Testing session. The horizontal solid lines allow the comparison of responding between the previous condition, where all IRTs were between 8 and 20 s, and the current condition.

between 8 and 20 s. It can be concluded, then, that with the exception of SH 1, SH subjects engaged in IRTs during the 20-s components as predicted by both the type of inaccurate instructions to which they were exposed and the range of IRTs reinforced during SHORT Testing. This finding is consistent with the phenomenon of resurgence: During extinction conditions (i.e., 20-s components), the most recently reinforced response not under extinction recurred for 3 of the 4 SH subjects.

Figure 12 shows that for all LO subjects, responding changed in the 20-s component. The first IRTs outside the 8- to 20-s range for LO 1 and LO 3 were more than 20 s in duration as could be predicted by the type of inaccurate instruction to which they were exposed and by the fact that their behavior was insensitive to the SHORT contingencies. The 2 LO subjects who had short IRTs during the first few minutes of the initial 20-s component, LO 2 and LO 4, were also the LO subjects whose behavior was sensitive to the previous (SHORT) Testing condition (where IRTs between 4 and 8 s were reinforced). It can be concluded, then, that all the LO subjects engaged in IRTs during the 20-s components as predicted by both the type of inaccurate instructions to which they were exposed and the range of IRTs reinforced during SHORT Testing.

This finding is also consistent with the phenomenon of resurgence: During extinction conditions, the most recently reinforced response not under extinction recurred. For LO 1 and LO 3, the most recently reinforced responses not under extinction were the long IRTs observed during the IN and No Instructions conditions. For LO 2 and LO 4, short IRTs were most recently reinforced. When this range of responding was not reinforced during LONG

Testing, LO 2 engaged in a range of long IRTs similar to her range of responding during the IN Instructions session. Unlike LO 2, LO 4 continued to engage in short IRTs. It should be noted that LO 4 was the *only* LO subject whose behavior was sensitive to the SHORT condition from the beginning of that condition.

Data from Figures 11 and 12 can be summarized as follows: At least during the first 20-s component of the initial LONG Testing session, responses most recently reinforced or inaccurately instructed during the IN Instructions condition, recurred for 7 of the 8 subjects. In other words, short IRTs recurred for 3 SH subjects and for the 2 LO subjects who engaged in short IRTs during SHORT Testing, and long IRTs recurred for the other 2 LO subjects. SH 1's behavior, on the other hand, did not change during the LONG test: All her IRTs were between 8 and 20 s similarly to her behavior during the preceding No Instructions condition.

That SH 2, SH 3, and SH 4 earned at least a few of the points available during the 20-s components is likely due to their having a history of reinforcement for engaging in variable responding (see Joyce & Chase, 1990; LeFrancois et al., 1988; also, see General Discussion). By the time these 3 SH subjects were presented with the LONG condition, reinforcers already had been provided for engaging in IRTs between 10 and 18 s *and* IRTs between 4 and 8 s. The only SH Subject whose behavior was not sensitive to LONG Testing was SH 1, the only SH subject who did not receive reinforcers for engaging in IRTs between 4 and 8 s during SHORT Testing. During LONG Testing, she continued responding as she had been responding throughout 99.99% of SHORT Testing and throughout 100% of the previous No Instructions condition: by engaging in IRTs between 8 and 20 s.

That 2 of the LO subjects (LO 3 and LO 4) did not at least partially engage in IRTs between 20 and 26 s during the 20-s components is more difficult to interpret because these subjects had both a history of reinforcement for engaging in variable responding *and* for engaging in responses under the control of inaccurate instructions that stated to wait approximately 28 s before responding. LO 3's responding may have been due partially to the fact that this subject did not have a history of reinforcement for engaging in variable responding. Throughout most SHORT Testing and the previous No Instructions condition, all but one of this subject's IRTs were between 8 and 20 s. Even an analysis of LO 3's IRTs during the AC Instructions condition shows that, unlike the other 3 LO subjects, 97.56% of her IRTs were within the 8 to 20 s range. LO 4 did have a history of reinforcement for engaging in variable responding, but she also did not engage in IRTs between 20 and 26 s during the 20-s components.

Extinction Condition

Figures 13 and 14 show the percentage of IRTs between 10 and 18 s, within ± 2 s of the 10- to 18-s range, < 8 s, or > 20 s for the 4- and 20-s testing components and for Extinction. Figure 13 shows that Subject SH 1, whose responding during the 4- and 20-s components was never reinforced, engaged mostly in IRTs between 10 and 18 s during Extinction. Although Subjects SH 2 and SH 3 earned some reinforcers during LONG Testing, these subjects' responses only reliably came under the control of the SHORT contingencies as can be seen by the large number of short IRTs during the 4-s components. Consequently, the highest percentage of their IRTs during Extinction was short. Subject SH 4, whose responses

Figure 13. Percentage of IRTs between 10 and 18 s (black bars), within ± 2 s of the 10- to 18-s range (horizontally-striped bars), < 8 s (diagonally-striped bars), and > 20 s (grey bars) throughout the 4-s components of SHORT Testing, the 20-s components of LONG Testing, and Extinction for Short Instructions (SH) Subjects in Experiment 1.

Figure 14. Percentage of IRTs between 10 and 18 s (black bars), within ± 2 s of the 10- to 18-s range (horizontally-striped bars), < 8 s (diagonally-striped bars), and > 20 s (grey bars) throughout the 4-s components of SHORT Testing, the 20-s components of LONG Testing, and Extinction for Long Instructions (LO) Subjects in Experiment 1.

were most recently under the control of the LONG contingencies (i.e., she had a high percentage of long IRTs during LONG Testing), engaged in a high percentage of long IRTs during Extinction.

Figure 14 shows that Subjects LO 1 and LO 2, whose responses were most recently under the control of the LONG contingencies, engaged in a high percentage of long IRTs during Extinction. Subject LO 3, whose behavior during the changing contingencies went mostly unreinforced, engaged mostly in IRTs between 10 and 18 s during Extinction. Subject LO 4's responses during testing only completely came under the control of the SHORT contingencies as can be seen by the large number of short IRTs during the 4-s components. Consequently, most of her IRTs during Extinction were short.

Although the Extinction data are not very clear because of the high variability in responding during this condition, for most subjects it can be concluded that the range of IRTs recorded during extinction conditions was related to the range of IRTs most recently reinforced during testing: a finding that is also consistent with the phenomenon of resurgence.

Summary

The results from this experiment can be summarized as follows: First, the behavior of *all* subjects contacted the contingencies during SHORT Testing as can be seen by the differences in responding between the initial 10- and 4-s components for all subjects and between the initial 10- and 20-s components during LONG Testing for 7 of the 8 subjects. Second, when IRTs between 10 and 18 s were no longer reinforced during the initial 4-s component of SHORT Testing, previously instructed responses recurred for all subjects.

Third, the recurrence of these responses affected the probability that subjects would engage in responding that resulted in reinforcement during the unsignaled contingency changes. Fourth, when IRTs between 10 and 18 s were no longer reinforced during the initial 20-s component of LONG Testing, the most recently reinforced responses not under extinction recurred for 7 of the 8 subjects. Lastly, that 3 SH subjects engaged in 20- to 26-s IRTs during the initial LONG session shows that for some subjects, having a history of reinforcement for engaging in both long and short IRTs increased the probability of engaging in variable responding in the presence of novel contingencies (e.g., Joyce & Chase, 1992; LeFrancois et al., 1988; Weiner, 1970).

These results led to the conclusion that sensitivity to the specific contingency changes was at least a *joint* function of the specific responses emitted by the subjects when the inaccurate instructions were presented and subjects' history of responding under varying contingencies. Differences in responding between the first testing condition and the second testing condition, however, suggest that further manipulations are needed to support this conclusion. Experiment 2 sought this support by reversing the order of presentation of the testing contingencies: presenting LONG Testing before SHORT Testing. If results from Experiment 1 were to be systematically replicated, then the data would show that (a) LO Subjects are more likely to engage in long IRTs and SH subjects are more likely to engage in short IRTs during the 20-s components of the initial LONG Testing session, and (b) sensitivity during SHORT Testing is at least a joint function of resurgence and subjects' history of reinforcement for engaging in variable responding.

Experiment 2

Experiment 2 also examined the relation between responding in the presence of inaccurate instructions and subsequent responding during unsignaled contingency changes. Specifically, this experiment examined the effect of reversing the order of presenting the testing schedules. If the resurgence of rule-governed behavior influenced changes in behavior during these test conditions, then subjects who had been instructed to respond slowly would be more likely to engage in long IRTs during the initial unsignaled change and those who were instructed to respond quickly would be more likely to engage in short IRTs. Furthermore, if sensitivity during the second testing condition was at least a joint function of resurgence and subjects' history of reinforcement for engaging in variable responding, then responding during the second testing condition would depend on the range of IRTs for which subjects had been reinforced and their history of reinforcement for engaging in variable responding.

Method

Subjects

Eighteen female West Virginia University undergraduate students between the ages of 18 and 21 (mean age = 19.25) participated in this experiment. Students were paid for their performance in the experiment and for their attendance.

Apparatus

The same apparatus was used as in Experiment 1.

Procedure

The only difference between the procedure used in Experiment 1 and Experiment 2 involved the order of presenting the testing schedules (see Figure 15). The schedule of reinforcement presented during the first testing condition was a mix DRL 10-s LH 8-s/DRL 20-s LH 6-s schedule of reinforcement (LONG Testing), whereas the schedule in the second testing condition (SHORT Testing) was a mix DRL 10-s LH 8-s/DRL 4-s LH 4-s. As in Experiment 1, subjects were presented with the AC Instructions condition and were assigned randomly to 1 of 2 groups prior to the IN Instructions condition. Subjects in the SH group were instructed inaccurately to engage in 2-s IRTs and subjects in the LO group were instructed inaccurately to engage in 28-s IRTs. The same stability and eligibility criteria used in Experiment 1 had to be met before a subject could continue to the testing conditions.

Results and Discussion

Subject Attrition

Eight of eighteen subjects completed the experiment. Three SH subjects were excluded from the study because they engaged in IRTs > 20 s and 5 LO subjects were excluded from the study because they engaged in IRTs < 8 s during the IN or initial No Instructions conditions. One LO subject was excluded from the experiment because she did not meet the accuracy criterion in six AC Instructions sessions and 1 SH subject was excluded from the experiment because she did not meet the stability criteria after eight initial No Instructions sessions.

Figure 15. Sequence of conditions in Experiment 2 for Short Instructions (SH) and Long Instructions (LO) Subjects.

Accurate, Inaccurate, and No Instructions Conditions

Table 2 shows the number of AC, No Instructions, SHORT, and LONG sessions the 8 subjects needed to meet the accuracy or stability criteria. This table also shows subjects' total earnings and the mean amount of money earned per session. Overall, it took the SH subjects more sessions to meet the accuracy or stability criteria throughout all conditions, although the range of total money earned and the range of money earned per session were similar between groups.

Figure 16 shows the percentage of reinforced (those between 10 and 18 s) and unreinforced (all others) IRTs during the AC Instructions condition. The unreinforced IRTs are divided further into those that were short, long, or within ± 2 s of the contingencies. The upper panel shows data for all SH subjects and the lower panel shows data for all LO subjects. Six of the eight subjects (2 SH and all 4 LO) met the accuracy criterion in one session with few IRTs outside the reinforceable range. It took SH 6 and SH 8 three sessions to meet the accuracy criterion. As in Experiment 1, the number of sessions required by some of the subjects to follow the rule provided in the AC Instructions condition verified the need to provide subjects with an experimental history of reinforced rule following. Data from Figure 16 also show that before the introduction of the IN Instructions condition, all subjects had met the accuracy criterion and, therefore, had an experimental history of reinforced rule following.

Figure 17 shows the mean IRT, with its corresponding standard deviation, during all AC and IN Instructions sessions and during the initial No Instructions condition for all subjects. Note that the y-axis scale ranges are different for the bottom two panels. The upper

Table 2

Number of Sessions until Accuracy or Stability Criteria Were Met, Money Earned, and Mean Amount of Money Earned per Session for Short Instructions (SH) and Long Instructions (LO) Subjects in Experiment 2

Group	Subject	Accurate Instructions Sessions	No Instructions Sessions - 1 ^a	No Instructions Sessions - 2 ^b	SHORT Sessions	LONG Sessions	Money Earned	Mean Amount Earned per Session
SH	SH 5	1	6	5	3	3	\$53.68	2.68
	SH 6	3	3	3	4	5	48.92	2.45
	SH 7	1	4	10	3	3	51.45	2.24
	SH 8	3	5	3	3	3	43.78	2.30
	Mean	2	4.50	5.25	3.25	3.5	49.46	2.42
	Standard Deviation	1.15	1.29	3.30	0.50	1	4.26	0.20
LO	LO 5	1	3	5	3	3	45.96	2.70
	LO 6	1	3	8	4	4	53.53	2.43
	LO 7	1	3	3	4	4	44.91	2.64
	LO 8	1	4	3	3	3	46.85	2.93
	Mean	1	3.25	4.75	3.50	3.50	47.81	2.68
	Standard Deviation	0	0.50	2.36	0.58	0.58	3.89	0.21

^aFirst time the No Instructions condition was presented. ^bSecond time the No Instructions condition was presented.

Figure 16. Percentage of reinforced (black bars) and unreinforced (other bars) interresponse times (IRTs) during the Accurate Instructions condition in Experiment 2.

Figure 17. Mean interresponse time (IRT) during all Accurate (AC), Inaccurate (IN), and initial No Instructions conditions for Short Instructions (SH) and Long Instructions (LO) Subjects in Experiment 2. Range bars represent one standard deviation. Note that the y-axes are different for LO 5 and LO 6 (lower panels).

four panels show that the mean IRT during the IN Instructions session was always *lower* and had a *larger* standard deviation than the mean IRT from the previous AC Instructions session for *all* SH subjects except SH 8. The lower panels show data for all LO subjects. The mean IRT during the IN Instructions session was always *higher* and had a *larger* standard deviation than the mean IRT from the previous AC Instructions session for all LO subjects.

These data show that all the subjects who met the criteria for continuing in the study emitted responses indicating control by the inaccurate instructions presented during the IN Instructions session except SH 8: For most subjects, the mean IRT during this first session changed according to the inaccurate instruction presented, and responding was much more variable as can be seen by the larger standard deviation during the IN Instructions session. It is not clear why SH 8's responding was different, but it should be noted that SH 8 engaged in *two* short IRTs during the IN Instructions session (i.e., she followed the inaccurate instruction two times). The data from Figure 17 also show that after some initial instability in responding during the No Instructions condition, all subjects returned to engaging in stable IRTs between 10 and 18 s.

Figure 18 shows the percentage of points earned out of the maximum available during the first three conditions. As in Experiment 1, the median and mean latencies for registering a response were calculated to assess the most efficient rate of responding during a DRL 10-s LH 8-s schedule of reinforcement. In this experiment, the median latency for registering a point was .71, the mean latency was .75, and the standard deviation was $\pm .33$. Because there were some outlier latencies, the median latency was chosen over the mean latency. It was

Figure 18. Percentage of points earned out of the maximum available during the Accurate (AC), Inaccurate (IN), and initial No Instructions conditions for Short Instructions (SH) and Long Instructions (LO) Subjects in Experiment 2.

concluded, then, that the shortest amount of time it would take subjects to earn a point was 10.71 s (10 s for the dragging response plus .71 s for the register response). The most efficient responding during a DRL 10-s LH 8-s schedule of reinforcement, therefore, would lead to earnings of 5.60 points per minute or 89.60 points per session.

To calculate the percentage of available points earned, total points obtained during all sessions of the first three conditions were divided by 89.60 and converted to a percentage for each subject. Figure 18 shows that *all* subjects earned *fewer* of the maximum available points during the IN Instructions session than during the preceding AC Instructions session. Furthermore, all subjects were earning at least 65% of the available points by the end of the No Instructions condition. Overall, all 8 subjects who completed the experiment received a history of reinforcement for following rules in the AC Instructions condition. Additionally, all but one subject responded during the IN Instructions condition in ways that suggested initial control by the inaccurate instruction, and even this one subject followed the inaccurate instruction two times. This control by the inaccurate instructions was extinguished for all subjects within a few sessions and control by the contingencies of reinforcement occurred. The control by the inaccurate instructions provided subjects in the SH and LO conditions with differential response histories: During the IN Instructions condition, all but 1 of the SH subjects responded at high rates and all LO subjects responded at low rates.

Testing Conditions

LONG Testing. To examine resurgence, the responses emitted after the unsignaled changes were introduced in the first (LONG) testing condition were analyzed. During this

condition, the schedule of reinforcement in effect changed from a DRL 10-s LH 8-s schedule of reinforcement to a mix DRL 10-s LH 8-s/DRL 20-s LH 6-s schedule. As in Experiment 1, when IRTs reinforced during the previous conditions were extinguished during the 20-s components of LONG Testing, previously instructed responses during similar conditions (i.e., IN Instructions condition) recurred as expected. Figures 19 and 20 display successive IRTs during the initial LONG Testing session for all subjects. Successive IRTs are plotted on the y-axis. Each point represents a single response and its horizontal position shows the time that elapsed between that response and the previous response (except for the first point, which shows the time that elapsed between the onset of the session and the first response). The dashed lines separate the components (10- or 20-s). Because the last three No Instructions sessions required that all IRTs be between 8 and 20 s, the horizontal solid lines in these figures were set at 8 and at 20 s to allow a comparison between responding during LONG Testing and responding during the No Instructions condition.

Figure 19 shows that the first IRT outside the previously reinforced range for all SH subjects during the 20-s component was short. Analyses of the rest of the responses emitted during this initial session showed that only 1 SH subject (SH 6) reliably engaged in long IRTs during the 20-s components. Differences between the responding of SH 6 and that of the rest of the SH subjects in previous conditions suggest that factors outside experimental control may have contributed to her uncharacteristic responding. For example, data from the first AC Instructions session show that SH 6 was the only subject who did not at least partially follow the accurate instructions. Figure 20 shows that during the initial 20-s component, the first IRT

Figure 19. Successive interresponse times (IRTs) during the initial LONG session for Short Instructions (SH) Subjects in Experiment 2. IRTs are plotted on the y-axes and successive responses are plotted on the x-axes. The dashed lines separate the components within the LONG Testing session. The horizontal solid lines allow the comparison of responding between the previous condition, where all IRTs were between 8 and 20 s, and the current condition.

Figure 20. Successive interresponse times (IRTs) during the initial LONG session for Long Instructions (LO) Subjects in Experiment 2. IRTs are plotted on the y-axes and successive responses are plotted on the x-axes. The dashed lines separate the components within the LONG Testing session. The horizontal solid lines allow the comparison of responding between the previous condition, where all IRTs were between 8 and 20 s, and the current condition.

outside the previously reinforced range for all LO subjects was long. These results are also consistent with the phenomenon of resurgence. Lastly, Figure 20 shows that all LO subjects reliably engaged in long IRTs during the 20-s components of this session.

Figure 21 compares the percentage of points earned out of the maximum available during the first LONG session for all subjects. The most efficient way of responding during the 10-s component of a mix DRL 10-s LH 8-s/DRL 20-s LH 6-s schedule of reinforcement was calculated earlier (see description of Figure 18). The most efficient way of responding during the second component of this schedule of reinforcement, where responding every 20 s maximizes reinforcers, also was calculated. Because the median latency to make a register response in this experiment was .71, this number was added to 20 s and then 60 s was divided by this sum. The most efficient responding during the 20-s component, therefore, would lead to earnings of 2.90 points per minute or 23.30 points per testing session. To calculate the percentage of available points earned, the number of points obtained during the 20-s components of the first testing session was divided by 23.30 and converted to a percentage for each subject. The upper panel in Figure 21 shows that 3 of the 4 SH subjects reliably earned reinforcers only during the 10-s components. The lower panel, on the other hand, shows that *all* LO subjects reliably earned reinforcers during both testing components.

The data from Figures 19 through 21 can be summarized as follows: First, responding for all subjects changed upon contacting the unsignaled contingency changes. Second, at least the first IRT outside the 8- to 20-s range during the initial 20-s component was a function of the inaccurate instructions presented to each subject during the IN Instructions condition—

Figure 21. Percentage of points earned out of the maximum available during the first LONG session for subjects in Experiment 2. Black bars show this information for the 10-s components and grey bars show this information for the 20-s components.

findings that are consistent with the phenomenon of resurgence. Third, 4 of the 5 subjects who reliably engaged in long IRTs during the 20-s components *and* who reliably earned points throughout both testing components were in the LO group. These 5 subjects continued earning points throughout both components of all subsequent LONG Testing sessions.

Figure 22 shows successive IRTs during the last LONG Testing session for the 3 subjects (SH 5, SH 7, and SH 8) who did not reliably earn reinforcers during both components of the initial LONG session. These data showed whether these subjects eventually earned reinforcers during both LONG Testing components. IRTs are plotted on the y-axes and successive responses are plotted on the x-axes. The dashed lines separate the components (10- or 20-s). Figure 22 shows that although responses were more variable during the 20-s components than during the 10-s components, only SH 7 engaged in a few long IRTs that were within the reinforceable range during the 20-s components.

Results from LONG Testing support the suggestions (a) that responses instructed, although not reinforced, during the IN Instructions condition are likely to recur during unsignaled contingency changes (e.g., 20-s components), and (b) that this recurrence affects the probability that subjects will engage in responding during these unsignaled changes that results in reinforcement. Specifically, this LONG Testing condition showed that 4 of the 5 subjects who engaged in responding during the 20-s components that resulted in reinforcement had been inaccurately instructed to respond slowly (i.e., approximately every 28 s). These findings suggest that, unlike what was initially concluded in Aguilera and Chase (2003), providing a history of reinforcement for not following instructions was *not* sufficient

Figure 22. Successive interresponse times (IRTs) during the last LONG session for subjects in Experiment 2 whose behavior was not sensitive during the initial LONG session. IRTs are plotted on the y-axes and successive responses are plotted on the x-axes. The dashed lines separate the components within the LONG Testing session. The horizontal solid lines allow the comparison of responding between the previous condition, where all IRTs were between 8 and 20 s, and the current condition.

to predict whether subjects would engage in responding that would result in reinforcement during the unsignaled changes. As stated in Experiment 1, these differences between studies were consistent with the rationale for conducting this study: to determine the relation between resurgence and responding in a manner that results in reinforcement in the presence of unsignaled changes.

After the end of LONG Testing, the No Instructions condition was reintroduced. Subjects engaged only in IRTs between 8 and 20 s before the presentation of SHORT Testing.

SHORT Testing. During SHORT Testing, the contingencies changed from the DRL 10-s LH 8-s schedule of reinforcement used during the previous No Instructions condition to a mix DRL 10-s LH 8-s/DRL 4-s LH 4-s schedule. Figures 23 and 24 show successive IRTs during the initial SHORT Testing session for all subjects. Successive IRTs are plotted on the y-axis. The dashed lines separate the components (10- or 4-s).

Figure 23 shows that SH 5 and SH 8, 2 of the 3 subjects who did not reliably earn reinforcers during the 20-s components of LONG Testing, engaged in short IRTs within a few seconds of the presentation of the unsignaled contingency change. Thus, the responses that recurred during the unsignaled changes in SHORT Testing were those these 2 subjects had originally emitted during the IN Instructions condition. Analyses of the rest of their responses during this initial session showed that only SH 5 engaged in short IRTs during the 4-s components. SH 8, on the other hand, engaged in IRTs between 8 and 20 s during the rest of the session.

Successive Responses

Figure 23. Successive interresponse times (IRTs) during the initial SHORT session for Short Instructions (SH) Subjects in Experiment 2. IRTs are plotted on the y-axes and successive responses are plotted on the x-axes. The dashed lines separate the components within the SHORT Testing session. The horizontal solid lines allow the comparison of responding between the previous condition, where all IRTs were between 8 and 20 s, and the current condition.

Successive Responses

Figure 24. Successive interresponse times (IRTs) during the initial SHORT session for Long Instructions (LO) Subjects in Experiment 2. IRTs are plotted on the y-axes and successive responses are plotted on the x-axes. The dashed lines separate the components within the SHORT Testing session. The horizontal solid lines allow the comparison of responding between the previous condition, where all IRTs were between 8 and 20 s, and the current condition.

Figure 23 also shows that, unlike SH 5 and SH 8, Subjects SH 6 and SH 7 engaged in long IRTs within their first few responses during the initial 4-s component. SH 6's and SH 7's results are also consistent with the phenomenon of resurgence: During extinction conditions, the most recently reinforced responses not under extinction recurred. SH 6 and SH 7 were the only SH subjects who earned at least a few reinforcers during the 20-s components of LONG Testing. After engaging in two long IRTs, SH 6 reliably engaged in short IRTs during the 4-s components. SH 7 continued to engage in long IRTs even during the 10-s components of this initial SHORT session.

Overall, it can be concluded that all SH subjects engaged in IRTs during the first 4-s component of this initial SHORT session as predicted by the type of inaccurate instructions to which they were exposed and the range of IRTs reinforced during LONG Testing. This finding was consistent with the phenomenon of resurgence: During extinction conditions, the most recently reinforced response not under extinction recurred. For SH 5 and SH 8, the most recently reinforced responses not under extinction were the short IRTs observed during the IN Instructions condition. For SH 6 and SH 7, long IRTs had been most recently reinforced during the changing contingencies (i.e., 20-s components). When this range of responding was not reinforced during SHORT Testing, SH 6 engaged in a range of short IRTs similar to her range of responding during the IN Instructions session.

It is not clear why SH 7 continued engaging in long IRTs throughout this session, although it should be noted that SH 7 reported during the post-experimental debriefing that

she had fallen asleep, for brief periods of time and on various occasions, during the last part of the experiment. Based on her performance during SHORT Testing and her self-report, it is likely that she fell asleep during this testing condition.

Figure 24 shows that all LO Subjects, upon the presentation of the initial 4-s component, engaged in long IRTs when they were not engaging in previously reinforced IRTs. This finding is consistent with the phenomenon of resurgence: During extinction conditions (i.e. 4-s components), the most recently reinforced responses not under extinction recurred. Furthermore, 3 of the 4 LO subjects (LO 5, LO 7, and LO 8) also engaged in variable responding and reliably engaged in short IRTs during the 4-s components by the end of the first test session. LO 6, on the other hand, engaged in IRTs during this component that were either between 8 and 20 s or > 20 s. That 3 LO subjects started earning points during both testing components although they initially had IRTs outside the reinforceable range is likely due to their having a history of reinforcement for engaging in variable responding (see LeFrancois et al., 1988; Joyce & Chase, 1990; also, see General Discussion). Although LO 6 also had this same history and her responding was also variable, it is not clear why she was the only LO subjects who did not engage in IRTs between 4 and 8 s during this initial SHORT session. Nonetheless, it should be noted that although the data are not shown, LO 6 did engage in IRTs between 4 and 8 s during the 4-s components of subsequent SHORT sessions.

Data from Figures 23 and 24 can be summarized as follows: First, the responding of all subjects contacted the unsignaled contingency changes. Second, the most recently

reinforced responses not under extinction recurred during the initial 4-s component for all subjects. Third, 5 of the 8 subjects (2 SH and 3 LO) reliably engaged in IRTs between 4 and 8 s during the 4-s components of SHORT Testing. That 3 LO subjects reliably engaged in short IRTs during the initial 4-s component is likely due to their having a history of reinforcement for engaging in variable responding. For example, by the time these LO subjects were presented with SHORT Testing, they already had obtained reinforcers for engaging in IRTs between 10 and 18 s *and* IRTs between 20 and 26 s. That 2 SH subjects engaged in IRTs between 4 and 8 s during SHORT Testing is probably a function of the resurgence of responses emitted during the IN Instructions condition and also a function of having a history of reinforcement for engaging in variable responding. SH 8 may not have engaged in IRTs between 4 and 8 s because she did not have a history of reinforcement for engaging in variable responding: More than 97% of her IRTs during LONG Testing and 100% of her IRTs during the previous No Instructions condition had been between 8 and 20 s. Although it is not clear why SH 7's responding was different from that of the other subjects, this subject reported during the post-experimental debriefing, as noted above, that she had fallen asleep for brief periods of time and on various occasions during the last part of the experiment.

Extinction Condition

Figures 25 and 26 show the percentage of IRTs between 10 and 18 s, ± 2 s of the 10- to 18-s range, < 8 s, or > 20 s for the 4- and 20-s testing components and for Extinction. The two upper panels in Figure 25 show that SH 5 and SH 6, subjects who most recently earned reinforcers during the 4-s components, engaged mostly in short IRTs during Extinction. Data

Figure 25. Percentage of IRTs between 10 and 18 s (black bars), within ± 2 s of the 10- to 18-s range (horizontally-striped bars), < 8 s (diagonally-striped bars), and > 20 s (grey bars) throughout the 20-s components of LONG Testing, the 4-s components of SHORT Testing, and Extinction for Short Instructions (SH) Subjects in Experiment 2.

Figure 26. Percentage of IRTs between 10 and 18 s (black bars), within ± 2 s of the 10- to 18-s range (horizontally-striped bars), < 8 s (diagonally-striped bars), and > 20 s (grey bars) throughout the 20-s components of LONG Testing, the 4-s components of SHORT Testing, and Extinction for Long Instructions (LO) Subjects in Experiment 2.

for SH 8, the only SH subject who did not reliably earn reinforcers during the 20- or 4-s components, show that most of her IRTs during Extinction were between 10 and 18 s. The lower panel shows data for SH 7. She did not reliably earn reinforcers during the 20- or 4-s components, yet, during Extinction, SH 7 had mostly long IRTs. Figure 26 shows that although all LO subjects had received reinforcers for engaging in both long and short IRTs throughout testing, short IRTs had been reinforced most recently during the 4-s components. Subsequently, all LO subjects had a high percentage of short IRTs during Extinction.

Although the Extinction data are not clear because of the high variability in responding during this condition, for most subjects it can be concluded that the range of IRTs recorded during extinction conditions was related to the range of IRTs most recently reinforced during testing: a finding that is also consistent with the phenomenon of resurgence.

Summary

The results from this experiment can be summarized as follows: First, the behavior of *all* subjects contacted the changing conditions as can be seen by the differences in responding between the initial 10- and 20-s components during LONG Testing and between the initial 10- and 4-s components during SHORT Testing. Second, when IRTs between 10 and 18 s were no longer reinforced during the initial 20-s component of LONG Testing, previously instructed responses recurred for all subjects. Third, the recurrence of these responses affected the probability that subjects would engage in responding that resulted in reinforcement during the unsignaled contingency changes. Fourth, when IRTs between 10 and 18 s were no longer reinforced during the initial 4-s component of SHORT Testing, the most recently reinforced

responses not under extinction recurred for 7 of the 8 subjects. Lastly, that 3 LO subjects reliably engaged in 4- to 8-s IRTs during the initial 4-s component shows that having a history of reinforcement for engaging in both long and short IRTs increases the probability of engaging in variable responding in the presence of novel contingencies (e.g., Joyce & Chase, 1992; LeFrancois et al., 1988; Weiner, 1970).

These results further support the conclusion suggested during Experiment 1 that engaging in responding that results in reinforcement during the unsignaled changes was at least a *joint* function of the specific responses emitted when the inaccurate instructions were presented and subjects' history of responding during varying contingencies.

General Discussion

The results of both experiments found two factors that may affect the sensitivity of rule-governed behavior to unsignaled changes: (a) the recurrence of both directly reinforced responses and responses under instructional control, and (b) subjects' history of reinforcement for responding variably. Each of these two topics will be discussed before turning to the limitations of the current experiments and suggestions for future research.

Resurgence of Rule-Governed Behavior

The results of the current experiments suggest that specific instances of rule-governed behavior, regardless of whether these instances have been reinforced directly, may recur during extinction conditions. For example, during the initial 4-s component in the SHORT Testing condition of Experiment 1, at least the first IRT outside the previously reinforced 10- to 18-s range fell within the range of IRTs recorded during the IN Instructions session: SH

subjects engaged in short IRTs and LO subjects engaged in long IRTs. Similarly, SH subjects engaged in short IRTs and LO subjects engaged in long IRTs during the initial 20-s component in the LONG Testing condition of Experiment 2.

To conclude that the recurring responses found in these experiments are examples of resurgence, it may help to discuss the relation between the procedures used here and the procedures used in previous resurgence studies (e.g., Epstein, 1983; Lieving & Lattal, 2003). The procedures of the current experiment were different from these resurgence studies because the specific responses that recurred were not directly reinforced; instead, short and long IRTs were instructed. That these responses occurred reliably in the presence of inaccurate instructions without reinforcement demonstrates that rule following had been established for the subjects in this study. A combination of these subjects' pre-experimental history of reinforcement for following instructions (Hayes, Brownstein, Zettle, et al., 1986) and the reinforcement received during the AC Instructions condition were most likely responsible for their rule following. As in other examples of testing for stimulus control, the reliable occurrence of responding in the presence of stimuli, but in the absence of reinforcement, was used to conclude that the responses were under stimulus control. Because stimulus control also was tested with novel instances of stimuli, and the behavior still reliably occurred, evidence for a generalized operant also was obtained (Baron & Galizio, 1983). In this case, the stimuli were rules or instructions and responses could be considered instances of the generalized operant of "rule following" (see Catania, 1998).

Additionally, the results obtained in both experiments showed that responding was modified in orderly ways by changes in the environment. Such results support the conclusion that the responses observed in the presence of the inaccurate instructions were specific examples of a functionally defined operant (Catania, 1973). Thus, both Baron and Galizio's (1983) and Catania's (1973) criteria for defining a generalized operant and, more specifically, rule following, were met in the current experiments because: (a) the rate of responding when the inaccurate instructions were presented changed when the instructions changed, (b) responding was consistent with the instructions, and (c) no reinforcers were delivered directly. Thus, it seems clear that a functional operant had been demonstrated in the current experiments prior to the first extinction condition—the initial 4-s component in Experiment 1 and the initial 20-s component in Experiment 2—as has been the case in previous resurgence studies (e.g., Epstein, 1983; Lieving & Lattal, 2003).

The current study also found that after responding followed the inaccurate instructions, it contacted extinction contingencies. After a short period of time, responding consistently with the instructions was extinguished for all subjects. This procedure and result may be considered equivalent to the procedures used in previous resurgence studies where initial responses were extinguished. Furthermore, the procedures in these previous resurgence studies also concurrently reinforced another response while the initial response was extinguished. This step was observed in the present experiments whenever IRTs between 10 and 18 s were recorded during the IN and No Instructions conditions. During these conditions, specific instances of rule following were not reinforced, but an alternative

response was. Responding in the current experiments reliably came under the control of the scheduled contingencies and by the time the first testing condition was presented, all subjects were earning most of the available reinforcers.

The last step in previous resurgence studies has involved extinguishing the second response without reinforcing the initial response. In the current experiments, the second response (responding between 10 and 18 s) was under extinction when either 4- or 20-s testing components were introduced, although responding consistent with the 4- or 20-s components also was reinforced. Thus, instead of presenting a pure extinction condition where no responses were eligible for reinforcement, mixed schedules of reinforcement that differentially reinforced specific ranges of responding and extinguished the ranges previously reinforced were in effect. This difference between the current studies and other resurgence studies might limit the conclusion that the current results are consistent with resurgence. The finding, however, that responding during the initial testing was always in the direction of the inaccurate instructions, and not in the direction of the new reinforcement contingencies, argues that responding initially was controlled by the previous inaccurate instructions and not the new reinforcement contingencies. For example, initial responding during the 4-s component by the LO subjects in Experiment 1 and during the 20-s component by the SH subjects in Experiment 2 was always in the opposite direction of the reinforcement contingencies. Because responding controlled by the inaccurate instructions had been extinguished, its recurrence seems to be an example of resurgence. Furthermore, a pure extinction condition, where no reinforcers could be earned throughout the session, was in

effect during the last session of the current experiments. Although there was high variability in responding during this condition, for most subjects it was concluded that the range of IRTs recorded during this condition was a function of the range of IRTs most recently reinforced during the 4- or 20-s testing components: a finding that is also consistent with the phenomenon of resurgence.

Further evidence for interpreting the current results as examples of resurgence may be obtained by exploring other behavior analytic concepts that account for the recurrence or changes in responses with a previous history of reinforcement (see Lieving & Lattal, 2003, for a summary of the relations among resurgence, reinstatement, and induction). One concept in particular may be closely related to resurgence: spontaneous recovery. With spontaneous recovery, as with resurgence, a temporary recurrence of responses takes place after responding appears to have extinguished. Spontaneous recovery, however, is usually demarcated by the sharp initial recurrence and the sharp subsequent decrease of the response during extinction and these sharp transitions were not observed in the current study. Instead, an analysis of the testing data showed that the recurrence of responding frequently increased as a function of time, even during conditions where no reinforcers were being earned during the changing contingencies. For example, Figure 8 shows that Subject LO 2 continued engaging in long IRTs throughout the first SHORT Testing session of Experiment 1 although no reinforcers were being delivered for these responses. Another example can be seen in Figure 22, which shows that even after three LONG Testing sessions, Subjects SH 5 still engaged in short IRTs although no reinforcers were delivered for these responses. In addition,

spontaneous recovery refers to the pattern of responses seen while extinction is in effect for a single behavior. In the current study, as well as other studies of resurgence, there are at least two response classes that undergo extinction and it is the recurrence of the initial responses when the second response class is undergoing extinction that is of interest. In order for studies of spontaneous recovery to be equated with resurgence, other responses that occurred during the transition from reinforcement to extinction, especially when the behavior of interest was decreasing, would have to be measured. The finding that a response undergoing extinction “spontaneously” reoccurs during the transition, though, is not the same as resurgence of another response.

The finding that, without exception, the range of responding during the initial contingency change was related to the range of responding found in the presence of the inaccurate instructions supports the notion that the phenomenon of resurgence may contribute to the sensitivity of rule-governed behavior to novel contingencies. This conclusion is especially supported by the data in the first testing condition of both experiments that showed that long IRTs recurred for all LO subjects. Studies have typically shown that human subjects under extinction conditions maintain high rates of responding (e.g., Baron, Kaufman, & Stauber, 1969; Morgan & Lee, 1996; Weiner, 1970). Morgan and Lee conducted two studies that showed that 8 of 11 subjects initially engaged in high rates of short IRTs when presented with changes from a DRL 3-s, a DRL 5-s, or a DRL 10-s schedule of reinforcement to one of extinction. Baron et al. suggested that the high rates usually observed are due to subjects’ frequent exposure to ratio schedules of reinforcement in their every day life. That long IRTs

recurred for the LO subjects was strong evidence that responding was under the control of subjects' history in the presence of inaccurate instructions.

An analysis of rule governance in terms of resurgence might help interpret some incongruous results from studies on rule-governed behavior. For example, subjects in Shimoff, Matthews, and Catania (1986) received extensive training on how to identify and best respond under both random ratio (RR) and random interval (RI) schedules of reinforcement (see Catania, 1997, for the definitions of these schedules). Subjects subsequently were presented with a task where reinforcers could be earned under a multiple RR 40/RI 5-s schedule where components alternated every minute. When responding was stable, the schedule of reinforcement changed to a multiple RI 5 s/RI 10 s. Although rate of responding decreased, the authors were not convinced that this sensitivity was controlled by the contingencies. Instead, the authors suggested that the sensitivity may have been controlled by a covert rule that stated, "at the start of each component, wait a few seconds and then press; if the press produces a point press slowly for the remainder of the component, but otherwise press fast" (p. 152). To test this possibility, reinforcers were withheld during the beginning of some of the RI components. When this occurred, the rate of responding during this RI component increased to levels similar to those observed during the RR 40 component and subjects reported that a ratio schedule was in effect. These results led the authors to conclude that the covert rule controlled responding and that the differential sensitivity observed was really something they dubbed "pseudosensitivity."

Although there may be merits to concluding that responses in Shimoff et al. (1986) were not under the control of the contingencies, results from the current experiments suggest analyzing the effect resurgence may have had on responding during the extinction conditions. Perhaps the reason high-rate responding was emitted when low rates were extinguished is because the most recently reinforced responses, high-rate responding, resurged when reinforcers for emitting low rates no longer were delivered. Although it is unclear which explanation is better (i.e., covert rules or resurgence), at least the resurgence interpretation of the data may be tested further, whereas the inability to observe and manipulate covert responding precludes the further examination of the concept of pseudosensitivity.

Variability

The probability that subjects would engage in responding that resulted in reinforcement during the unsignaled contingency changes was not solely a function of the resurgence of instructed responses. Instead, it may be argued that, for example, the sensitivity of Subjects SH 2, SH 3, and SH 4's behavior to both components of the initial LONG Testing session may have been due in part to these subjects' history of reinforcement for responding under a variety of contingencies. LeFrancois et al. (1988) found that subjects who had a history of responding under a variety of schedules were more likely to engage in variable responding in the presence of novel contingencies than subjects who only had a history of responding under one schedule of reinforcement. LeFrancois et al.'s results may apply to the current study because before the presentation of the first testing condition, all subjects had a history of responding to at least two different environments. First, the responding of all

subjects came under the control of the AC Instructions condition. Next, subjects followed the instructions during the IN Instructions condition and subsequently engaged in stable IRTs between 10 and 18 s by the last three sessions of the initial No Instructions condition. Perhaps under the variable contingencies in these experiments, some subjects may have “learned to try” different response patterns (see Shahan & Chase, 2002; Skinner, 1953), thus increasing the chances that their responses would be reinforced during the unsignaled contingency changes.

Another way of describing the concept of “learning to try” involves analyzing the phenomenon of resurgence as it directly applies to variability. It has been shown that a history of reinforcement for producing solutions that require variable responding increases variable responding during subsequent contingency changes (see Shahan & Chase, 2002, for a discussion of this topic). If variability is conceptualized as a generalized operant (see Neuringer, 1993; Page & Neuringer, 1985), the reinforcement of which is not dependent on specific topographies, then it may be argued that just as specific instances of rule-governed behavior were said to resurge in this study, so can variability be said to resurge during extinction conditions (see Antonitis, 1951, and Morgan & Lee, 1996, for a discussion of extinction-induced variability). By the time subjects completed the current experiments, subjects had been presented with at least four transitions where variability could have been directly reinforced: IN Instructions condition to No Instructions condition, No Instructions condition to initial testing condition, initial testing condition to No Instructions condition, and No Instructions condition to final testing condition.

Future Research

Because the resurgence of generalized operants has been examined only in the current experiments and in Wilson and Hayes (1996), further experiments in this area are warranted. Specifically, studies that replicate the current findings with *different* instances of rule-governed behavior than those examined in the current experiments and with generalized operants other than rule following and relational responding (e.g., imitation, variability, and matching) would further the generality of the present results. Analyses of the resurgence of other kinds of rule-governed behavior can be conducted with inaccurate instructions for a non-timing-related task such as completing math equations. Although subjects would need to have the option of engaging in a wide variety of other tasks, only one would have to result in reinforcement (e.g., completing word problems). For the subjects who eventually would engage in this alternative task, an extinction condition could be presented whereby no reinforcers would be delivered for engaging in any of the tasks. Whether specific instances of rule-governed behavior (i.e., completing math equations) resurged could be examined.

Because the procedures used in the current experiments were different than those used in previous resurgence studies, future studies may examine the resurgence of generalized operants with procedures that are more typical to those used in other resurgence experiments (e.g., Epstein, 1983; Lieving & Lattal, 2003). For example, a conventional extinction condition could be presented in lieu of the mixed schedules of reinforcement used in this experiment. Although a conventional extinction procedure was used at the end of the current experiments, it was presented after reinforcement had been available for both short and long

IRTs. Nonetheless, the current results obtained under this condition that showed that most subjects engaged in IRTs related to the range of IRTs most recently reinforced during the 4- or 20-s testing components suggest that comparable results to those obtained in the current experiments would be obtained if a conventional extinction condition was used in lieu of the mixed schedules.

A number of limitations of the current experiments might also be addressed in the future. For example, the variability in responding found both within and between groups needs to be minimized. It is not clear why it took 8 subjects two or three sessions to meet the accuracy criterion in the AC Instructions condition. To minimize the differences across subjects' pre-experimental history with instructions, future studies may require that subjects who partake in the experiment meet the accuracy criterion in only one session. Alternatively, if the goal of future research is to examine these differences in instructional control from the beginning of the experiment, the subjects could be matched across groups depending on how long it takes them to meet this criterion. Additionally, subjects also may be matched depending on the variability of their performance during the AC Instructions condition to examine the relation between levels of variability during this condition and the variability during testing conditions.

Another important source of variability that may be controlled in future studies is the range of responding recorded in the presence of the inaccurate instructions. Perhaps subjects who do not follow the inaccurate instructions *at least* for a minimum period of time should not be included in the experiment. In this study, 2 subjects (LO 1 and SH 8) did not follow the

inaccurate instructions as reliably as the other subjects, although both subjects followed the inaccurate instructions at least *once*. These subjects, instead, continued engaging in IRTs between 10 and 18 s during the IN Instructions condition. Furthermore, subjects who follow the inaccurate instructions for more than a *maximum* number of sessions also may need to be excluded from the experiment. For example, it was suggested in Experiment 1 that LO 2 had a history of response persistence in the absence of reinforcers because she responded for three No Instructions sessions without reinforcement. This history may have affected her responding during SHORT Testing. Although LO 2 did not earn reinforcers reliably during the initial two SHORT sessions, she continued to engage in variable responding and, by the third SHORT session, was earning points under both testing components.

Because one of the main conclusions was that having a history of engaging in variable responding may have increased the probability that reinforcers would be obtained during the unsignaled contingency changes, procedural manipulations that decrease, or at least standardize this variable, should be implemented. Although one possibility involves the omission of the AC Instructions condition to avoid the transition from a phase where following rules is reinforced to one where it is not, it should be noted that previous attempts to follow this suggestion were unsuccessful. Specifically, the AC Instructions condition was added to this study to *decrease* the variability of the responses once the inaccuracy of the instructions was contacted during the IN Instructions condition. Limiting subjects' range of responding made it feasible to analyze the relation between the responses during AC, IN, and No Instructions conditions and the responses during testing. Without these criteria, subjects

would have had a history of both short and long IRTs and either could have recurred during testing. Nonetheless, alternative manipulations that also allow this restriction to occur may be implemented in the future.

Lastly, it should be noted that the present experiments exclusively used female college students as subjects. Further generality of the experimental conclusions could be obtained by systematically replicating the current experiments with subjects from different populations (e.g., male students, children, and older individuals).

Summary

This study adds to an understanding of the conditions necessary for the resurgence of instructed responses. With the exception of Wilson and Hayes (1996), previous studies that examined resurgence required that the responses expected to recur be reinforced within the experiment and no study had examined the resurgence of responses solely under instructional control. This study demonstrated that such responding, as long as the generalized operant of rule following has been established, is likely to recur when other responses are under extinction. Furthermore, the current procedure may provide a model that can be used to analyze other generalized operants. Because resurgence has been suggested as an important process in the production of responses under extinction conditions, it is important for resurgence studies to expand their methodology to procedures that allow the analysis of generalized operants. Resurgence studies allow us to examine an organism's previous history of responding to assess the relation between past responding and current responding, and the current procedure also allows the analysis of generalized operants under stimulus control.

Although it has been suggested that the contingencies under which resurgence occurs and the variables that control this effect have remained largely unexamined (e.g., Lieving & Lattal, 2003; Morgan & Lee, 1996), the present dissertation suggested some variables that may affect resurgence.

In conclusion, the current study extends the results of Aguilera and Chase (2003) by showing that a history of reinforcement for not following instructions is not sufficient to produce responding that will be reinforced during unsignaled changes in contingencies. The current study showed that such responding is largely a function of two sets of variables: recurrence of previously instructed or reinforced responses and a history of reinforcement for responding variably. Lastly, this study lends support to the notion that rule-governed behavior may be understood by the same principles discovered with basic operant experiments. As such, results from basic resurgence studies such as Lieving and Lattal's (2003), which found that resurgence was a repeatable effect, may be used to understand further the mechanisms responsible for instances of instructed sensitivity and insensitivity of rule-governed behavior to changing contingencies.

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Appendix A

CONSENT and INFORMATION FORM

TITLE OF RESEARCH: Effects of Instructions on Problem-Solving Tasks

INTRODUCTION: I have been invited to participate in this research study which has been explained to me by either Philip N. Chase, Ph.D., Carolina Aguilera, M.A., or one of their assistants. This research will be conducted by Philip N. Chase, Ph.D., Carolina Aguilera, M.A., or one of their assistants and may be partially funded by the Department of Psychology Alumni Fund and/or the Office of Academic Affairs.

PURPOSE OF THE STUDY: I understand that the purpose of this study is to learn more about how instructions facilitate problem-solving.

PROCEDURES: I understand that this project may require approximately 10 hours of my time. I understand that before each session, my watch will be requested of me if I am wearing one and that it will be kept in a safe location and returned to me immediately following each session.

I understand that I will participate in approximately one session per day and that during each session, I will be given some instructions to follow in order to earn points in various computer games. Each point that I earn will be exchangeable for money. I understand that if I complete the experiment, I will receive a \$1.00 bonus for every session I attend. The attendance bonus will be paid at the end of the experiment.

I understand that because of experimental protocol, it is important for me to come every day at my agreed upon time. I understand that if I miss a session, I will be asked to come in for a make-up session within a week of the missed session. I also understand that if I miss two or more sessions, or if I do not call in advance of missing a session, I may be dropped from the experiment. If I become ineligible to continue because of missed sessions, I understand that I will not receive the attendance bonus.

I understand that I will be paid at the end of the experiment and that the experimenters will keep careful track of my earnings. So that I may keep accurate records, they will also give me an earnings statement at the end of each session.

I understand that I may be able to earn approximately \$5.50 per hour of participation, and that this amount includes both my performance earnings and my attendance bonus. I understand that I may be able to earn approximately \$55.00 for my performance during the experiment. There will be no monetary costs to me as a subject. Approximately 16 subjects will participate in this study.

TITLE OF RESEARCH: Effects of Instructions on Problem-Solving Tasks

RISKS AND DISCOMFORTS: I understand that there are no known or expected risks from participating in this study, except for the mild frustration associated with completing computer tasks. Furthermore, I am aware that there may be unforeseeable risks in participating in any experiment.

ALTERNATIVES: I understand that I have the option not to participate in this study.

BENEFITS: I understand that this study will not necessarily be of direct benefit to me, but the knowledge gained may be of benefit to others. I understand that I will earn money based on my performance and attendance.

CONTACT PERSONS: For more information about this research, I can contact Dr. Philip N. Chase at 293-2001, ext. 626, or Carolina Aguilera at 293-2001, ext. 822. For more information regarding my rights as a subject, I may contact the Executive Secretary of the Institutional Review Board at (304) 293-7073.

CONFIDENTIALITY: I understand that any information about me obtained as a result of my participation in this research will be kept as confidential as legally possible. I understand also that my research records, just like hospital records, may be subpoenaed by court order or may be inspected by federal regulatory authorities. In any publications that result from this research, neither my name nor any information from which I might be identified will be published.

VOLUNTARY PARTICIPATION. Participation in this study is voluntary. I understand that I am free to withdraw my consent to participate in this study at any time. Refusal to participate or withdrawal will involve no penalty or loss of benefits and will not affect my grades or class standing. I have been given the opportunity to ask questions about the research, and I have received answers concerning areas I did not understand.

Upon signing this form, I will receive a copy.

I willingly consent to participate in this study.

Signature of Subject or Subject's Representative	Date	Time
Signature of Investigator or Investigator's Representative	Date	Time

Appendix B

Instructions read before the first session:

This computer will run the experimental session. Instructions on what you need to do to earn points will be presented on the screen. Read these instructions carefully and when you are ready to begin, press on the AStart@ button that will appear on the last screen of instructions. After 16 minutes, you will get a message telling you to call the experimenter. Please do so. Pay close attention to the instructions presented. They will tell you how you might earn points. When you have followed the game instructions correctly, you will hear a beep. Every time this happens, a button labeled ARegister@ will appear on the screen. You have to register your point by pressing this button. When you register a point, you will hear another beep and the point counter on your screen will increment by one. It is important that you always register your points when you earn them because you cannot earn more points until you register your last point.

Sometimes it takes people a little while to learn new things. Please be patient if you do not start earning points right away. The computer is not broken and there is nothing wrong with you either. Try to earn as many points as possible throughout the whole study. Due to the repetition of the task, you may experience boredom. But, just remember that you are here to earn as much money as possible. Please do not use the keyboard for this task; instead, use the mouse. Lastly, since this study is ongoing, please refrain from discussing your experiences with other students. Do you have any questions?

Appendix C

Instructions read after the first experimental session, before the first time the extra-experimental game is presented:

You will now have 5 minutes to play another computer game. It is up to you to figure out how to play this second game. Play it as many times as you can in the 5 allotted minutes. I will let you know once the 5 minutes are up. It is to your advantage to try to earn as many points as possible because the two individuals with the highest overall scores at the end of the study will receive a \$50.00 and a \$25.00 bonus check for first and second place, respectively.

Because very few people will be participating in this experiment, your chances of winning one of these two prizes are very high. After you play this second game for 5 minutes, you will have a 5 minute break.

Instructions read before the second experimental session, after the 5 minute break:

Now that the break is over, you will get to continue playing the game you played in the beginning of the session. Remember that in this game, the points you earn will be redeemable for money. After 16 minutes, the computer will once again tell you to come get me. Please do so. Don't forget to try to earn as many points as possible through the whole experiment.

Instructions read after the second experimental session:

We are now done for the day. All of your future sessions will be similar to today's session. You will get to play the game where your points are redeemable for money for the first 16 min. Then you will play a game where your points will increase your chances of winning the bonus money that will be given at the end of the experiment. You will then have a 5 minute

break and, after the break, you will get to play the game where your points are exchangeable for money once again.