The Effects of Schedules of Reinforcement on Instruction-Following in Human Subjects with Verbal and Nonverbal Stimuli

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The experiment reported here represents a partial replication of an experiment by Newman, Buffington, and Hemmes (in press) and analyzes responding in college students as a function of three different schedules of reinforcement (FR 1, FR 2, FR 3) and either verbal discriminative stimuli (instructions) or nonverbal discriminative stimuli (different colored cards). All consequences (tokens) were based on behavior consistent either with the verbal discriminative stimulus (SD) or with the nonverbal SD. The schedule of reinforcement varied across subjects, and accuracy of the verbal and nonverbal SDs varied across phases from. Results showed that the behavior of all continuous reinforcement (FR 1) subjects was sensitive to the accuracy of the verbal SDs, but the behavior of subjects in the nonverbal SD conditions showed more sensitivity than the behavior of subjects in verbal conditions under intermittent schedules (FR 2 and FR 3). These findings suggest that the behavior of subjects in experiments where instructions are sometimes pitted against actual contingencies of reinforcement is a function not only of the instruction, but also of the type of reinforcement schedule used.

The behavior of human subjects exposed to operant schedules of reinforcement often fails to demonstrate schedule control when the subjects are presented with inaccurate instructions regarding the consequences of the instructed behavior (e.g., Buskist, Bennett, & Miller, 1981; Cerutti, 1991; Hayes, Brownstein, Haas & Greenway, 1986; Hayes, Brownstein, Zettle, Rosenfarb & Korn, 1986; Higgins & Morris, 1984; Joyce & Chase, 1990; Lippman & Meyer, 1967; Kaufman, Baron, & Kopp, 1966; Matthews, Catania, & Shimoff, 1985; Matthews, Shimoff, Catania, & Sagvolden, 1977; Shimoff, Catania, & Matthews, 1981; Shimoff, Matthews, & Catania, 1986; Weiner, 1970). Shimoff et al. (1981) suggested that such "insensitivity" to schedule parameters is a defining characteristic of instructional control.

For some, instructions inherently lead to insensitivity, perhaps due to a subject's

long reinforcement history for instruction-following (Reese, 1989). Baron and Galizio (1983) and Galizio (1979), in contrast, explain insensitivity as a failure to effectively contact prevailing contingencies for compliance or noncompliance with the instructions. Many studies that have demonstrated insensitivity often used lean intermittent schedules of reinforcement such as random ratio (RR) or random interval (RI) schedules (Matthews, et al., 1985; Shimoff, et al., 1986), RI and differential reinforcement of low rate (DRL) schedules (Shimoff, et al., 1981), or DRL and fixed ratio (FR) schedules (Hayes, et al., 1986a, 1986b). It is possible that the lean schedules used in these studies do not allow subjects to determine the best response strategy for earning available reinforcers because of the relative infrequency of reinforcement. If the schedules were denser such that subjects came into greater contact with the contingencies for compliance and noncompliance, insensitivity might not be seen.

Some would argue that the study by DeGrandpre and Buskist (1991) differed in

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significant ways from other studies on schedule insensitivity because there were no collateral consequences, that is, consequences associated with responding independent of instruction-following. DeGrandpre and Buskist provided consequences only for instruction-following or noncompliance and, therefore, no performance could have been predicted if there had been no instructions. In other studies, however, insensitivity is said to be observed when subjects follow instructions and do not respond as one would expect if there were no instructions present, that is, as a function of the prevailing schedule of reinforcement (Baron & Galizio, 1983; Joyce & Chase, 1990). When the responding of subjects whose behavior is shaped changes to maximize reinforcement, and the responding of instructed subjects does, not this is called insensitivity (Shimoff, et al., 1981). Thus, insensitivity is said to be seen when one observes responding not supported by the programmed consequences. If instruction-following does not lead to a maximum rate of reinforcement, relative to another response strategy, we would expect instruction-following to extinguish (DeGrandpre & Buskist, 1991; Galizio, 1979; Newman, Buffington, & Hemmes, 1991). If instruction-following is a response class that is sensitive to its consequences (e.g., token reinforcement), then we can examine insensitivity to the consequences of instruction-following itself as DeGrandpre and Buskist (1991) did.

The DeGrandpre and Buskist (1991) procedure actually allows for a cleaner demonstration of insensitivity than some studies (e.g., Buskist, Bennett, & Miller, 1981; Kaufman, Baron, & Kopp, 1966). This may occur because, in some cases, the programmed consequences might not be entirely incompatible with the inaccurate instructions (Baron and Galizio, 1983). For example, when subjects are told that they are responding under a VR schedule of reinforcement, when the actual schedule is a VI, the subject's VR-like responses are being reinforced (and thus maintained) by the programmed VI schedule. These accidental partial reinforcement effects

described by Baron and Galizio (1983) are avoided in DeGrandpre and Buskist's 0% accuracy phases.

Newman, Buffington and Hemmes (in press) followed DeGrandpre and Buskist's procedure, but gave reinforcers on either a CRF, FR 2, or FR 3 schedule. Using college students as subjects, Newman et al. reinforced compliance, non-compliance, or no bias across phases. Newman et al. demonstrated that with CRF, subjects were able to earn all available reinforcers across a number of conditions of accuracy of instructions. When the schedule was leaned to FR 2 and FR 3, however, subjects demonstrated loss of collateral consequence control and followed instructions at a greater rate than with CRF. This loss of collateral consequence control is similar to that observed in many studies of human performance when subjects are exposed to schedules of reinforcement and given inaccurate instructions.

The present experiment replicated the procedures of Newman et al. (in press), but added two additional groups. These two groups were exposed to FR 2 and FR 3 with colored cards serving as antecedent stimuli. The purpose of the current arrangement was to test the two models of insensitivity presented above. The pattern of responding demonstrated by subjects under FR 2 and FR 3 with the nonverbal cues should allow conclusions to be drawn regarding whether the insensitivity displayed in Newman et al. (in press) was due to some inherent property of the instructions, or to the intermittent schedule of reinforcement. If subjects show insensitivity with the nonverbal stimuli, then we can conclude that the insensitivity seen in the prior study was due to the schedule and the failure of subjects to make effective contact with the contingencies for the response options and for instruction-following (Baron & Galizio, 1983). If no insensitivity is observed with the nonverbal cues that precede each discrete trial, but is seen with the verbal instructions that precede each discrete trial, then we can conclude that the insensitivity seen in the prior

study was indeed due to some property of the verbal instructions provided.

METHOD

Subjects

The subjects were 18 undergraduate students taking an introductory psychology course at a metropolitan college. Subjects volunteered for the experiment in order to satisfy the research participation requirement of the course. All subjects received credit for having participated in the experiment regardless of their performance. All subjects were debriefed after the experiment.

Setting and Apparatus

The setting was a large office on a college campus. A table was placed in the middle of the room. The subject and experimenter sat across from one another, with a Battleship (TM: Milton-Bradley Co.) board game open on the table between them. The Battleship game is a 10x10 slot peg grid enclosed in plastic.

Design and Procedure

At the beginning of each trial in the verbal SD condition, subjects were told to take a peg from the left or from the right side of the playing board. For these subjects, instructions were in the form of "Take a peg from the (left or right) side of the board to earn tokens." Instructions were delivered by experimenters who were unaware of the purpose of the experiment or the rule-governed behavior literature. Tokens (pennies) were delivered according to the contingencies described below. Each instruction, the response that followed it, and either the delivery or non-delivery of a token constituted a single trial. Compliance with the instruction was the dependent measure.

For subjects in the nonverbal SD condition, each trial began with the experimenter holding up either a black or a white index card at eye level. Experimenters in this condition said nothing while presenting the black and white cards. In all other ways, the procedures were exactly the same for all subjects. Procedurally, the

black card corresponded to an instruction to take a peg from the left side, and the white card corresponded to an instruction to take a peg from the right side. Responding to the card was the dependent measure.

Prior to the experiment, the following statement was read to the subjects in the instruction conditions:

Welcome to the learning lab of Dr. Nancy Hemmes. In this experiment, you will be given instructions to take a peg from either the left or right side of the board. You may place the peg anywhere on the playing grid. The instructions will vary in their accuracy. You will receive tokens (pennies) for correct responding. The tokens will each be worth one ticket in a lottery to be held at the end of the semester for a \$100.00 prize. Sometimes the best way to earn tokens will be to follow instructions. Other times the best way to earn tokens will be to do the opposite of what you are instructed. You should try to earn as many tokens as you can. It will be possible to earn 150 tokens. You can take breaks when you desire. Completing this experiment will satisfy a portion of the department's research participation requirement. If you have any questions about what is expected of you during this experiment or how to earn tokens, you may ask questions now.

Subjects who received nonverbal cues were read this statement prior to the experiment:

Welcome to the learning lab of Dr. Nancy Hemmes. In this experiment, you will be shown black and white cards. These cards will be your cue to take a peg from either the left or the right side of the board. The relation between card and the correct side from which to take a peg may change during the experiment. You will receive tokens (pennies) for correct responding. The tokens will each be worth one ticket in a lottery to be held at the end of the semester for a \$100.00 prize. Sometimes the best way to earn tokens will be to perform the same behavior that earned tokens before. Other times, the best way to earn tokens will be to do the opposite of what previously led to tokens. You should try to earn as many tokens as you can. It will be possible to earn 150 tokens. You can take breaks when you desire. Completing this experiment will satisfy a portion of the department's research participation requirement. If you have any questions about what is expected of you during this experiment or how to earn tokens, you may ask questions now.

Three subjects were assigned randomly to each of the six groups listed in Table 1. Each phase lasted for 30, 60, or 90 trials for the FR 1, FR 2, and FR 3 groups, respectively. The differing number of trials was

Table 1
Conditions and schedules of reinforcement for the six groups.

Group	Instruction Used	S ^{R+} Schedule	# Trials
1	Verbal	CRF	30
2	Nonverbal	CRF	30
3	Verbal	FR 2	60
4	Nonverbal	FR 2	60
5	Verbal	FR 3	90
6	Nonverbal	FR 3	90

to allow each subject to earn up to 150 reinforcers.

During the 100% accuracy phases, the only way to earn tokens was to comply with instructions (or, in the case of the subjects in the nonverbal *SD* condition, to take a peg from the right side when shown a white card and from the left side when shown a black card). For the FR 1 groups, a token was delivered after each compliance response. For the FR 2 groups, every second compliance response led to a token. For the FR 3 groups, every third compliance response produced a token.

During the 50% accuracy phases, half of the tokens were delivered after compliance responses and the other half were delivered after noncompliance responses. A randomized list of “compliance” or “non-compliance” trials was used to determine whether compliance or noncompliance responses would produce tokens. For the FR 1 subjects, one half of the tokens were delivered after each compliance response, and one half after each noncompliance response. For the FR 2 groups, one half of the tokens were delivered after every second compliance response, and one half after every second noncompliance response. For the FR 3 groups, one half of the tokens were delivered after the third compliance response and one half after the third noncompliance response.

During the 0% accuracy phases, the only way to earn tokens was to do the opposite of what one was instructed to do. For the

FR 1 groups, each instance of noncompliance led to the delivery of a token. For the FR 2 groups, every second noncompliance response earned a token. And for the FR 3 groups, every third noncompliance response led to a token.

RESULTS

Data for all subjects are shown in Figures 1-6. In each figure, the percentage of compliance is plotted in five trial blocks. For the subjects in the verbal *SD* condition, the data points represent compliance with the verbal instruction. For the subjects in the nonverbal *SD* condition, the data points represent responding controlled by the original contingency, namely, in the presence of the white card (*SD*), picking a peg from the right side of the board produces a token, and in the presence of the black card (*SD*), picking a peg from the left side of the board produces a token.

Figure 1 shows the data for subjects in the verbal FR 1 condition and Figure 2 shows data for subjects in the nonverbal FR 1 condition. In both conditions, compliance and, thus, sensitivity to the programmed contingencies was generally observed across subjects. In other words, responding generally conformed to the accuracy of the discriminative stimulus (verbal instruction or card).

The data for subjects in the verbal FR 2 condition are shown in Figure 3. All three subjects showed stable response patterns

Fig. 1. Percent of appropriate responding to the verbal instruction in the FR 1 condition. (Numbers across the top indicate accuracy of instructions within each phase.)

across phases. Subject YZM followed every instruction given, never sampling noncompliance once. Subject MCM sampled noncompliance in three of the five phases, but never lower than 40% instruction-following, and never consistently. Subject NHF showed random responding across phases, with no pattern evident.

Figure 4 shows data for subjects in the nonverbal FR 2 condition. Subject GMF's responding varied from 0-100% in two phases, from 20-80% in two phases, and from 20-100% in the last phase. No pattern is evident. The responding of Subject DRF, however, shifted across phases according to the accuracy of the SD. Although the

Fig. 2. Percent of appropriate responding to the nonverbal instructions in the FR 1 condition.

responding of Subject DLM was more variable, it showed patterns similar to those of subject DRF.

Figure 5 shows the data for subjects in the verbal FR 3 condition. Neither subject CBF nor subject AAM showed any sensitivity in response patterns across phases. The responding of Subject BTM, in contrast, showed greater sensitivity across

phases. During the first 100% accurate instruction phase, compliance stabilized at 100% instruction-following. During the 50% phase, responding was more variable, ranging from 20-100%. During the 0% accurate instruction phase, although responding still varied between 0-80%, a greater concentration of blocks saw 40% or less compliance. During the 50% accurate

Fig. 3. Percent of appropriate responding to the verbal instruction in the FR 2 condition.

instruction phase, instruction-following rose, with the majority of the blocks being 40% or above. In the last 100% accurate instruction phase, the majority of the blocks were 60% compliance or above.

Figure 6 shows the data for subjects in the nonverbal FR 3 condition. The response pattern of Subject CZF showed little change across phases. The responding of

Subjects JIF and MOM, in contrast, showed generally appropriate shifts in response pattern across phases.

DISCUSSION

During both the verbal and nonverbal SD conditions under the FR 1 schedule, the behavior of all subjects showed sensitivity to the changing contingencies. This is con-

Fig. 4. Percent of appropriate responding to the nonverbal instruction in the FR 2 condition.

sistent with the results of Newman et al. (in press). During the verbal FR 2 condition, no subject's behavior showed sensitivity to the changing contingencies. This response pattern, again, is no different from what was observed in Newman et al. The behavior of two of the three subjects in the nonverbal FR 2 condition, however, showed sensitivity to the changing rela-

tionship between card color and side choice. The responding of one subject (BTM) in the verbal FR 3 condition was arguably sensitive to the changing contingencies. The responding of the other two subjects (AAM & CBF), however, was insensitive to these changing contingencies. In contrast, the responding of two of the three subjects in the nonverbal cue FR 3

Fig. 5. Percent of appropriate responding to the verbal instruction in the FR 3 condition.

condition (JIF and MOM) showed strong sensitivity to the changing relationship between card color and side choice.

These results, although tentative, suggest that there may be an interaction between the particular schedule of reinforcement and the type of SD. Under the FR 1 schedule, the consequences for compliance were constant enough that no sub-

ject's behavior showed insensitivity. This result supports Baron and Galizio's (1983) suggestion that insensitivity may be partially explained as a failure to effectively contact collateral contingencies, that is, those associated with the schedule of reinforcement in effect. More firm conclusions would require additional replications, particularly in view of the enormous inter-

Fig. 6. Percent of appropriate responding to the nonverbal instruction in the FR 3 condition.

subject variability in this area (Hayes, et al., 1986a). As the schedule was made more intermittent, however, responding of subjects in the verbal conditions showed slightly more insensitivity than did responding of subjects in the nonverbal conditions. Because sensitivity was shown under FR 1, we cannot simply state that insensitivity is a

defining characteristic of instructional control. A more plausible alternative suggested by Reese (1989) is that human subjects come to the experimental situation with a long reinforcement history for instruction-following, thus making instruction-following more probable. Without the long reinforcement history for the relationship between card color and side choice,

responding showed more sensitivity to the changing contingencies regarding card color and side choice. An arbitrarily chosen symbol that is equivalent to the instruction was not sufficient to cause insensitivity.

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