Function-Altering Effects of Rule Phrasing in the Modulation of Instructional Control

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Abstract This study evaluated the effects of four instructional variants on instruction following under changing reinforcement schedules using an operant task based on Hackenberg and Joker's *Journal of the Experimental Analysis of Behavior*, 62, 367–383 (1994) experimental preparation. Sixteen college-aged adults served as participants and were randomly assigned to one of four instruction conditions (directive, generic, non-directive, and control). Results suggest textual verbal behavior modulated instruction following. Specifically, directive and generic instructions produced greater levels of instructional control and relatively lower levels of schedule control compared to non-directive instructions. Thus, participants in the directive and generic groups responded in accordance with the instructions even when schedules of reinforcement favored deviation from the instructed pattern. In contrast, participants in the non-directive group responded toward the optimal pattern. In the control condition, participant responding was variable but toward the optimal pattern. Findings are interpreted within the framework of Skinner's analysis of verbal behavior and formulation of rule governance.

Keywords Rule-governed behavior · Instructional control · Schedule control · Progressive-time schedules · Fixed-time schedules · Verbal behavior · Adult humans

Skinner defined *rules* as discriminative stimuli that specify a contingency (1966, 1969). Skinner's formulation of rule-governed behavior offers a behavioral account of

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complex human responding. Under Skinner's account of rule-governance as a form of discriminated responding (1974), behavior may rapidly come under the control of rules without explicit contact with the specified contingency, resulting in rule-governance (see also, Glenn, 1987). However, this account alone does not explain *why* a human might follow a specific rule, nor does it suggest ways to modulate rule-governance using simple procedural manipulations. Skinner argued, "We tend to follow rules because previous behavior in response to similar verbal stimuli has been reinforced" (1969, p. 148). Reinforcement and punishment for rule-governance occurs when (a) consequences are socially mediated and, therefore, delivered by the rule-provider (*pliance*; see Zettle & Hayes, 1982) and/or (b) the contingency specified by the rule is experienced via environmental events (*tracking*; see Zettle & Hayes). Rule-governance is thereby a discriminated operant that generalizes across sufficient exposure to the specified contingencies (Vaughan, 1985). Indeed, a growing body of literature demonstrates that rules can significantly alter the contact of behavior with natural contingencies (Baron & Galizio, 1983; Baron, Kaufman, & Stauber, 1969; Bicard & Neef, 2002; Fox & Pietras, 2013; Galizio, 1979; Hackenberg & Joker, 1994; Hayes, Brownstein, Hass, & Greenway, 1986; Hayes, Brownstein, Zettle, Rosenfarb, & Korn, 1986; Joyce & Chase, 1990; Miller, Hirst, Kaplan, DiGennaro Reed, & Reed, 2014; Shimoff, Cantania, & Matthews, 1981; Shimoff, Matthews, & Catania, 1986; Vaughan, 1985).

One of the most robust findings in the rule-governance literature, according to Hayes (1993), is that instructions tend to produce rigid patterns of behavior that may be discrepant from that of the programmed contingencies. This finding has stimulated several areas of research evaluating variables and methodological manipulations that affect the relative degree of rule following. Research indicates rule-governed behavior may be modulated by several variables, including completeness of the rules (e.g., Podlesnik & Chase, 2006), feedback on the performance of a task (Baron et al., 1969), the function-altering phrasing of the rules (e.g., Schlinger & Blakely, 1987; Zettle & Young, 1987), changes in the contingencies and accuracy of the rules (e.g., Baumann, Abreu-Rodrigues, & da Silva Souza, 2009; Fox & Pietras, 2013; Hackenberg & Joker, 1994), and the degree of discrepancy between stated rules or instructions¹ and actual reinforcement contingencies (e.g., DeGrandpre & Buskist, 1991; Galizio, 1979). For example, results from Galizio suggest that responding in an avoidance paradigm will follow the instruction when the instruction is accurate; however, responding may deviate when instructions are inaccurate and individuals contact the actual contingency in the form of the loss of points. In general, findings from this line of research suggest the degree of accuracy of instructions modulates rule-governance.

Building on this line of research evaluating the interaction of instructional accuracy and dynamic contingencies, Hackenberg and Joker (1994) developed an elegant arrangement involving changing within-subject reinforcement schedules. Human subjects earned points exchangeable for money by choosing between concurrently

¹ We use the term "instructions" here and throughout the manuscript consistent with cited authors' terminology, which may or may not describe antecedent manipulations that provide incomplete contingency specification. Note Skinner's formal definition of rules includes *accurate* specification of all three terms in the three-term operant contingency.

available colored boxes on a computer screen. Responses to a blue box advanced an active progressive time (PT) schedule (ranging from 4 to 50 s), while responses to a red box were reinforced on a fixed-time (FT) 60-s schedule that simultaneously reset the PT schedule to 0 s. To maximize net point delivery, and subsequently money earned, the preparation programmed reinforcement contingencies to favor switching to the red box after particular patterns of blue box selections. Instructions for all subjects were initially accurate for the PT 4 schedule (“The way to earn the most points is to select the blue flashing box, then select the solid blue box four consecutive times, then select the red box”; p. 370). However, as the PT schedule advanced, instruction did not differ, resulting in instructions that became increasingly discrepant with programmed contingencies. This paradigm thereby permitted evaluation of the crossover between rule-governance (i.e., instructional control) and contingency shaping (i.e., schedule control). Indeed, subjects initially displayed responding indicative of instructional control when instructions were relatively accurate, but as the instructions became more disparate from programmed contingencies, participant responding came under control of the schedule. A similar study by Fox and Pietras (2013) indicates monetary penalties for deviating from rules may strengthen instructional control—similar to Galizio’s findings (1979)—but subjects will still emit schedule-controlled response patterns if the reinforcement contingencies favor schedule control over instructional control.

Additional studies have illuminated the interaction between verbal behavior and schedule control in altering the functional properties of the rule (Danforth, Chase, Dolan, & Joyce, 1990; Mistr & Glenn, 1992; Okouchi, 1999; Schlinger & Blakely, 1987; Shimoff et al., 1981) and subsequently modulating rule-governance. For example, Miller, Hirst, Kaplan, DiGennaro Reed, and Reed (2014) sought to evaluate the phrasing of textual instructions in modulating levels of schedule/instructional control within an extension of the Hackenberg and Joker (1994) arrangement. Specifically, Miller et al. exposed human subjects to the same operant task used by Hackenberg and Joker. Subjects in a non-directive group experienced Hackenberg and Joker’s instructions to follow the initially accurate PT 4 schedule with modified phrasing of “might consider.” Subjects in the directive group experienced the same instructions but with “must” instead of “might consider” to evaluate the extent to which “must” and “might consider” modified the instructional mand and affected levels of instructional control. Subjects in the non-directive group deviated from the instructed response pattern, emitting highly variable patterns of responding; two of the three subjects in this group featured patterns of schedule control. The three subjects in the directive group, however, demonstrated strict instructional control, despite receiving fewer points and less money.

Although the results of Miller et al. (2014) corroborate previous research demonstrating instruction manipulations in the form of varied textual verbal behavior can substantially modulate instructional control, the PT values selected (i.e., PT 4, 12, 20) may have made it difficult to interpret the degree of schedule control. That is, two response patterns could have produced the maximum number of points (i.e., optimal response pattern) during the PT 12 schedule, one of which overlapped with the optimal pattern during the PT 20 schedule (i.e., a switch point of 2). Relatedly, the preparation adopted by Hackenberg and Joker (1994) included PT values below the optimal pattern specified by the instructions where instruction-consistent responding produced relatively more points (i.e., PT values between 1 and 3). Despite Hackenberg and Joker’s

call for further examination of the influence of *higher* rates of reinforcement on instruction following, research evaluating this issue remains relatively underexplored. This feature was not present in the Miller et al. preparation and we do not know how the phrasing of textual instructions influences responding when the PT values are below the value described by the instructions and thereby produce higher rates of reinforcement. Additionally, Hackenberg and Joker and Miller et al. presented the PT values in an ascending and then descending sequence. Researchers have yet to examine the varied presentation of PT values above and below the instructed pattern.

Moreover, the extent to which the directive instruction (“you must”) produced greater instructional control and the non-directive instruction (“you might”) produced greater schedule control than the original instruction (“the way to earn”) in Hackenberg and Joker (1994) is unknown. It is possible that two outcomes might be obtained: (a) a continuum of mand strength might be obtained ranging from the total absence of instruction that evokes no instructional control to a strong mand that evokes stringent instructional control, or (b) various phrasing might be categorically labeled as a weak or strong instruction. Finally, as noted by Hackenberg and Joker, previous studies have not included a control condition that lacked a mand (i.e., specific instruction) altogether, which reduces the degree to which the effects of including a mand at all can be evaluated. Such a control condition would provide a basis for comparing responding in the presence of mands to responding evoked by the base task itself and the underlying contingencies. The present study systematically replicated and extended Hackenberg and Joker and Miller et al. We examined the effects of four instructional variants including “the way to earn” (Hackenberg & Joker), “you must” and “you might” (Miller et al., 2014), and a control condition that omitted information about an optimal pattern of responding.

Method

Participants

Participants were 16 undergraduate or graduate students recruited from courses in applied behavioral science or via flyers posted on campus. Fifteen participants were female and one was male. Mean participant age was 20.3 years (range, 19–23). Inclusionary criteria included a minimum age of 18 and English as a native language. The latter requirement was included in an attempt to maintain similar likely histories with the nuanced differences across instruction conditions (i.e., with the contingencies associated with the words “must” and “might”). One participant reported an attention-deficit disorder but was not excluded from the study. No other disabilities were reported.

Payment

Participants earned a fixed US\$1.50 payment for each session attended and US\$0.04 per point earned during the session. Point earnings averaged US\$1.63 and ranged from US\$1.32 to US\$1.93 per block (described below). Average total compensation for each session was US\$8.02 (range, US\$6.77–US\$9.23).

Apparatus

Sessions for the present study took place in a research room measuring 2.2 m by 2.0 m by 2.4 m containing a table, folding chair, a floor lamp, decorative items (e.g., poster, artificial flowers), and computer equipment. A mirrored pane of glass separated the research room from an adjacent observation booth. The experimental preparation was presented on a touch-screen monitor with dimensions 48.3 cm by 26.7 cm. Stimuli presented on the screen included two 8-cm by 8-cm colored squares—one red and one blue—presented on a black background. The squares were side-by-side on the screen separated by approximately 6.5 cm. The location of the squares (left or right) was determined according to a random function each time the stimuli were presented. Instructions were comprised of black text within a white rectangle, positioned above the squares, and were displayed continuously. A point counter was available in the lower left corner of the screen and was displayed continuously. The delivery of a point was signaled by a brief auditory tone and a 1-point increase by the counter.

Procedure

Sessions were approximately 1.25 h in duration, consisting of four 15-min blocks with a 1–2-min break between blocks. Participants attended sessions 2 days per week at the same time. On average, participants completed the study in seven sessions (range, 5–12). Prior to beginning the first block of each session, the experimenter asked the participant to read aloud the instructions displayed on the screen. For each of the subsequent three blocks in each session, the participants were not required to read the instructions again, but were informed the same instructions still applied. The written instructions were displayed on the screen above the stimuli for the duration of each block. After the experimenter exited the room, the participant pressed a start button on the touch screen and the block commenced. The program presented participants with a series of choice trials with the presence of both the red and blue squares displayed on the screen below the instructions.

The red and blue squares were positioned horizontally and associated with a fixed-time (FT) and progressive time (PT) schedule, respectively. At the beginning of a block and following the delivery of a point, the blue square flashed once indicating the PT requirement was equal to 0 s (i.e., no delay to point delivery). Pressing the blue square initiated the PT schedule of point delivery such that subsequent presses on the blue square resulted in the delivery of a point after an increasing delay until the schedule was reset. The delay increased with each subsequent press of the blue square by the programmed step size (i.e., 2, 4, 12, or 20 s). For example, in the PT 4 condition, the first PT selection resulted in the immediate delivery of a point, the second selection resulted in a point being delivered after 4 s, the third PT selection yielded a point after 8 s, the fourth selection yielded a point after 12 s, and so on. Pressing the red square resulted in the delivery of a point after a fixed 60-s delay (i.e., FT 60-s schedule). Following the delivery of a point, presses on the red square also reset the PT schedule on the blue square back to 0 s at which point the blue box flashed. During the delay following presses on either square, the selected square remained on the screen while the other disappeared. The program also displayed the message, “Please wait ...” After the delivery of a point, an inter-trial interval of 2 s occurred followed by the presentation of

another choice between the red and blue squares. All participants experienced three PT step sizes, including PT 4 and 20. Fourteen participants experienced PT 2 and two participants experienced PT 12.

The program ended a block following the first point delivery after 15 min had elapsed. At the end of each block, a message on the screen prompted participants to use the keyboard to complete the sentence: “The way to earn the most points is _____.” After participants typed a response, the experimenter entered the room and informed the participant about the number of points earned (i.e., “You earned X points that time.”). Following the fourth and final block of the session, the experimenter told the participant the amount of money he or she had earned that day (i.e., “You earned $\$X.XX$ today.”).

The initial PT schedule for the blue square was 4 s for all participants. Once a stable pattern of responding was observed, the PT schedule was changed according to a pseudorandom sequence constrained such that all three PT schedules were implemented before repeating; the same schedule values were not consecutively arranged during the study. Sessions continued until stable data were obtained twice for each of three PT schedules experienced. The criterion for stability is discussed below.

Experimental Design and Conditions

One component of the experimental design was the within-subjects comparison of switch point patterns across PT schedules. In addition, participants were randomly assigned to one of four instruction conditions: directive, non-directive, generic, and control allowing for a between-groups comparison to evaluate the effects of the phrasing of instructions on responding. The instructions for the directive condition were identical to the same condition in Miller et al. (2014) and read²:

Instructions: please read/listen carefully. To begin, press the green square on your screen. To earn points, press gently on a colored shape when presented with a choice. Each point you earn is worth 4 cents. For example, if you earn 300 points, you will be paid \$12.00. You must select the blue flashing box, then the solid blue box 4 times, then the solid red box. Each session will last for about 15 min, with a 2-min rest period between sessions. You may leave the room during the rest period. At the end of each session, a message will come up on the screen asking you to record your thoughts about the experiment. When four sessions have been completed you may leave. Of course, you may leave at any time during the exercise in the event of an emergency. Thanks for your participation.

For participants assigned to the non-directive condition, the instructions were the same with the exception of a slight modification to the underlined section above. Rather than the phrase “You must select [...]”, the instructions read: “You might consider selecting [...]” This phrasing is also a replication of the same condition in Miller et al. A third group of participants, assigned to the generic condition, received instructions

² We use the term “session” in the instructions to refer to a 15-min block, which should not be confused with the same term used in the description of the experimental preparation. We retained this phrasing to be consistent with Hackenberg and Joker (1994) and Miller et al. (2014) and enhance participant understanding

replicating the language used in the original Hackenberg and Joker (1994) study: “The way to earn the most points is to select [...]” Finally, a fourth group served as a control. These participants received identical instructions as the directive condition, except that the underlined section was omitted. Thus, control participants received general instructions on how to operate the program, but did not receive a pattern of responses to follow.

Dependent Variables

Switch Points Because the preparation used time-based contingencies for the concurrently available alternatives, different sequences of responses on the red and blue squares influenced point delivery/accumulation. As a result, optimal responding could be defined in two ways. From a molecular perspective, optimal responding is the response that minimizes the delay to point delivery. This pattern supports PT selections until the PT delay equals or exceeds the FT delay. For example, in a PT 4 schedule a participant must select the blue box 15 times before both delays are equal to 60 s. Responding to molecular contingencies would result in more immediate point delivery; however, across an entire block, it yields an average of 1.9 points per minute. From a molar perspective, optimal responding is the pattern that results in maximum point delivery across the entire block, which requires participants to forgo more immediate point delivery available via the PT schedule or resetting the PT schedule to 0 s by selecting the FT schedule before reaching a switch point of 5. This response pattern yields an average of 3.2 points per minute across the entire block. For the purposes of the present study, optimal responding is the pattern that results in maximum point delivery (i.e., molar response pattern).

The optimal pattern involved selecting the blue box (PT schedule) a certain number of times, selecting the red box (FT schedule) once, then repeating this pattern. For the PT 4 schedule, the optimal pattern of responding was the instructed pattern (i.e., selecting the blue box five times followed by the red box). Maximizing point accumulation under other PT schedules required deviating from the instructed pattern by selecting the blue box either more (PT 2) or less (PT 12 and 20) than five times before the red box. To capture molar patterns of behavior in the present experiment, the switch point (i.e., the number of PT schedule selections occurring prior to an FT schedule selection) was used as the primary dependent variable. Thus, the instructed switch point is five, which includes selecting the initial flashing blue box.

The frequency of blue-box selections preceding a selection of the red box was recorded as an individual switch point. If the red box was selected twice consecutively, a switch point of zero was recorded, and if no red box selections occurred for an entire 15-min block, no switch points were recorded. PT schedules were implemented across blocks until a stable pattern of responding was observed at which point a new PT schedule was implemented for the next block regardless of when stability was achieved (i.e., within a session or the first block of the next session). We calculated the median switch point for each block. Stability was defined as identical median switch points for three consecutive blocks. However, the steady-state switch point for one PT step size was based on two consecutive median switch points for two participants (N2 and N3) due to time restrictions. The switch point value at which participant responding stabilized is referred to hereafter as the steady-state median switch point.

Points Earned In addition to recording switch points, the percentage of the maximum number of points possible for each block was calculated as a percentage. This metric provided a measure of control by contingencies as the PT schedule changed. The percentages were determined following a series of calculations. We first calculated the optimal response pattern for each PT schedule assessed and determined the maximum number of points produced by this pattern with 0-s latency to respond. We then divided the total points earned for each condition for each PT schedule by the points possible and multiplied by 100 to obtain a percent. During PT 4 blocks, the theoretical maximum number of points possible (calculated assuming a 0-s latency from choice presentation to respond constrained to a 15-min block) was 49 points with the optimal switch point being 5. Maximizing points during other PT schedule blocks required deviating from the instructed pattern. For PT 2 blocks, the optimal switch point was 7 with 62 points possible. For PT 12 blocks, the optimal switch point was either 2 or 3³ with 35 points possible and for PT 20 blocks, the optimal switch point was 2 with 32 points possible.

Verbal Reports At the end of each block, the program prompted participants to provide a brief verbal description about the best way to earn points (described previously). We conducted an informal analysis of the verbal reports to supplement and potentially provide insight on the observed response patterns. Specifically, we reviewed verbal reports of each participant across all blocks throughout the study to identify any consistent patterns.

Results

Steady-State Switch Point Data

The far left column of Fig. 1 depicts steady-state switch point data across each PT schedule for the directive condition. All participants who experienced the directive instruction (D1, D2, D3, and D4) demonstrated identical patterns of responding across each PT schedule. Participants' steady-state switch points corresponded with the instructed pattern of responding during the PT 4 schedule—a median individual switch point of five—when instruction following produced the maximum number of points and money. This pattern of responding continued for the initial and replication PT 2 and PT 20 schedules.

The second column of Fig. 1 depicts steady-state switch point data for the generic condition across each PT schedule. G2, G3, and G4 displayed patterns of responding identical to participants in the directive condition, with a steady-state switch point of 5 during all PT schedules. G1 demonstrated optimal responding during the PT 4 and 20 schedules and obtained a median switch point of 5 and 2, respectively. Note this participant experienced a PT 12 schedule in lieu of a PT 2 schedule. During the PT

³ Different sequences of responses on the red and blue squares influenced point delivery/accumulation. Based on our calculations, two optimal switch points maximized point delivery for PT 12. Other PT schedule values had only one optimal switch point.

Fig. 1 Steady-state median switch points from PT to FT schedule selection as a function of step size. From left to right, the columns depict the directive, generic, non-directive, and control conditions, respectively. Open circles denote data for the ascending sequence and closed circles denote data for the replication sequence. Asterisks indicate a steady-state switch point obtained with two consecutive median switch points. The long dashed, short dashed, and solid lines depict the molecular, molar, and instructed response patterns, respectively

12 schedule, G1 responded in accordance with the instructions during the initial sequence; however, deviated from the instructed pattern for the replication sequence and obtained a median switch point of 2.

Steady-state switch points for participants in the non-directive condition (depicted in the third column of Fig. 1) showed patterns different from participants in the directive and generic conditions. During the initial PT 4 schedule, three of four participants (N1, N2, and N3) obtained median switch points equal to the instructed response pattern. However, responding for these participants deviated from the instructed pattern during the PT 2 and 20 schedules. Generally, steady-state switch points deviated from the instructed pattern in the direction of optimal responding based on the molar pattern. Responding was in *exact* accordance with the optimal response pattern for N2 during the initial PT 20 only. Steady-state switch points across participants ranged from 5 to 9 and 2 to 3 for the PT 2 and PT 20 schedules, respectively. We were unable to obtain data for N2 and N4 in some of the replication PT schedules due to time constraints outlined by the governing human subjects' committee.

Steady-state switch point data for each PT schedule for the control condition are depicted in the far right column of Fig. 1. Responding for C1 was consistent with the

optimal response pattern for the molar contingencies. The median switch points for C2 and C3 were in the direction of the optimal molecular pattern. Median switch points for C1 and C2 ranged from 10 to 14 for PT 2, 7, to 9 for PT 4, and 2 to 3 for PT 20. Responding for C4 never stabilized during the initial PT 4 schedule; as such, C4 does not have steady-state switch points for any conditions.

Individual switch point data

Figure 2 depicts individual switch points for each participant during all conditions. Overall response patterns were similar for the directive (far left column) and generic (second column) conditions. With the exception of G1 (and to a lesser extent, G3 and D3), the data indicate infrequent and only slight deviations from the instructed pattern. G1 maintained instruction-consistent responding until the first exposure to PT 20, at which point responding changed to meet the optimal pattern before returning to the instructed (and optimal) pattern during the PT 4 replication.

Responding in the non-directive condition was markedly different from responding in the directive and generic conditions. Although three of four participants in the non-directive condition stabilized at a switch point of 5 during the initial PT 4 (see Fig. 1), individual switch point data reveal all participants deviated from the instructed pattern. Individual switch points ranged from 0 to 15, which were more variable than the ranges observed in the directive (0 to 6) and generic (0 to 6) conditions. This pattern of variability was also observed in PT 2 and 20 schedules, which resulted in prolonged exposure to the schedules to meet stability criterion (e.g., PT 4 replication sequence for

Fig. 2 Individual switch points from PT to FT schedule selection for all participants. From left to right the columns depict the directive, generic, non-directive, and control conditions, respectively. Open circles indicate the first switch point at the start of a session block. The connecting solid line denotes all other switch point

participant N3) or terminating the experiment due to time constraints (e.g., PT 2 and 20 replication sequence for participant N4).

Responding in the control condition was similar to the patterns observed in the non-directive condition. Individual switch points ranged from 6 to 21 for PT 2, 0 to no switch point for PT 4, and 0 to 5 for PT 20. As noted previously, C4 never met the stability criterion for the initial PT 4 schedule.

Points earned

Figure 3 displays the mean percentages of points earned out of the maximum points possible for each condition across all PT step sizes. During the initial PT 2 schedule, participants in the directive, generic, and non-directive conditions earned the same percentage of possible points with the control group earning the fewest. However, in the PT 2 replication, participants earned nearly the same percentage of possible points regardless of condition. When the optimal pattern matched the instructed pattern (i.e., initial and replication PT 4 schedule), participants in the directive and generic conditions earned the most points; participants in the non-directive and control conditions earned fewer points. This finding reversed in the initial and replication PT 20 schedule: the directive and generic conditions earned fewer points and the non-directive and control conditions earned higher points. When considering the raw number of points earned per block as compared to the percentage of possible points, total points earned were a decreasing function of PT step size. That is, participants earned the most total points per block in the PT 2 ($M = 55.22$), followed by PT 4 ($M = 43.66$) and PT 12 ($M = 32.24$). Participants earned the fewest points per block in the PT 20 schedule ($M = 24.39$).

Verbal reports

Participants in the directive condition made written statements about correct responding or following the instructions even when the instructions were inaccurate. For example, participants reported the best way to earn points was to “touch the correct colored square,” “be accurate in choosing correctly,” “follow the instructions,” and “follow the

Fig. 3 Average percentage of possible points earned for each group during each PT schedule. Note only G1 and C1 experienced PT 12 and only two of four participants in the control and non-direction conditions experienced the PT 20 replication

direction.” This pattern differed from participants in the generic condition who tended to rephrase the instructions. Verbal reports of generic participants involved variations of: “pressing the flashing blue button followed by pressing the solid blue button four times and then pressing the red solid button.” Verbal reports contained this same content throughout the study for all participants in the directive and generic conditions except one. Toward the end of the study, verbal reports for D3 indicated suspicion about the accuracy of the instruction (e.g., “follow the instructions I guess” and “who knows but you can earn some points by following the instructions”). Despite this observation, instruction-consistent responding persisted.

When describing the best way to earn points, three of four participants in the non-directive condition (N2, N3, and N4) did not provide a number of PT or FT selections. Instead, N2 and N4 frequently referenced “occasionally,” “more often,” or “sometimes” pressing the red or blue square. N3 mentioned the time elapsed rather than number of presses (e.g., “select the blue flashing box then the blue box until the time waiting is about 45 seconds then the red.”). Even without explicit instructions, verbal reports for three of four participants in the control condition (C1, C2, and C3) typically included statements about the number of PT selections needed to earn the most points. For example, “press the blue square about 15 times until the duration is long and then click on the red square” and “Press the blue square and then every 5 or so press the red square.”

Discussion

The purpose of this study was to examine the effects of four instructional variants on instruction following during a choice task amidst varied reinforcement schedules. Specifically, we evaluated the degree to which textual instructions (“must,” “might consider,” “the way to earn,” and no instructions) modulate the persistence of instruction following under changing reinforcement schedules (i.e., instructional control). Overall, the results of the present study suggest instructional variants differentially modulated the extent to which instruction following occurred and participant responding contacted programmed reinforcement schedules. The original generic instruction in Hackenberg and Joker (“the way to earn”) resulted in similar levels of instructional control as the directive (“must”) instruction and relatively lower levels of schedule control than the non-directive (“might consider”) instruction. Moreover, our results demonstrate that phrasing of textual instructions may influence responding when the PT values are below the value described by the instructions (i.e., PT 2 not evaluated by Miller et al., 2014).

With the exception of G1, responding for participants in both the directive and generic conditions is suggestive of strong instructional control. Although the molar and molecular response patterns for the PT 2 and 20 schedules favored deviation from the instructed pattern, responding for participants in the directive and generic conditions persisted in accordance with the instructions across these schedule values. That is, despite earning fewer points for following the instruction during the PT 20 and 2 schedules, steady-state switch points never deviated from the instructed response pattern for any of the participants in the directive condition and for the majority of participants in the generic condition regardless of the programmed schedule. Deviations

in responding from the instructed pattern for G1 in the PT 12 and 20 schedules were generally indicative of schedule control in accordance with the molar optimal response pattern. However, G1 is the only participant in the directive and generic conditions who experienced PT 12 making it difficult to explain these results. Response patterns during the non-directive and control conditions showed more variability and may suggest these conditions produced schedule-controlled responding, although in different ways. Responding for a majority of participants in the non-directive condition (N1, N2, and N3) more closely matched the optimal molar response pattern. The control condition produced schedule-controlled behavior in the direction of the optimal molecular pattern for two of four participants (C2 and C3). The latter finding is unsurprising; contingencies ought to control behavior thereby yielding molecular response patterns in the absence of instruction to guide moment-to-moment responding.

Findings for the directive (“you must”) and generic (“the way to earn the most points”) conditions were comparable, suggesting these instructions may function similarly. Miller et al. (2014) suggested the directive condition might function as a *command*, which often results in stronger instructional control. Although instructions in the generic condition may not necessarily function as a command, they more clearly specify contingencies that directly benefit the responder (i.e., more points exchangeable for money) which could produce responding similar to instruction-controlled responding. Participants likely have a history of reinforcement for compliance or punishment for noncompliance with instructions containing verbal stimuli that alter the functional properties of the instruction similarly to the generic and directive condition instructions. Inspection of the verbal reports for the directive and generic conditions reveals participants restated the rule or communicated the importance of following the instructions, which is consistent with their patterns of behavior on the task (i.e., instruction-controlled responding).

Participants in the non-directive condition responded in the *direction* of the optimal molar pattern but did not match the optimal response pattern and, thus, participants did not maximize points earned. The phrasing “might consider” could imply that multiple response patterns produce points and may have promoted exploratory or varied responding. This explanation is supported by the finding that all participants in the non-directive condition deviated from the instructed pattern in the initial PT 4 when the instructions were accurate. That is, deviation from the rule was not due to a history of earning fewer points for instruction following and/or contacting more reinforcers for deviating from the instructions when they became inaccurate. Participants in the control condition exhibited variable response patterns in the direction of the optimal molecular pattern. Without the provision of instructions, exploratory behavior might be expected, which is evident in the initial PT 4 schedule for all control participants.

The variability in participant responding for the non-directive and control conditions resulted in several participants experiencing only one or some conditions. For example, responding of two participants assigned to the control group did not stabilize in the time required and they did not experience all of the PT schedules. The increased variability in these conditions supports previous findings that instructions hasten acquisition and quickly bring behavior into contact with programmed contingencies (e.g., Glenn, 1987). These findings further suggest the instructional statement modulates this process. The phrasing of instructions may exert weak control and/or promote response variability, which in turn may increase the number of responses emitted before

contacting the programmed contingencies or before behavior comes under schedule control (e.g., non-directive condition). Inspection of the verbal reports for the non-directive and control participants reveals variability in their descriptions of the way to earn the most points, as well. Although most control participants commented on a specific number of PT selections, C4 and non-directive participants provided relatively generic comments. Quite possibly, participants whose responding more quickly stabilized may have been engaging in covert verbal behavior in the form of counting responses, whereas, the behavior of participants whose responding was markedly variable may have been controlled by a less reliable measure such as the passage of time as N3's verbal reports suggest. Although response patterns of participants assigned to the control condition suggest contingencies failed to establish stable response patterns or that behavior is insensitive to changing contingencies, the observed findings may be a function of the constraints imposed by the number of sessions. Perhaps responding would have stabilized and come under strong schedule control if sessions were not terminated.

The results for the directive and non-directive conditions replicate the findings of Miller et al. (2014). Specifically, responding in the directive condition was indicative of instructional control and responding in the non-directive condition was generally in accordance with the schedule of reinforcement. The results for the non-directive and control conditions were similar to the findings in Hackenberg and Joker (1994) in that participants responded in the direction of the optimal pattern, but with a switch point lower than the optimal pattern. Our findings for the generic condition, however, differ from Hackenberg and Joker who documented that all participants deviated from the instructed pattern at PT schedules ranging from PT 9 to 50. Three of four participants in Hackenberg and Joker deviated at schedule values lower than the highest schedule value assessed in the present study (i.e., PT 20). Hackenberg and Joker evaluated responding under an ascending sequence in which the PT schedule increased by 1 s whereas the present study evaluated PT schedules of inconsistent size differences (i.e., PT 4 is 2 s larger than PT 2 but PT 20 is 16 s larger than PT 4) presented in a pseudo-random order. Perhaps the differences in the PT schedule values and the order in which they were presented across the two studies influenced instructional control. Future research is necessary to address that possibility.

Our findings contribute to the literature in several ways. The present study was a systematic replication of Miller et al. (2014) and addressed several important limitations: the absence of a control condition, adoption of ascending and descending sequences, and PT values below the optimal pattern specified by the instructions. Miller et al.'s absence of a control condition limited conclusions about the effects of textual instructions on behavior. That is, the pattern of responding observed under non-directive instructions may have been either a function of the absence of instructional control, or instructional control that evoked a specific, but different, pattern of responding. In the present study, control participants adhered roughly to the optimal molecular pattern, which differed from each of the three conditions in which some form of instruction was provided. Thus, we may conclude the effects obtained were most likely a function of the instructions. The dissimilarity between control and non-directive participants indicates that the non-directive instructions produced a pattern of responding that is distinct from responding in the absence of experimenter-provided mands (i.e., instructions). Specifically, the results suggest that non-directive instructions

may have brought behavior into contact with the molar contingencies. The provision of some instruction, even a relatively weak mand, produced responding distinct from that evoked by the task alone.

These data also corroborate previous findings that initial experience with instructions may control behavior, regardless of later consequences (e.g., Baron et al., 1969). In the present study, participants in experimental (i.e., not control) conditions experienced initially accurate instructions with feedback in the form of points and a tone delivered during the operant task. We also extended previous findings by demonstrating that systematic manipulation of qualitatively different verbal behavior (i.e., textual instructions) can interact with schedule control to modulate rule-governance; these findings have translational utility for applied settings. An optimistic interpretation of these findings is that textual instructions that *initially* correspond with experienced contingencies may establish long-term desired performance, regardless of whether this instruction-consequence correspondence degrades over time, at least for the directive and generic conditions. Initial correspondence, however, may not be sufficient to maintain long-term control in the non-directive condition. Future research should determine the longitudinal nature of instruction-controlled behavior in the face of degraded accuracy, as well as the duration with which initial instructions must be accurate to obtain persistent instructional control in the presence of differing contingencies. Moreover, evidence from the applied literature suggests that intermittent correspondence with initial training might be enough to mitigate transitioning from instructional control to schedule control (i.e., treatment integrity failures) when rules becomes increasingly less accurate or feedback is less frequent (see discussion by Vollmer, Sloman, & St. Peter Pipkin, 2008; also see Pereplechikova, Hilt, Chereji, & Kazdin, 2009); however, basic operant research on this topic to support these applied findings and recommendations is necessary. Similar to the conclusions of Miller et al. (2014), these findings may prove useful for contingency managers in applied settings who wish to evoke various degrees of adherence to instructions. In cases where strict adherence is necessary, such as scenarios where safety, law, policy, and regulations are important, stronger instructions can be used to increase at least initial adherence. In other scenarios where variability, creativity, and exploratory behavior is desired, differing phrasing can be used to produce those patterns as well. These implications may only hold in the relatively isolated settings of our experimental preparation, though, and the presence of extraneous factors in applied settings might reduce the degree to which these findings generalize.

Despite these contributions, several limitations are worth noting and suggest areas for future research. First, the within-subject comparisons incorporated three PT schedule values, which is fewer than those used by Hackenberg and Joker (1994). Although the program did not signal changes in the PT schedules, the differences may have been salient and influenced responding in ways we did not measure or control. Next, restrictions imposed by the human subjects committee limited the number of sessions participants could experience. A majority of participants completed the study within these session restrictions; however, two participants assigned to the control group and one in the non-directive group did not complete the full study. The responding of control group participants appears to be controlled by the reinforcement schedules, but the lack of stability and limited exposure to the PT schedules for two participants prevent us from making strong conclusions. Relatedly, only two participants

experienced PT 12, which limits the conclusions we can make. Future research should extend the data collection time frame to examine if stability criterion is met and/or ensure participants experience all PT schedule values. Several participants were recruited from behavioral science courses and it is therefore possible participants had knowledge of rule-governed behavior that may have influenced responding. We also cannot rule out the possibility that participants discussed the study because participants attended study sessions concurrently and sequentially. Finally, we designed the experimental preparation so participants first experienced the PT schedule accurately described by the instructions (i.e., PT 4). The extent to which responding might change if participants initially contacted inaccurate instructions is unknown. Quite possibly, participant's responding in subsequent conditions, including the PT 4 schedule, would be different than responding we observed in the present study. To address this question, future research could sequence the PT schedule values so participants contact initially inaccurate instructions.

Compliance with ethical standards

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Conflict of interest The authors declare that they have no conflict of interest.

Informed consent Informed consent was obtained from all individual participants included in this study.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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