Effect of instructions on the micro-structure of human schedule performance

Xiaosheng Chen and Phil Reed

Swansea University, UK

Correspondence address: Phil Reed,

Department of Psychology,

Swansea University,

Singleton Park,

Swansea, SA2 8PP, UK.

e-mail: p.reed@swansea.ac.uk

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Abstract

Three experiments examined the effect of instructions on human free-operant performance on random ratio (RR) and random interval (RI) schedules. Both rates of responding, and the micro-structure of behaviour, were explored to determine whether bout-initiation and within-bout responding may be controlled by different processes. The results demonstrated that responding in acquisition (Experiments 1 and 2) and extinction (Experiment 3) was impacted in line with given instructions. During acquisition, rates were higher on RR compared to RI for the accurate and minimal instructions. During extinction, rates decreased when there were minimal instructions. However, instructions had a greater impact on within-bout responding, than they did on bout-initiation responding. Overall rates of responding, and within-bout rates, varied in line with the nature of the instructions, but bout-initiation responding did not (Experiments 1 and 2). Resistance to extinction was increased by instructions in terms of overall responding and within-bout rates, but not in terms of bout-initiation rates (Experiment 3). These data are consistent with the hypothesis that bout-initiation responding may be less impacted by instructions than within-bout responding, speculatively, the former is stimulus-driven, automatic/habitual, and less accessible to conscious processing.

Keywords: schedules of reinforcement; bout-initiation; within-bout responding; habits; automaticity.

The role played in controlling human performance on free-operant tasks by verbal rules relating responding to reinforcement has long been regarded as important, empirically (Bradshaw & Reed, 2012; Raia, Shillingford, Miller, & Baier, 2000; Shimoff, Matthews, & Catania, 1986), theoretically (Catania & Reynolds, 1968; Hayes, Brownstein, Zettle, Rosenfarb, & Korn, 1986; Reed, 2020), and clinically (Bargh, 1989; Pace, Iwata, Cowdery, Andree, & McIntyre, 1993). The impact of verbal instructions on schedule performance has been discussed for over half a century (Holland, 1958; Skinner, 1969), but evidence regarding its effects and the nature of its influence remains scant and partly contradictory (cf. Bradshaw, Freegard, & Reed, 2015; Hayes et al., 1986; Fox & Kyonka, 2017). Moreover, the effects of instructions on human schedule behaviour have previously been studied only at the level of overall response rate (e.g., Bradshaw, Freegard, & Reed, 2015; Hayes et al., 1986), but it is now believed that schedule-controlled behaviour comprises two different forms of responding – 'bout-initiation' and 'within-bout' responding (Brackney, Cheung, Neisewander, & Sanabria, 2011; Cheung, Neisewander, & Sanabria, 2012; Reed, Smale, Owens, & Freegard, 2018: Shull, 2011). The impact of instructions on the micro-structure of human free-operant responding is not known, and instructions may impact one form of operant responding to a greater degree than the other. Examining the effects of instructions on the micro-structure of free-operant performance is the key aim of the current investigation, as this may ultimately fill current gaps in knowledge regarding how instructions control free-operant responses, and illuminate the factors controlling different operant responses.

Human free-operant performance is related to participant-produced verbalisations about the nature of the schedule to which they are exposed (Bradshaw et al., 2015; Leander, Lippman, & Meyer, 1968; Matthews, Shimoff, Catania, & Sagvolden, 1977). For example, Matthews et al. (1977) reported human performance tended to be related to the participants' self-generated descriptions of the schedules, rather than the contingencies to which they were

exposed. Reed (2020) noted that when language was suppressed by a concurrent verbal task, human performance on random ratio (RR) and random interval (RI) schedules resembled that of nonhumans to a greater extent than when language was not suppressed. Moreover, the concurrent task had a stronger association with within-bout, compared to bout-initiation, responding. However, a difficulty with approaches that attempt to relate verbal rules produced by participants to schedule-controlled behaviour is that it offers only correlational evidence, limiting the conclusions that can be drawn.

A further set of studies manipulated verbal control by providing instructions prior to exposure to the schedule, often with mixed results (cf. Baron & Galizio, 1983; Mathews et al., 1977; Raia, Shillingford, Miller, & Baier, 2000; Shimoff et al., 1986). In a study reported by Hayes et al. (1986), participants were required to move a light through a matrix by pressing the button to cause light movements according to a multiple fixed ratio, differential reinforcement of low rate schedule. Participants experienced one of four different instruction types: 'minimal' (*your task is to score as many points as possible*), 'respond rapidly' (*your task is to score as many points as possible, the best way to push the buttons is rapidly*), 'respond slowly' (*your task is to score as many points as possible*, *the best way to push the buttons is slowly with several seconds between each push*), and 'accurate' (*your task is to score as many points as possible, when the stimulus is one colour, respond rapidly, when it is another, responded with several seconds in between each).* Behaviour was consistent with the presented instructions, which may or may not have been consistent with the operative schedule (see also Mathews et al., 1977; Shimoff et al., 1986). However, after being placed into extinction, instructed participants ('accurate', 'respond rapidly', and 'respond slowly') showed little reduction in responding, but those in the 'minimal' instructions group did extinguish responding. Similarly, Joyce and Chase (1990) presented participants with complete or incomplete instructions regarding a complex conditioning task. After acquisition

training, all groups demonstrated schedule-sensitivity, but participants with incomplete instructions were subsequently more sensitive to a new contingency, compared to participants receiving complete instructions.

Complicating these conclusions, Bradshaw et al. (2015) noted that these results were not clear for all participants in the above-mentioned studies, and these studies used procedures quite different from those typically seen in nonhuman schedule studies. Moreover, even when human participants are given accurate instructions, they sometimes produce nonhuman-like behaviour on schedules (Baron, Kaufman, & Stauber, 1969; Kaufman & Baron, 1966) due to interactions between self-generated verbal rules, experimenter-provided rules, and response outcomes (Hackenberg & Joker, 1994; Fox & Kyonka, 2017). Thus, there is still debate about the degree to which instructions control behaviour on free-operant schedules, even at the level of overall response rate, which inhibits theoretical understanding of the phenomenon. The first aim of the current study is to further explore the role of instructions, using a procedure more similar to those used in nonhuman procedures (Bradshaw et al., 2015) to clarify this impact.

However, recent investigations have suggested that understanding factors controlling free-operant behaviour requires consideration of more than overall response rates, as schedule-controlled behaviour comprises both 'bout-initiation' and 'within-bout' responses, which are controlled different factors from one another (Brackney et al., 2011; Cheung et al., 2012; Reed et al., 2018: Shull, 2011). Bout-initiation responses are taken to be controlled by factors such as the previous rate of reinforcement experienced in the conditioning context and motivation (Brackney et al., 2011; Reed et al., 2018; Shull, 2011). In contrast, within-bout responding appears to be controlled by the action of reinforcement on responding; that is, it appears to impact behaviour through goal-directed mechanisms and/or appears to shape inter-response times (Brackney et al., 2011; Shull, 2011; Reed, 2020). The existence of two forms

of schedule-controlled behaviour, under different forms of contingency control, leaves open the suggestion that instructions may act differentially on these forms of operant responding. For example, it has been suggested that within-bout responses, due to their putative goal-directed nature may be more susceptible to influences that require conscious awareness such as linguistic control, and bout-initiation responses, being largely stimulus driven may be less susceptible to such influences (Chen, Osborne, & Reed, 2020). If so, then instructions may impact within-bout responses more readily.

Unfortunately, little is known about the impact of verbal stimuli on the micro-structure of human schedule performance. It has been noted that the presence of a language-suppressing task has a greater effect on within-bout than bout-initiation responses (Reed, 2020), which suggests that instructions might impact within-bout responding more than bout-initiation responding. However, the effect of instructions on the micro-structure of free-operant responding has not been directly investigated, and this is the second aim of the current series of studies. If instructions differentially impact the micro-structure of free-operant responding, then this would open novel possibilities for understanding both the role of instructions in controlling human conditioned behavior, and the broader issues regarding the nature of these two response forms.

The fact that the two forms of response are impacted by different factors has been used in other conditioning paradigms to explore the nature of these response types. For example, Garr and Delamater (2019) employed a discrete-trial conditioning procedure involving acquisition of a two-response sequence (left lever then right lever) for reinforcement. They noted times to make the first (‘initiation’) and second (‘completion’) response were differently impacted by reinforcer devaluation: in moderately trained rats, initiation time was disrupted; whereas, in extensively trained rats, completion times were disrupted. Balleine, Garner, Gonzalez, and Dickinson (1995) examined a two-response

sequence comprising different responses (lever press, chain pull, or tray push). Reducing motivation disrupted performance of the first (initiating) response more when the rats were re-exposed to the food while satiated, but it impacted the second (completion) response when the satiated rats were not re-exposed to food before test.

Such dissociations are often discussed in terms of 'habits' and 'actions', with manipulations concentrating on the reinforcer being taken to impact only actions and not habits (Dezfouli & Balleine, 2012; Garr & Delamater, 2019). While free-operant responding has been explored in terms of actions and habits (Balleine & Dickinson, 1998; Garr, Bushra, Tu, & Delamater, 2020; Pérez, Aitken, Zhukovsky, Soto, Urcelay, & Dickinson, 2016), the parallels between this action/habit analysis and the current free-operant procedure and micro-analysis are unclear. For example, reducing motivation by pre-feeding in the current free-operant procedure has been found to differentially impact bout-initiation (first) responses (Brackney et al., 2011; Podlesnik, Jimenez-Gomez, Ward, & Shahan, 2006). As this procedure was conducted when rats were not re-exposed to the reinforcer before test, this appears to be the opposite pattern of results to those reported by Balleine et al. (1995), using their heterogeneous response chain procedure, and who found re-exposure was needed before the first response in a chain was impacted. Similarly, Dezfouli and Balleine (2012) suggested that initiation responding was goal-directed, and completion responses were habits. This stands in contrast to the suggestion made by Chen et al. (2020) and Reed et al. (2018) that bout-initiation responding was an automatic stimulus-driven habit (being related to the associative value of the context), and within-bout responding was a consciously controlled goal-driven action (being related to the shaping action of reinforcement). If verbal instructions, of which the participants presumably are consciously aware, impact within-bout but not bout-initiation responding, then it suggests that bout-initiation responses are automatic habits and within-bout responses were under conscious control (Reed, 2020).

However, the nature of these tasks are quite different from one another, making generalisations difficult, especially in the absence of a great deal of empirical evidence regarding the effects of instructions and the nature of bout-initiation and within-bout responding. To further explore these effects, the current series of studies adopted a 'cut-off' method (Mellgren & Elsmore, 1991; Sibley, Nott, & Fletcher, 1990) to reveal the micro-structure of free-operant responding. The cut-off method designates short inter-response times (IRTs) as within-bout responses, and long IRTs as bout-initiation responses (Mellgren & Elsmore, 1991; Reed, 2015). In the context of human schedule studies, an IRT of 1000ms has proved a good index of this distinction (Reed, 2015; Reed et al., 2018).

In summary, the three experiments presented here, examine the relationship between verbal instructions and human schedule performance to extend and clarify results from previous studies, and explore whether instructions differentially impact the two forms of responding in free-operant performance. These issues are explored in the context of both acquisition (Experiments 1 and 2), and extinction (Experiment 3) of responding. It is hoped that these results will not only allow the impact of instructions to be further delineated at the micro-structure level, but also allow theoretical suggestions about the nature of the control over bout-initiation and within-bout responding to spark further investigations.

Experiment 1

Experiment 1 investigated the effect of instructions on human schedule behaviour at the 'micro' level. Although previous studies have shown instructions impact human free-operant behaviour (Bradshaw et al., 2015; Hayes et al., 1986), there are no studies focusing on the effects of instruction on the micro-structure of responding. To this end, participants were randomly divided into two groups that received one of two sets of instructions modelled

after those employed by Hayes et al. (1986): 'minimal' (*your task is to score as many points as possible*), and 'accurate' (; i.e. *"your task is to score as many points as possible, when the stimulus is one colour, respond rapidly, when it is another, responded with several seconds in between each").*

The performances of the two groups on a multiple RR, RI schedule, with both components receiving the same rate of reinforcement, was studied (after Bradshaw & Reed, 2012). This multiple schedule was employed as both the overall and micro-structure of human responding on such a schedule is well known (Reed, 2015; Reed et al., 2018). This contingency also offers a clearer analogy to studies involving nonhumans than previous experiments focusing on the role of instructions (cf. Hayes et al., 1986; Joyce & Chase, 1990).

It would be expected that overall responding would be greater on the RR than the RI schedule, and that this pattern would also be seen for within-bout rates of responding, but not for bout-initiation responding (Reed et al., 2018; Shull, 2011). It might also be expected that any effect of instructions would be greater at the start, than the end, of training, reflecting the introduction of many competing variables, such as contact with the actual contingencies and self-generated rules (Hackenberg & Joker, 1994). However, the study also explored the suggestion that any effects of instructions (in the 'accurate' group) would be greater on within-bout responses, compared to bout-initiation responses (Reed, 2020).

Method

Transparency and Openness.

We report how we determined sample size, data exclusions, and manipulations. Data are available on request. Data were analysed using SPSS version 26.

Participants

A sample of 79 students (52 males, 38 females) was recruited via the Psychology Department subject-pool. G-Power calculations suggested that for a medium effect size (*f'* = .25), for 85% power, using a rejection criterion of $p < .05$, a sample size of 54 would be sufficient to detect interactions in a three-factor mixed-model analysis of variance. Participants received credits for their participation, but no financial payment. Participants were aged between 18 to 30 years (mean = 20.15 $\pm$ 2.11 SD). No participant self-reported previous history of mental illness. However, previous studies have demonstrated that individuals high in depression, or schizotypy, show atypical schedule performance (Dack, McHugh, & Reed, 2009; Randell, Ranjith-Kumar, Gupta, & Reed, 2009). A score of higher than 10 on Beck's Depression Inventory was taken as a cut-off for individuals displaying high levels of depression, producing atypical schedule performance (Dack et al., 2009). A score of greater than 6 on the Unusual Experiences scale of the Oxford Liverpool Inventory of Feelings and Experiences Brief (one standard deviation above the mean; Mason et al., 2005) was taken as a cut-off for individuals displaying high levels of this trait, who display atypical performance (Randell et al., 2009). Given this, after psychometric measurement, 4 participants were excluded on this basis, leaving 75 in the study (minimal = 38; accurate = 37). Ethical approval for this, and all studies reported here, was given by the Psychology Ethics Committee of Swansea University.

Apparatus

The experimental task was presented on a standard desktop computer. Visual Basic (6.0) was used to programme the task, which had two reinforcement schedule types. The programme first presented an RR schedule, wherein points (40), acting as reinforcers, were awarded for presses to the space bar according to a RR-30 schedule. On this schedule, each space bar had a 1/30 probability of being followed by reinforcement. Participants also lost

one point for each space bar response, regardless of whether or not that response was reinforced. This procedure was adopted, as it has previously been established that the presence of such a response cost generates schedule performance by humans that is similar to that observed in nonhumans (Bradshaw & Reed, 2012; Raia et al., 2000). It has been argued that the absence of a response cost for a simple computer keypress creates little reason to regulate performance in line with the contingency of the schedule, especially in contrast to effort needed for nonhumans to make a response in a conditioning chamber (see Bradshaw & Reed, 2012; Reed, 2011). The total started at 100 points for all participants.

Second, an RI schedule was delivered, whereby 40 points were awarded following the first response after a specified amount of time had elapsed. The RI schedule was yoked to the preceding RR schedule, so that each successive reinforcement in the RI schedule was delivered only after the elapse of time that it had taken for the corresponding reinforcer to be awarded on the RR trial. The response cost contingency also applied to the RI schedule, and the points total started at 100 points. This total was reset after each successive trial.

The computer task was presented on a white screen, with a stimulus box placed in the centre upper portion of the screen. The box was approximately 8cm wide × 3cm high, and was blocked with a single colour (either blue or pink), to indicate the schedule type (each schedule was associated with a particular colour for each participant). A new schedule was indicated by the colour in the box changing. For the first trial (RR), it was blue (for half the participants), followed by pink for the second trial (RI), and the colour alternated, in this manner for the subsequent trials. Participants were informed that the box would change colour when a new trial commenced, but were not informed of which schedule type the colour indicated. Underneath the colour stimulus box, the word “POINTS” (in capital letters) was positioned, and below this, the running total of the points accumulated during the trial appeared in figures.

Materials

Beck's Depression Inventory (BDI; Beck, Ward, Mendelson, Mock, & Erbaugh, 1961) assesses depression (Cronbach α = .73 to .92: Beck, Steer, & Garbin, 1988). A score of higher is taken as a cut-off for individuals displaying high levels of depression.

Oxford Liverpool Inventory of Feelings and Experiences - Brief Version (O-LIFE(B); Mason, Linney, & Claridge, 2005) measures schizotypy (Cronbach α = .62 to .80).

Procedure

Participants were tested individually in a quiet room, which contained a desk and computer, with the monitor situated approximately 60cm from them. Participants gave written consent, and read the study information and instructions for the task. Participants commenced the task in their own time, and were required to fill in basic demographic details about themselves, and the BDI and O-LIFE questionnaires, before the schedule task was presented.

Each schedule presentation (trial) was 4min long, and a RR schedule trial was always presented immediately prior to the yoked RI schedule trial. There were four such presentations of the yoked RR–RI pairs. The procedure of yoking RI trials to preceding RR trials ensured that reinforcement in the RI schedule was delivered after a similar elapse of time that it had taken for the corresponding reinforcers to be awarded on the RR trial.

Participants were randomly allocated to one of two groups: 'minimal' or 'accurate' instructions after Hayes et al. (1986; Bradshaw et al., 2015). Prior to the task beginning, all participants, irrespective of group, were presented with the following instructions on the screen:

"*When the task begins, use the space bar to score **as many points as possible**. There are eight games in total. The first game is identified with a large blue [pink] rectangle at the top of the screen. When the first game is over, the rectangle will change to pink [blue] to indicate the start of the next game. The rectangles alternate between blue and pink to indicate the changing games for the remainder of the task. Your goal in each game is to reach the **highest score possible**. All you need to do is to find the best pattern of space bar hits to score **as highly as possible** in each game.*"

In addition to these, a further set of instructions appeared to participants on a further screen. The minimal instruction group was told:

"*Remember, your task is to score as many points as possible by pushing the space bar.*".

The accurate instruction group was told:

"*Remember, your task is to score as many points as possible by pushing the space bar. The rectangle which changes colour on the trials is important. When it is one colour, rapid pushes on the space bar will work best. When it is the other colour, pushes with several seconds in between them will work best.*".

The participants were then instructed to click a start button to continue with the experiment.

Results and Discussion

Overall response rates

Figure 1 about here

Figure 1 shows the group-mean overall response rates for each schedule across the four trials. Both groups responded faster on the RR schedule than on the RI schedule (Raia et al., 2000; Reed et al., 2018). The accurate group demonstrated this schedule-differentiated responding sooner than the minimal group, suggesting performance in the minimal instruction group was more affected by the training (trials) than in the accurate instruction group. A three-factor mixed-model analysis of variance (ANOVA), with group (accurate x minimal) as a between-subject factor, and schedule (RR x RI) and trial as within-subject factors, was conducted on these data. The ANOVA results, effect sizes and confidence limits, and appropriate Bayes statistic, are reported. There were significant main effects of schedule, $F(1,73)=92.93$, $p<.001$, MSe=24738.90, $\eta^2_p=.560$[95%CI =.403:,662], $pH_1/D=.999$, and trial, $F(3,219)=2.63$, $p=.050$, MSe=7005.78, $\eta^2_p=.040$[.000:.083], $pH_1/D=.756$, and significant interactions between group and trial, $F(3,219)=3.64$, $p=.014$, MSe=7005.78, $\eta^2_p=.048$[.002:.102], $pH_1/D=.932$, and all three factors, $F(3,219)=2.83$, $p=.050$, MSe=4249.13, $\eta^2_p=.037$[.000:.087], $pH_1/D=.674$. No other main effect or interaction was significant.

Separate two-factor mixed-model ANOVAs (group x schedule) were conducted on the first and last trials. On the first trial, there was a significant main effect of schedule, $F(1,73)=62.20$, $p<.001$, MSe=7337.56, $\eta^2_p=.460$[.290:.581], $pH_1/D=.999$, and a significant interaction, $F(1,73)=8.87$, $p=.004$, MSe=7337.56, $\eta^2_p=.108$[.012:.249], $pH_1/D=.895$, but no main effect of group. There was a large-sized simple effect of schedule for the accurate group, $F(1,73)=58.25$, $p<.001$, $\eta^2_p=.444$[.272:.568]; but only a smaller-sized simple effect of schedule for the minimal group, $F(1,73)=12.21$, $p<.002$, $\eta^2_p=.143$[.027:.289]. In contrast, on the last trial, there was a significant main effect of schedule, $F(1,73)=47.67$, $p<.001$, MSe=12255.57, $\eta^2=.395$[.222:.527], $pH_1/D=.999$, but not of group nor interaction.

Micro-structure

Figure 2 about here

Figure 2 displays the bout-initiation (top panel) and within-bout (bottom panel) rates of responding for the two schedules across the four trials of training, using a 1000ms cut-off analysis, as suggested in previous explorations (Reed et al., 2018). There were no consistent differences in rates of bout-initiations across the schedules or groups (top panel). A three-factor mixed-model ANOVA (group x schedule x trial) revealed a significant (if inconsistent) interaction between schedule and trial, $F(3,219)=3.85$, $p=.010$, MSe=864.87, $\eta^2_p=.050[.003:.106]$, most likely due to the greater RI rate on trial 4, but no other main effects or interactions were significant.

The bottom panel of Figure 2 reveals higher within-bout rates for the RR than the RI schedule for the accurate group from the start of training. A smaller difference developed over time for the minimal group. A three-factor mixed-model ANOVA (group x schedule x trial) revealed significant main effects of schedule, $F(1,73)=64.01$, p<.001, MSe=5937.91, $\eta^2_p=.467[.297:.587]$, $pH1/D=.999$, group, $F(1,73)=5.05$, $p=.028$, MSe=6019.58, $\eta^2_p=.065[.000:.193]$, $pH_1/D=.573$, and trial, $F(3,219)=19.20$, $p<.001$, MSe=5937.19, $\eta^2_p=.208[.113:.290]$, $pH_1/D=.999$. There were significant interactions between group and schedule, $F(1,73)=25.27$, $p<.001$, MSe=5937.91, $\eta^2_p=.257[.100:.404]$, $pH_1/D=.999$, and between all three factors, $F(3,219)=2.64$, p=.050, MSe=344.40, $\eta^2_p=.035[.000:.084]$, $pH_1/D=.693$, but no other interaction was significant.

Separate two-factor mixed-model ANOVAs (group x schedule) were conducted for the first and last block of training. On the first trial, this analysis revealed a significant main effect of schedule, $F(1,73)=18.61$, $p<.001$, MSe=3775.81, $\eta^2_p=.460[.290:.581]$, $pH_1/D=.999$,

and a significant interaction between group and schedule, $F(1,73)=6.75$, $p=.011$, MSe=3775.81, $\eta^2_p=.108[.012:.249]$, $pH_1/D=.895$, but no main effect of group. Simple effect analyses revealed no significant difference between the schedules for the minimal group, $F(1,73)=1.19$, $p=.05$, $\eta^2_p=.016[.000:.111]$, $pH_0/D=.899$, but a significant difference for the accurate group, $F(1.73)=18.81$, $p<.001$, $\eta^2_p=.205[.063:.353]$, $pH_1/D=.999$. On the last trial, there was a significant main effect of schedule, $F(1,73)=41.82$, p<.001, MSe=4237.39, $\eta^2_p=.038[.000:.153]$, $pH_1/D=.669$, and an interaction between group and schedule, $F(1,73)=14.12$, $p<.001$, MSe=4237.39, $\eta^2_p=.001[.000:.039]$, $pH_1/D=.893$, but no main effect of group. Simple effect analyses revealed a small-sized significant difference between the schedules for the minimal group, $F(1,73)=3.79$, $p=.05$, $\eta^2_p=.049[.000:.170]$, $pH_1/D=.969$, and a large-sized difference for the accurate group, $F(1,73)=50.01$, $p<.001$ $\eta^2_p=.407[.233:.537]$, $pH_1/D=.999$.

Figure 3 about here

Figure 3 shows the Q-Q (quantile-quantile) plots for the IRT distributions from all participants, from all schedules, in each of the experiments reported in the current paper, as well as for all experiments combined. This was conducted to assess the legitimacy of using a 1000ms cut off. A Q–Q plot is a means to visually compare two distributions, by plotting their quantiles each one another. Quantiles are sometimes referred to as percentiles, and reflect points below which certain proportions of data fall. In a normal distribution, half the data fall below the .5 quantile (50th percentile). If two distributions are the same, plotting their quantiles will fall on a straight line. The standardized residual is the difference of the observed and expected values, divided by the square root of the expected value, and is a means of plotting how closely the two distributions follow one another. Thus, any point on a

Q-Q plot corresponds to one of the quantiles of the second distribution (*y*-coordinate; in this case the IRT distribution obtained) plotted against the same quantile of the first distribution (*x*-coordinate; in this case the expected value from a single normal distribution). The line represents the plot that would be expected if the two distributions were the same as one another (i.e. if both represented a single normal distribution). If the data deviate from this straight line it suggests that the data do not represent a single normal distribution. If the distribution is bimodal, then you might expect two straight lines (one from each of the two normal distributions). In this case, if there were two sorts of responses (response-initiation, and within-burst), then it would be expected that there would be two such distributions, perhaps represented by a broken-stick appearance in the Q-Q scatterplot. The point at which the line 'breaks' would give an estimate of the IRT value that divides the two distributions. The top left panel of Figure 4 shows the distribution of IRTs for Experiment 1 had a break point around 1 quantile above the mean (in this case, at 929ms). This suggests that a cut-off of 1000ms was reasonable for these data.

Taken together, these results corroborate that humans respond faster on RR than on RI schedules (Raia et al., 2000; Reed et al., 2018), and that schedule performance appears to comprise two forms of responding, which are differentially sensitive to aspects of the contingencies (Reed, 2015; Shull, 2011). As rates of reinforcement were equated between the RR and RI schedules, the lack of bout-initiation difference suggests bout-initiation is associated with overall rates of reinforcement. In contrast, within-bout rates followed the same pattern as seen for the overall rates of responding.

Instructions clearly impacted free-operant responding, with overall response rates differing between the accurate and minimal instruction groups (Bradshaw et al., 2015; Hayes et al., 1986). Giving instructions affected within-bout but not bout-initiation rates when using the cut-off method. This result concerning instructions is novel in the context of schedules of

reinforcement, but it is consistent with the findings reported by Reed (2020) that within-bout, but not bout-initiation, rates are impacted by a concurrent language task.

Experiment 2

The aim of Experiment 2 was to replicate and extend the findings reported in Experiment 1. Previous studies have shown that the effect of instructions on human schedule behaviour can be quite variable, so it was thought prudent to demonstrate that the effects noted in Experiment 1 could be replicated. Additionally, Experiment 1 had used only two instruction types, but previous work had used four types of instruction (Hayes et al., 1986). As this work has received little replication (see Bradshaw et al., 2015), and no analysis in terms of the effects of instructions on the micro-structure of responding, it was thought important to further develop the current analysis along these lines. To this extent, the micro-structure of responding on RR and RI schedules was analysed. However, participants experienced one of four types of instructions: 'minimal' and 'accurate', as in Experiment 1, along with two sorts of partially accurate instructions ('go fast' or 'go slow'), after Hayes et al. (1986). In previous studies, go-fast instructions have produced similar effects to accurate instructions, but go-slow instructions have produced similar effects to minimal instructions (Bradshaw et al., 2015; Joyce & Chase, 1990).

Method

Participants and Apparatus

A sample of 103 students (41 males and 62 females) was recruited via the Psychology Department subject-pool. They received subject-pool credits for their participation, but no financial payment. The sample was aged between 18 to 23 years (mean = 18.93 $\pm$ .86), and

were without any self-reported previous history of mental illness. Four participants were excluded from the study due to high scores on their psychometric scales, leaving 99 in the study (minimal = 23; accurate = 20; go-slow = 28; go-fast = 28). The apparatus and materials were as described in Experiment 1.

Procedure

The procedure was as described in Experiment 1, with the exception that participants were randomly allocated to one of four groups: minimal instructions, accurate instructions, go-fast instructions, and go-slow instructions (after Hayes et al., 1986). Prior to the task, all participants were presented with initial instructions on the computer screen, as described in Experiment 1. In addition, a further set of instructions appeared to participants on a further screen.

The minimal group was told:

"*Remember, your task is to score as many points as possible by pushing the space bar.*"

The accurate group was told:

"*Remember, your task is to score as many points as possible by pushing the space bar. The rectangle which changes colour on the trials is important. When it is one colour, rapid pushes on the space bar will work best. When it is the other colour, pushes with several seconds in between them will work best.*"

The go-fast group was told:

"*Remember, your task is to score as many points as possible by pushing the space bar. The best way to push the buttons is rapidly.*"

The go-slow group was told:

"*Remember, your task is to score as many points as possible by pushing the space bar. The best way to push the buttons is slowly with several seconds between each push*."

The participants were then instructed to click a 'Start' button to continue with the experiment.

Results and Discussion

Overall response rates

Figure 4 about here

Figure 4 shows the group-mean overall response rates for both schedules during the first and last blocks of training. These blocks were analysed as instruction effects tended to differ between the start and end of training in Experiment 1. Overall response rates were highest for the go-fast group, and lowest for the go-slow group. Responding to the RR schedule was greater than that to the RI schedule for all groups, but this pattern was most pronounced at the start of training in the accurate and go-fast instruction groups.

A three-factor mixed-model ANOVA (group x schedule x trial) revealed significant main effects of trial, $F(1,93)=9.26$, $p=.003$, MSe=7182.81, $\eta^2_p=.091$[.011:.211], $pH_1/D=.917$, schedule, $F(1,93)=124.18$, $p<.001$, MSe=4807.15, $\eta^2_p=.572$[.438:.663], $pH_1/D=.999$, and group, $F(3,93)=26.26$, $p<.001$, MSe=13671.81, $\eta^2_p=.459$[.296:.560], $pH_1/D=.999$. There were significant interactions between trial and group, $F(3,93)=11.98$ $p<.001$, MSe=7182.81, $\eta^2_p=.279$[.119:.396], $pH_1/D=.999$, schedule and group, $F(3,93)=5.56$, $p<.001$, MSe=4807.15, $\eta^2_p=.152$[.026:.265], $pH_1/D=.782$, and between all three factors, $F(3,93)=4.04$, $p=.009$, MSe=3289.83, $\eta^2_p=.115$[.008:.222], $pH_1/D=.695$, but not between schedule and trial.

On the first trial, there were significant main effects of schedule, $F(1,95)=82.39$, $p<.001$, MSe=3012.92, $\eta^2_p=.465[.317:.573]$, $pH_1/D=.999$, and group, $F(3,95)=37.11$, $p<.001$, MSe=11386.71, $\eta^2_p=.281[.138:.411]$, $pH_1/D=.999$, and a significant interaction, $F(3,95)=2.97$, $p=.036$, MSe=3012.92, $\eta^2_p=.086[.000:.184]$, $pH_1/D=.794$. Simple effect analyses demonstrated significantly higher RR rates for all groups; which were large-sized effects for the accurate group, $F(1,95)=36.03$, $p=.277$, $\eta^2_p=.275[.133:.405]$, $pH_1/D=.999$, and go-fast group, $F(1,95)=24.56$, $p<.001$, $\eta^2_p=.205[.078:.337]$, $pH_1/D=.999$; and were moderate for the minimal group, $F(1,95)=19.86$, $p<.001$, $\eta^2_p=.172[.055:.304]$, $pH_1/D=.999$, and go-slow group, $F(1,95)=6.14$, $p=.018$, $\eta^2_p=.061[.020:.170]$, $pH_1/D=.718$. On the last trial, there were significant main effects of schedule, $F(1,95)=68.94$, $p<.001$, MSe=5061.05, $\eta^2_p=.421[.271:.536]$, $pH_1/D=.999$, and group, $F(3,95)=5.76$, $p<.001$, MSe=9455.87, $\eta^2_p=.153[.029:.266]$, $pH_1/D=.824$, and a significant interaction, $F(3,95)=6.26$, $p<.001$, MSe=5061.05, $\eta^2_p=.165[.036:.279]$, $pH_1/D=.903$. Simple effect analyses revealed higher RR rates for all groups, which were large-sized for the accurate group, $F(1,95)=17.01$, $p<.001$, $\eta^2_p=.152[.042:.281]$, $pH_1/D=.997$, and go-fast group, $F(1,95)=61.84$, $p<.001$, $\eta^2_p=.394[.244:.513]$, $pH_1/D=.999$, and small to moderate for the minimal group , $F(1,95)=2.74$, $p=.036$, $\eta^2_p=.028[.000:.119]$, $pH_1/D=.502$, and go-slow group, $F(1,95)=7.33$, $p=.018$, $\eta^2_p= .072[.005:.185]$, $pH_1/D=.811$.

As in Experiment 1, participants responded faster on the RR than the RI schedule (see also Bradshaw et al., 2015; Raia et al., 2000). Instructions impacted schedule effects, with accurate instructions producing a larger-sized schedule difference than minimal instructions, again replicating the results from Experiment 1. The go-fast instructions also produced a pronounced response rate difference between the schedules, and the go-slow instructions a less pronounced RR versus RI response rate difference, consistent with findings reported from Bradshaw et al. (2015). This effect has been interpreted as reflecting the greater

variability in response rate that accompanies higher rates, making the participants more sensitive to response-reinforcement variations in the contingencies (Bradshaw et al., 2015; Joyce & Chase, 1990; Reed, 2015). Although there may be multiple causal factors, it is clear that accurate and go-fast instructions produced schedule-differentiated behaviour more quickly than minimal or go-slow instructions.

Micro-structure

Figure 5 about here

Figure 5 shows the group-mean bout-initiation (top panel) and within-bout (bottom panel) response rates for the two schedules, for the first and last trials, using a 1000ms cut-off analysis. The top right panel of Figure 3 shows the distribution of these data for Experiment 2 was distinctly positively skewed, with a break point around 1 quantile above the mean (in this case, at 1167ms). This suggests that a cut-off of 1000ms is reasonable for these data. Inspection of bout-initiation rates (top panel Figure 5) shows responding tended to be higher in the go-fast group, and lowest in the go-slow group, but this was not a large effect. Responding tended to decrease from the first to the last trial, except for the go-slow group. A three-factor mixed-model ANOVA (group x schedule x trial) revealed significant main effects of trial, $F(1,95)=14.38$, $p<.001$, MSe=207.43, $\eta^2_p=.132[.031:.259]$, $pH_1/D=.999$, and group, $F(3,95)=5.92$, $p<.009$, MSe=432.28, $\eta^2_p=.158[.031:.271]$, $pH_1/D=.831$, as well as significant interactions between trial and group, $F(3,95)=4.36$, $p=.006$, MSe=207.43, $\eta^2_p=.089[.000:.187]$, $pH_1/D=.374$, and (replicating the effect in Experiment 1) schedule and trial, $F(3,95)=9.70$, $p=.002$, MSe=145.41, $\eta^2_p=.235[.085:.352]$, $pH_1/D=.888$, most likely due

to higher RI rates on the final trial. However, there were no other main effects or interactions, suggesting instruction group did not impact on schedule performance.

Within-bout responding (bottom panel Figure 5) was faster on the RR than the RI schedule. Instructions had an impact on responding, with the go-fast group responding at the highest rate, and the go-slow group responding at the lowest rate, and this was most pronounced at the start of training. The RR versus RI difference was more pronounced for the accurate and go-fast groups, especially on the first trial. A three-factor mixed-model ANOVA (group x schedule x trial) revealed significant main effects of group, $F(3,95)=5.72$, $p<.001$, MSe=10722.69, $\eta^2_p=.153[.029:.265]$, $pH_1/D=.791$, and schedule, $F(1,95)=25.43$, $p<.001$, MSe=3754.59, $\eta^2_p=.211[.082:.343]$, $pH_1/D=.999$, as well as interactions between trial and group, $F(3,95)=6.28$, $p<.001$, MSe=7178.19, $\eta^2_p=.166[.036:.279]$, $pH_1/D=.887$, and schedule and group, $F(3,95)=2.68$, $p=.05$, MSe=3754.59, $\eta^2_p=.078[.000:.173]$, $pH_1/D=.535$. No other main effects nor interactions were significant, suggesting the effects of instruction did not change over training.

As the schedule and group interaction was significant, simple effects for schedule were conducted for each group using data averaged across all four trials. There was a large-sized effects of schedule for accurate instructions, $F(1,95)=11.31$, $p=.001$, MSe=3447.89, $\eta^2_p=.106[.018:.229]$, $pH_1/D=.999$, and go-fast instructions, $F(1,95)=6.92$, $p=.010$, $\eta^2_p=.068[.004:.180]$, $pH_1/D=.902$, but no effect for minimal or go-slow instructions.

These findings are broadly supportive of those noted in Experiment 1, and in previous studies (Reed, 2016). Overall response rates were higher on RR than RI schedules; bout-initiation responding was not consistently schedule-differentiated, but within-bout responding was different across the schedules. Overall responding was impacted by instructions, as in Experiment 1. In addition, these data extend previous investigations regarding partially accurate instructions, corroborating that go-fast instructions produce similar effects to

accurate instructions, but go-slow instructions produced similar effects to minimal instructions. It is thought that this schedule-sensitivity effect is due to the increase response variance that accompanied higher rates (and corresponding decrease in variability with lower response rates), allowing greater contact with the contingencies (Bradshaw et al., 2015; Joyce & Chase, 1990).

Instructions had no consistent effect on bout-initiation responding; where there were differences bout-initiation rates were higher on the RI than the RR schedule. There was evidence that instructions impacted within-bout responding early in training, as in Experiment 1. Accurate and go-fast instructions promoted the within-bout response rate differences on the schedules, but go-slow instructions did not promote this schedule difference. It has been noted that the effects of instructions on human behaviour are highly variable from study to study, and the current differences may reflect this suggestion. Whatever the explanation, the preceding two experiments reported here show that within-bout responding is more impacted by verbal instructions than bout-initiation responding. This is consistent with the findings reported by Reed (2020), and tends to suggest that within-bout responding may be modifiable through consciously controlled processes mediated by language, in way that bout-initiation responding is not.

Experiment 3

The results of Experiments 1 and 2 suggest that instructions impact RR-RI schedule performance, and also impact within-bout rates more than bout-initiation rates. The final study sought to replicate some of these effects, and to examine the effect of instructions on extinction of responding, both at the overall and micro-structure levels. It has been suggested that the micro-structure of responding persists in extinction, with the main effect of this

manipulation being to reduce the number of bout-initiations, but leave the rate of within-bout responding unaltered (Cheung et al., 2012). For example, Brackney et al. (2011) found that when reinforcement was stopped after extended training, only bout-initiation responding reduced (see also Podlesnik et al., 2006; Shull et al., 2002). It is not known if similar effects would occur with humans earlier in training, as in the current procedure. Some experiments examining extinction have noted that instruction-driven responding is less sensitive to extinction than contingency-shaped responding (Bradshaw et al., 2015; Hayes et al., 1986). However, these effects have not been examined at the level of the mirco-structure of responding. Given the previous novel findings reported here, both bout-initiation and within-bout responses might be expected to decline, but instructions should not retard the decline in bout-initiation responses as much as they do within-bout responding.

Method

Participants and Apparatus

A sample of 106 students (43 males and 63 females) was recruited, as described in Experiment 1. The sample was aged between 18 and 26 years (mean = 18.96 $\pm$ 1.12). Nine participants were excluded from the analyses (due to high scores on psychometric scales), leaving 99 in the sample (26 accurate, 20 minimal, 20 go-slow, 31 go-fast).

The apparatus and materials were as described in Experiment 2, with the exception that the task in this study comprised 20 trials. Reinforcement was delivered in the first eight conditioning trials (four RR and four RI, respectively), according to an RR-30 schedule and a yoked RI schedule (as described in Experiment 1). The remaining twelve trials were extinction trials, whereby no reinforcement was delivered.

Procedure

Participants were randomly allocated to one of four groups: minimal instructions, accurate instructions, go-fast instructions, go-slow instructions (after Hayes et al., 1986a). The procedure was as described in Experiment 2 for the initial conditioning trials. The 12 extinction trials (whereby no reinforcement was delivered at all), followed after the 8 trials of the conditioning task. These trials were identical to the preceding conditioning trials, except they were 2min of length, and no reinforcers (points) were delivered. Of the 12 extinction trials, 6 were for the component previously associated with the RR schedule, and 6 for the component previously associated with the RI component. Participants were not informed that no points could earned after the first 8 trials, and they continued to lose 1 point for each response, and the experiment was continuous throughout the trials (i.e. there was no gap between conditioning and extinction).

Results and Discussion

Overall response rates

Table 1 about here

The acquisition data over the four trials of training followed the same pattern as seen in Experiment 2. However, as the focus of this study was the extinction phase, only the last session of training is presented in Table 1, along with the group-mean bout-initiation and within-bout rates for that session. Response rates were higher for the RR than the RI schedule for all groups, but this difference was more pronounced for the accurate and go-fast groups. A mixed-model ANOVA (schedule x group) revealed significant main effects of schedule $F(1,93)=92.09$, $p<.001$, MSe=5249.06, $\eta^2_p=.498$[.352:.602], $pH_1/D=.999$, and

group, $F(3,93)=3.40$, $p=.019$, MSe=8037.84, η^2_p= 099[.001:.202], $pH_1/D=.999$, and an interaction between the two factors, $F(3,93)=5.49$, $p=.002$, MSe=5249.06, $\eta^2_p=.151$[.026:.264], $pH_1/D=.997$. There were large-sized significant simple effects of schedule for the accurate group, $F(1,93)=35.39$, $p<.001$, $\eta^2_p=.277$[.132:.407], $pH_1/D=.999$, and for the go-fast group, $F(1,93)=93.58$, $p<.001$, $\eta^2_p=.502$[.356:.605], $pH_1/D=.999$, but small-sized effects for the minimal group, $F(1,93)=5.45$, $p=.021$, $\eta^2_p=.056$[.001:.164], $pH_1/D=.642$, and go-slow group, $F(1,93)=6.78$, $p=.018$, $\eta^2_p=.068$[.004:.182], $pH_1/D=.931$.

In terms of bout-initiation rates, a mixed-model ANOVA (schedule x group) revealed no main effects or interaction. However, within-bout rates were higher for the RR than RI schedule for all groups, indicating that the instructions had no impact on this aspect of responding. A mixed-model ANOVA (schedule x group) revealed a significant main effect of schedule $F(1,93)=31.99$, $p<.001$, MSe=5099.29, $\eta^2_p=.256$[.116:.388], $pH_1/D=.999$, but not of group or interaction.

Figure 6 about here

Figure 6 shows group-mean overall response rates for the two schedules during the first and last session of extinction. Responding decreased by the end of extinction, with a more pronounced decrease for the RR schedule. A three-factor mixed-model ANOVA (schedule x group x trial) revealed significant main effects of trial, $F(1,93)=85.59$, $p<.001$, MSe=9741.73, $\eta^2_p=.479$[.332:.582], $pH_1/D=.999$, and schedule, $F(1,93)=40.96$, $p<.001$, MSe=4485.72, $\eta^2_p=.306$[.158:.439], $pH_1/D=.999$, and significant interactions between trial and group, $F(3,93)=4.51$, $p=.005$, MSe=9741.73, $\eta^2_p=.127$[.014:.236], $pH_1/D=.998$, schedule and trial, $F(1,93)=55.62$, $p<.001$, MSe=4659.15 $\eta^2_p=.374$[.222:.496], $pH_1/D=.999$, and

between all three factors, $F(3,93)=5.35$, $p=.002$, MSe=4659.15, $\eta^2_p=.054$[.000:.163], $pH_1/D=.996$. There were no other main effects or interactions.

Separate two-factor ANOVAs (schedule x trial) were performed for each instruction group. For the accurate group, there was a main effect of trial, $F(1,25)=14.25$, $p<.001$, MSe=13531.79, $\eta^2_p=.363$[.080:.569], $pH_1/D=.999$, but no effect of schedule or interaction. For the minimal group, there were significant main effects of trial, $F(1,19)=50.14$, $p<.001$, MSe=8116.58, $\eta^2_p=.725$[441:.827], $pH_1/D=.999$, and schedule, $F(1,19)=28.66$, $p<.001$, MSe=2124.37, $\eta^2_p=.601$[.261:.748], $pH_1/D=.999$, and a significant interaction $F(1,19)=31.87$, $p<.001$, MSe=3169.98, $\eta^2_p=.627$[.294:.764], $pH_1/D=.999$ (due to a greater decrease in the RR responding). For the go-slow group, there were significant main effects of trial, $F(1,19)=43.13$, $p<.001$, MSe=5242.68, $\eta^2_p=.692$[.391:.807], $pH_1/D=.999$, and schedule, $F(1,19)=17.16$, $p<.001$, MSe=72287.16, $\eta^2_p=.475$[.127:.665], $pH_1/D=.999$, and a significant interaction $F(1,19)=21.37$, $p<.001$, MSe=4100.99, $\eta^2_p=.529$[.179:.702], $pH_1/D=.999$ (indicating a greater decrease for the RR schedule). For the go-fast instruction group there were significant main effects of trial, $F(1,30)=5.99$, $p=.020$, MSe=10462.01, $\eta^2_p=.162$[.003:.378], $pH_1/D=.751$, and schedule, $F(1,30)=5.28$, $p=.029$, MSe=6249.24, $\eta^2_p=.146$[.000:.361], $pH_0/D=.996$, and a significant interaction $F(1,30)=19.12$, $p<.001$, MSe=7386.33, $\eta^2_p=.381$[.119:.568], $pH_1/D=.997$ (indicating a drop in the RR, but not RI, rate over extinction).

There are few studies that directly compare extinction across RR and RI schedules with matched rates of reinforcement (but see Bradshaw et al. 2015). Responding fell more on RR than on RI schedules. This is consistent with higher baseline rates of responding on RR schedules, but also with the suggestion that participants would show greater reduction in responding should the response-reinforcer relationship be removed on RR schedules (Perz et al., 2016). Participants with minimal instructions and go-slow instructions demonstrated a

larger-sized reduction in responding for the RR schedule, relative to the other two groups. This finding is in line with previous studies, suggesting that accurate and go-fast instructions retard extinction, perhaps due to an insensitivity to the change in actual contingencies produced by performance being instruction-governed (Bradshaw et al., 2015; Hayes et al., 1986). However, it should be noted that the decrease was not the result of lower levels of responding at the end of extinction, but of a higher responding (extinction burst) at the beginning of extinction. No impact of instructions on extinction was seen for the RI schedule. It is possible that this reflects a lower baseline rate from which to see any differential declines, or that the lack of a strong response-reinforcer contingency on the RI schedule makes instructions less impactful.

Micro-structure

Figure 7 about here

Figure 7 shows the group-mean bout-initiation (top panel) and within-but (bottom panel) rates on the first and last extinction session, using the 1000ms cut-off analysis. The bottom left panel of Figure 3 shows the distribution of these data for Experiment 3 was distinctly positively skewed, with a break point around 1 quantile above the mean (in this case, at 841ms). This suggests that a cut-off of 1000ms is reasonable for these data. There was a reduction in bout-initiation responding during extinction (top panel Figure 7), which tended to be greater for the RR schedule, but was not impacted by instruction group. A three-factor mixed-model ANOVA (group x schedule x trial) revealed significant main effects of trial, $F(1,93)=68.20$, $p<.001$, MSe=120.89, $\eta^2_p=.426$[.274:.542], $pH_1/D=.999$, and schedule, $F(1,93)=6.33$, $p=.014$, MSe=89.79, $\eta^2_p=.064$[.003:.177], $pH_1/D=.724$, and a significant trial

and schedule interaction, $F(1,93)=5.78$, $p=.023$, MSe=81.55, $\eta^2_p=.059[.001:.169]$, $pH_1/D=.620$. No other mains effects or interactions were significant. There was a large-sized simple effect of reduction in bout-initiation for the RR schedule across extinction, $F(1,93)=63.36$, $p=.023$, $\eta^2_p=.408[.255:.526]$, $pH_1/D=.999$, and a small-sized reduction in RI bout-initiation, $F(1,93)=23.70$, $p=.023$, $\eta^2_p=.205[.076:.339]$, $pH_1/D=.999$.

There was a reduction in within-bout responding (bottom panel Figure 7), which tended to be greater in the minimal instruction group than in the other three groups, and greater for the RR than the RI schedule. A three-factor mixed-model ANOVA (group x schedule x trial) showed significant main effects of trial, $F(1,93)=25.53$, $p=.002$, MSe=5427.40, $\eta^2_p=.215[.084:.349]$, $pH_1/D=.999$, and schedule, $F(1,93)=11.94$, $p<.001$, MSe=4675.40, $\eta^2_p=.113[.021:.239]$, $pH_1/D=.975$, and interactions between trial and schedule, $F(3,93)=8.07$, $p=.006$, MSe=3819.00, $\eta^2_p=.207[.062:.324]$, $pH_1/D=.806$, trial and group, $F(3,93)=3.16$, $p=.028$, MSe=5427.40, $\eta^2_p=.093[.000:.193]$, $pH_1/D=.924$, and schedule and group, $F(3,92)=2.99$, $p=.035$, MSe=4675.40, $\eta^2_p=.088[.000:.187]$, $pH_1/D=.880$. No other mains effects or interactions were significant. To analyse the interactions, a series of simple effect analyses were conducted. These revealed that, irrespective of group, there was a large-sized significant decrease in within-burst responding over extinction for the RR schedule, $F(1,93)=28.09$, $p<.001$, MSe=4575.40, $\eta^2_p=.232[.067:.365]$, $pH_1/D=.999$, but a smaller-sized decrease for the RI schedule, $F(1,93)=5.29$, $p=.023$, MSe=4575.40, $\eta^2_p=.054[.001:.162]$, $pH_1/D=.798$. Irrespective of schedule there was a decrease in within-burst responding only for the minimal instructions group, $F(1,93)=16.82$, $p<.001$, MSe=3819.12, $\eta^2_p=.153[.042:.234]$, $pH_1/D=.986$. Irrespective of trial there was a higher rate for the RR schedule only for the minimal instructions group, $F(1,93)=6.42$, $p<.001$, MSe=3819,12, $\eta^2_p=.065[.003:.178]$, $pH_1/D=.812$.

The micro-structure analyses show bout-initiation and within-bout rates decreased over extinction, with a greater effect for the RR, compared to the RI, schedule. This is not entirely consistent with the data reported from rat subjects, where it is suggested that extinction impacts the rate of bout-initiation but not within-bout responding (Brackney et al., 2011; Podlesnik et al., 2006). However, at some point, responding will all but cease in extinction, and this will impact both types of responding. It may be that the previous rat procedures only used extinction periods not comparable to the current periods – which given the differences in subjects and procedures would not be unlikely. Instructions had no effect on extinction for bout-initiation responding. Instructions did impact within-bout responding, with only the minimal instructions group showing a large-sized reduction in responding across trials.

General Discussion

Three experiments examined the effect of instructions on human schedule performance at the micro-level to determine whether bout-initiation and within-bout responding were differentially controlled. The studies replicated the basic finding of higher rates being emitted on an RR compared to an RI schedule, when the two were equated for reinforcement rate (Ferster & Skinner, 1957; Raia et al., 2000; Reed et al., 2018; Zuriff, 1970). Moreover, human free-operant responding appeared to comprise two different forms of responding – bout-initiation and within-bout responding – which were differentially impacted by aspects of the contingency, as noted in previous studies (Brackney et al., 2011; Reed et al., 2018; Shull, 2011). Responding in both acquisition (Experiments 1 and 2), and extinction (Experiment 3), was impacted by instructions, replicating the effects noted in several previous studies (Bradshaw et al., 2015; Hayes et al., 1986; Shimoff et al., 1986).

However, instructions had a greater impact on within-bout responding, than they did on bout-initiation responding, in line with suggestions made by Reed (2020).

In all experiments, human free-operant responding was shown to be higher on RR schedules than on RI schedules with the same rate of reinforcement as one another. This result is in line with results from previous studies using both humans (Raia et al., 2000; Randell et al, 2009; Reed et al., 2018), and those using nonhumans (Ferster & Skinner, 1957; Reed, 2015; Zuriff, 1970). In addition, it was shown that when the rate of reinforcement was equated on an RR and on an RI schedule, then rates of bout-initiation were similar across the two schedules. This has been shown for nonhumans (Brackney et al., 2011; Shull, 2011) and humans (Reed et al., 2018). Such a result implies bout-initiation responding is associated with the reinforcement rate experienced in the conditioning context (Shull, 2011), and may be stimulus-driven based on the associative value of the context (Reed et al., 2018; Shull, 2011). In contrast, within-bout responding was higher response for the RR compared to the RI schedule; an effect consistent with previous studies (Reed et al., 2018; Shull, 2011), and with the suggestion that such responses are controlled by contiguous action of the reinforcer on the response (Reed, 2020; Shull et al., 2002).

Overall response rates were impacted by instructions as in several previous studies, which confirms the implications that this is an influence over human free-operant responding (Hayes et al., 1986; Joyce & Chase, 1990). Participants given accurate instructions demonstrated schedule-differentiated responding sooner than those in the minimal instruction group (Experiments 1 and 2). Responding of participants given either go-fast or go-slow instructions was also in line with these instructions; go-fast instructions producing higher rates than go-slow instructions. The go-fast instructions also tended to produce more schedule consistent behaviour than go-slow instructions, potentially due to the greater variability in responding that accompanies higher response rates producing greater contact

with the schedule contingencies (Bradshaw et al., 2015). This instructional effect was greater earlier in training, which may reflect the introduction of many competing variables over training, such as contact with the actual contingencies, and the productions self-generated rules (Hackenberg & Joker, 1994). Although the responding of participants given minimal or accurate instructions was similar at the end of acquisition in Experiments 1 and 2, these groups responded differently to extinction in Experiment 3. The latter group showing greater extinction than the former group – again replicating previous studies (Hayes et al., 1986).

The establishment of these findings is important for further developments in this long investigated area (Holland, 1958), given the paucity of evidence from larger group-based studies previously (see Bradshaw et al, 2015). However, a novel result to emerge from the current series of studies was that within-bout responding displayed a greater tendency to be impacted by instructions than bout-initiation responding. As verbal instructions impacted within-bout but not bout-initiation responding, then this does suggest that these responses not easily impacted by consciously controlled mechanisms, as presumably the instructions operate through such a route (Reed, 2020). This is in line with the proposal made by Reed et al., 2018; Reed, 2020) that bout-initiation responding on free-operant schedule may be an unconscious, stimulus-driven response; and only when a response has been made initially (i.e. for within-bout responses) does responding enter the realm where it can be consciously controlled.

On first inspection, this view appears to differ from several advanced in other conditioning contexts (Dezfouli & Balleine, 2012; Balleine & Dickinson, 1998; Perez et al., 2016). Such views suggest instrumental responding comprises responses that are regarded as habits, as well as responses regarded as goal-directed actions. These two types of responding are sometimes said to be rather more specific to particular schedules – habits predominating on RI schedules, and actions on RR schedules (Balleine & Dickinson, 1998; Perez et al.,

2016). This is thought to be the case, as on RR schedules there are more opportunities to learn about action-outcome covariance than on RI schedules. This process may well play a role, but the current studies could suggest a different, or additional, set of factors operate within each schedule. Moreover, recent studies reported for RI schedules have suggested a greater role for response-reinforcer contiguity in determining the goal-directedness of actions (Garr et al., 2020). This latter view might lend some support for the suggestion that within-bout responding, being temporally closer to reinforcement than bout-initiation responding, may be under goal-directed conscious control, and bout-initiation responding could be regarded as a stimulus-driven habit. It is important to note that these suggestions are speculative, as the current studies did not use reinforcer devaluation techniques to differentiate goal-directed actions from stimulus-driven habits. Future research could begin to explore these effects in humans, and studies using rats could look at within-bout versus initiations in free-operant contexts when using reward devaluation tests.

The current results and suggestions also contrast with view regarding the nature of initial and terminal responding in response chains (Balleine et al., 1995; Dezfouli & Balleine, 2012). The generally accepted view in this context is that the initial response is goal-directed and under conscious control, whereas the subsequent responses are automatic habits not subject to the same conscious control (Dezfouli & Balleine, 2012). However, results from several studies using devaluation procedures, suggest a rather more complex state of affairs. Garr and Delamater (2019) noted that devaluation (taken to impact goal-directed responses), did impact response initiation in moderately trained rats, but impacted response completion in well-trained rats. If this could be translated to bout-initiation and within-bout responding, it would suggest that early in training, bout-initiation responding should be goal-directed and, perhaps, under conscious control, and within-bout responses should be automatic and habitual. However, alter in training the situation would reverse. It is not clear to what

‘moderately’ and ‘well-trained’ would equate in the current procedures, as humans reach asymptotic performance relatively quickly in terms of time, perhaps due to the relatively large numbers of reinforcers that even short periods can produce. At this point, it is difficult to speculate further on the basis of such cross-experimental and cross-procedural comparisons.

In summary, the current results demonstrate that within-bout, but not bout-initiation, responding on free-operant schedules are impacted by instructions. This adds further evidence to suggest that once responding is underway it comes under conscious control, but that its initiation may be stimulus-driven.

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Table1: Group-mean (standard deviation) response rates per minute for overall responding, bout-initiation, and within-bout, rates for the two schedules, for the four instruction groups, on the last block of training.

	Accurate		**Minimal**		**Go-slow**		**Go-fast**	
	RR	RI	RR	RI	RR	RI	RR	RI
Overall	187.56 (99.41)	67.59 (57.77)	166.65 (80.88)	112.09 (96.33)	148.27 (109.43)	77.00 (96.33)	247.56 (73.62)	87.10 (77.63)
Bout-initiation	20.83 (14.11)	20.83 (15.40)	11.44 (8.05)	20.95 (10.34)	14.64 (8.10)	17.49 (10.39)	26.13 (10.68)	26.27 (23.73)
Within-bout	272.31 (71.31)	199.45 (90.43)	273.62 (58.83)	246.44 (215.53)	289.63 (64.65)	249.87 (210.54)	298.34 (55.90)	202.13 (78.55)

Figure 1: Experiment 1: Mean overall response rates for RR and RI schedules both groups (Accurate and Minimal groups) on all trials. Error bars = 95% confidence intervals.

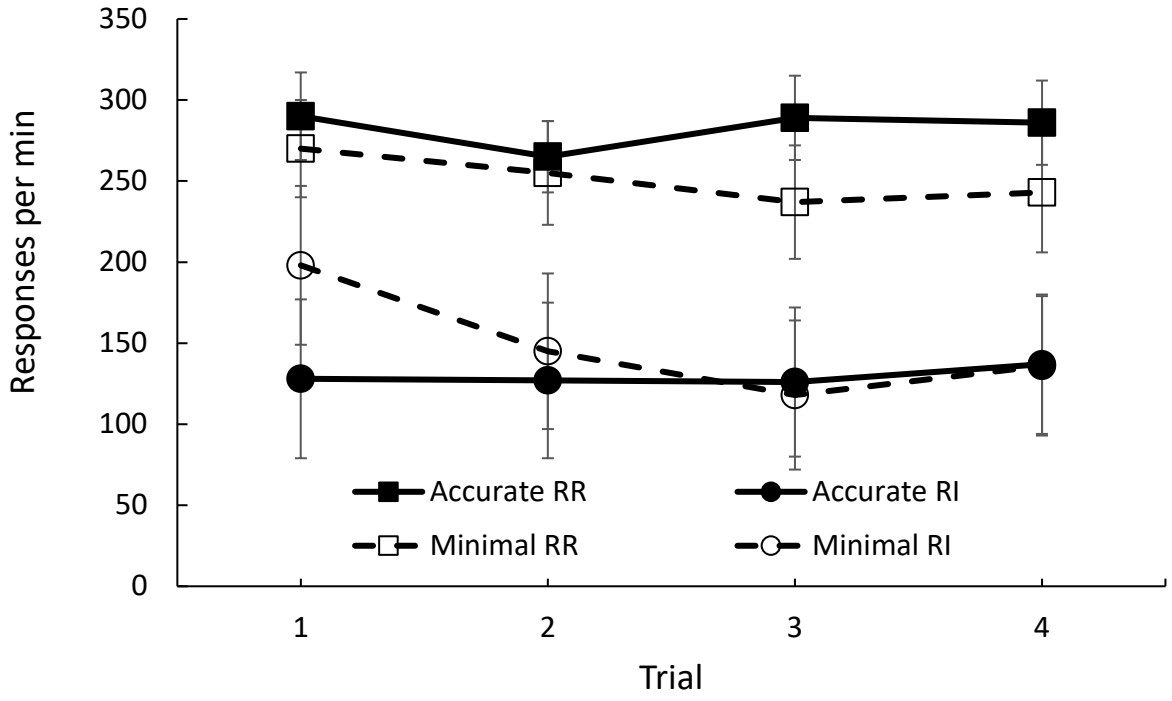

Figure 2: Experiment 1: Mean overall response rates for RR and RI schedules both groups (Accurate group and Minimal group) on all trials, using the cut-off method. Top panel = response initiation rates. Bottom panel = within-bout rates. Error bars = 95% confidence intervals.

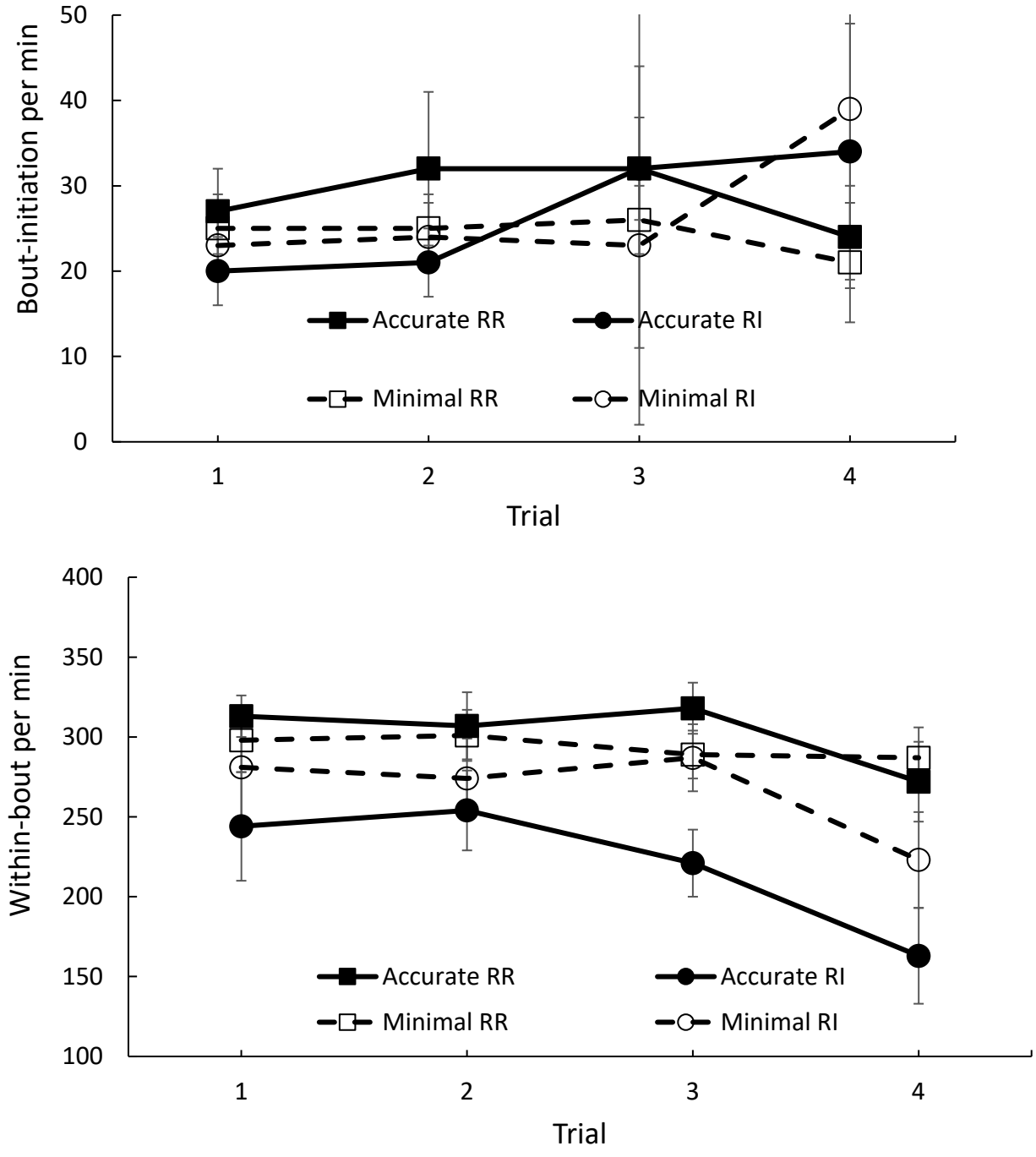

Figure 3: Q-Q plots of IRT values for all participants in each experiment. Top left panel = Experiment 1; Top right panel = Experiment 2; Middle left panel = Experiment 3; Middle right panel = all experiments combined; Bottom left panel = RR IRT distribution for all experiments; Bottom left panel = RI IRT distribution for all experiments.

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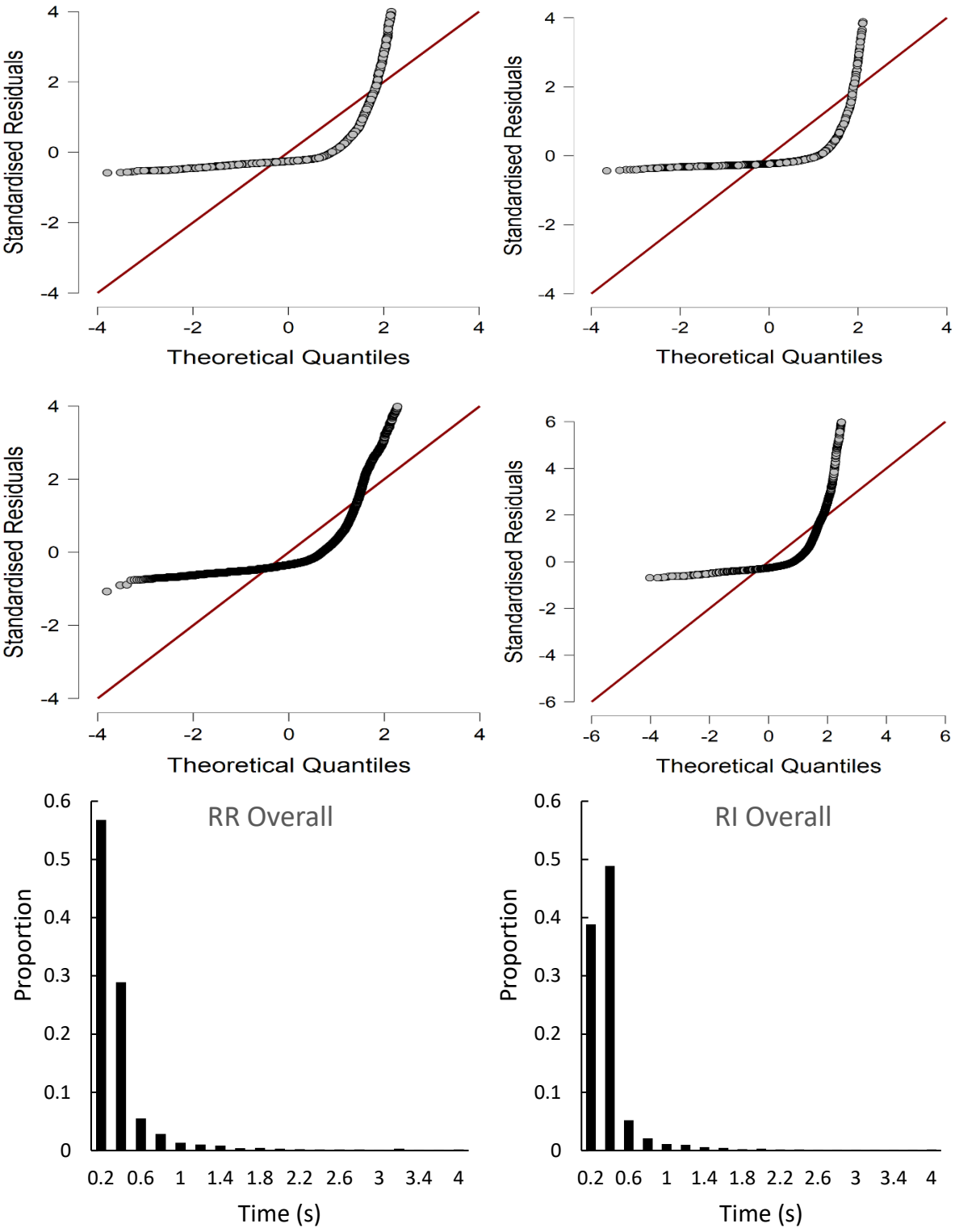


Figure 4: Experiment 2: Mean overall response rates for RR and RI schedules for the four groups (accurate, minimal, go-slow and go-fast groups) on the first and last trials. Error bars = 95% confidence intervals.

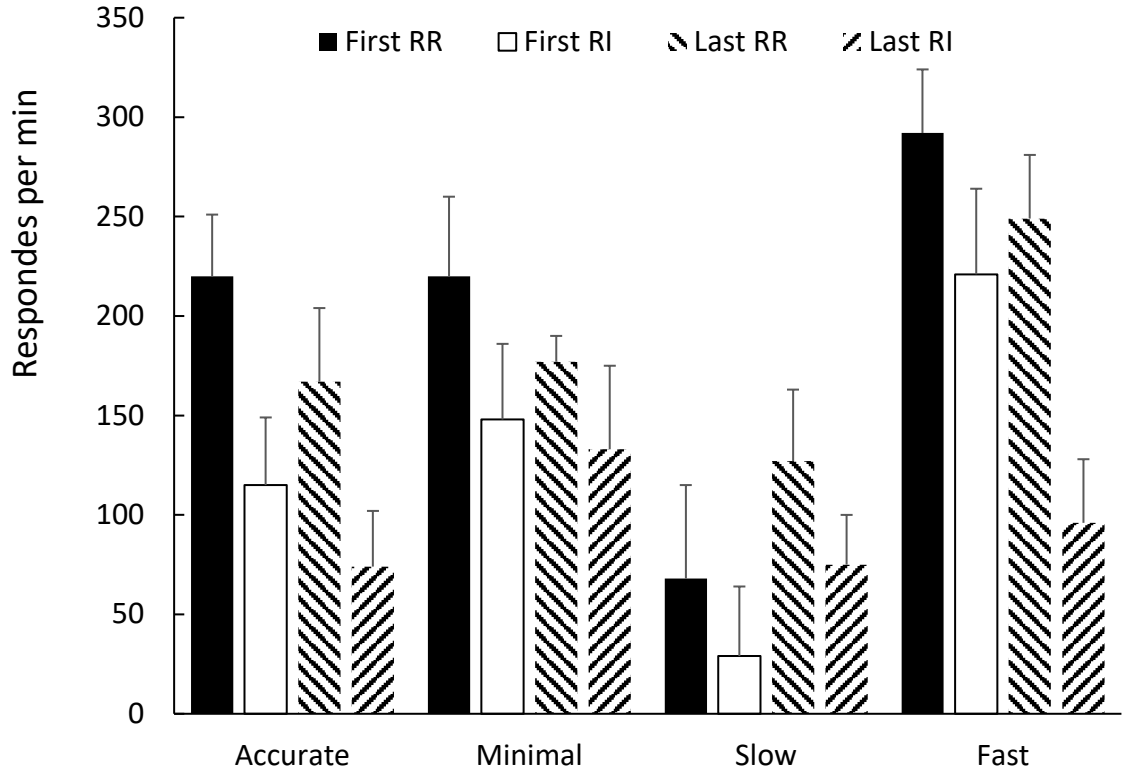


Figure 5: Experiment 2: Mean response rates for RR and RI schedules for the four groups (accurate, minimal, go-slow and go-fast groups) on the first and last trials, as calculated using the cut-off method. Top panel = bout-initiation rates. Bottom panel = within-bout rates. Error bars = 95% confidence intervals.

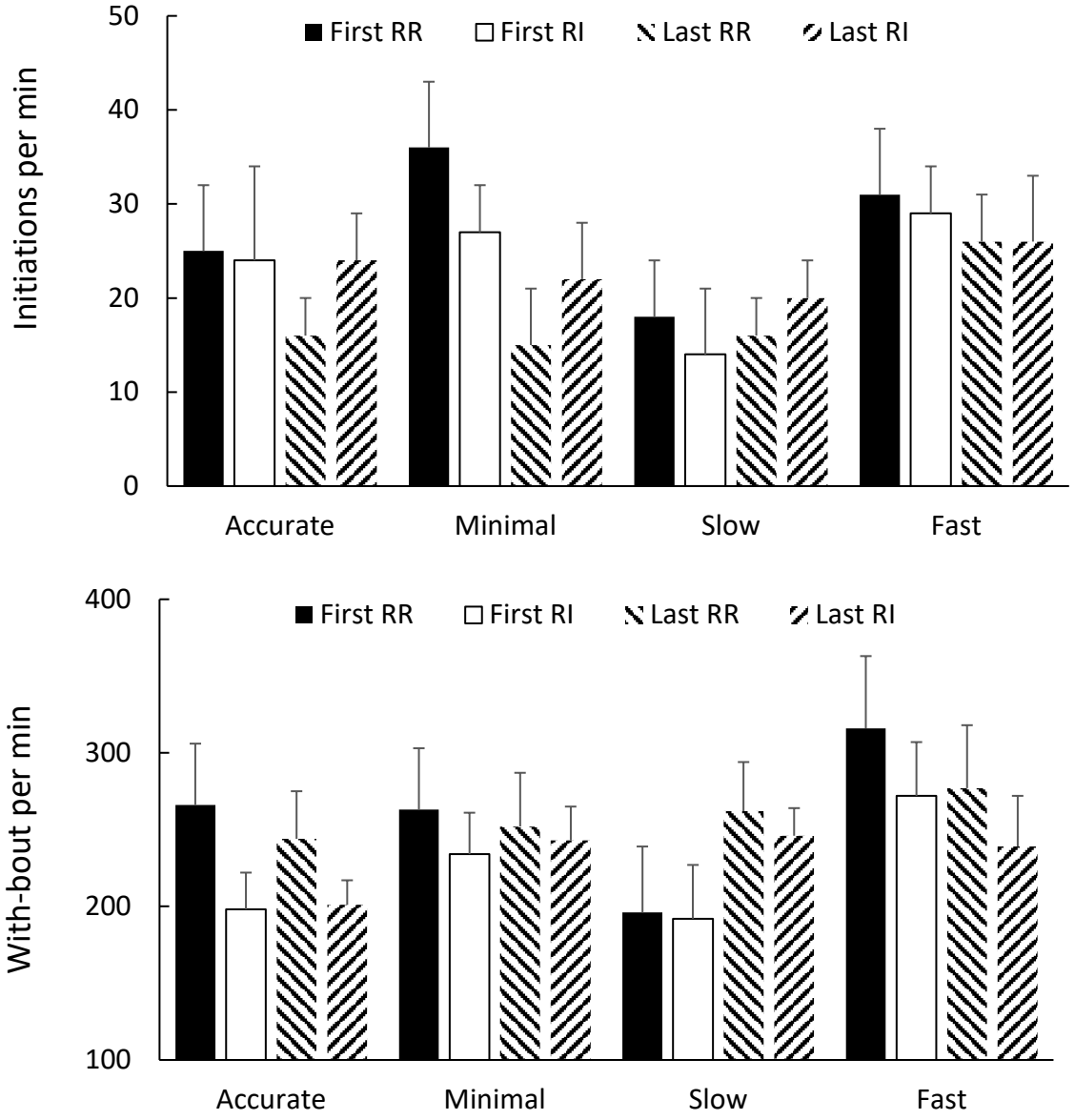


Figure 6: Experiment 3: Group-mean responding on the first and last extinction trials for both schedules for all groups (accurate, minimal, go-slow and go-fast groups). Error bars = 95% confidence limits.

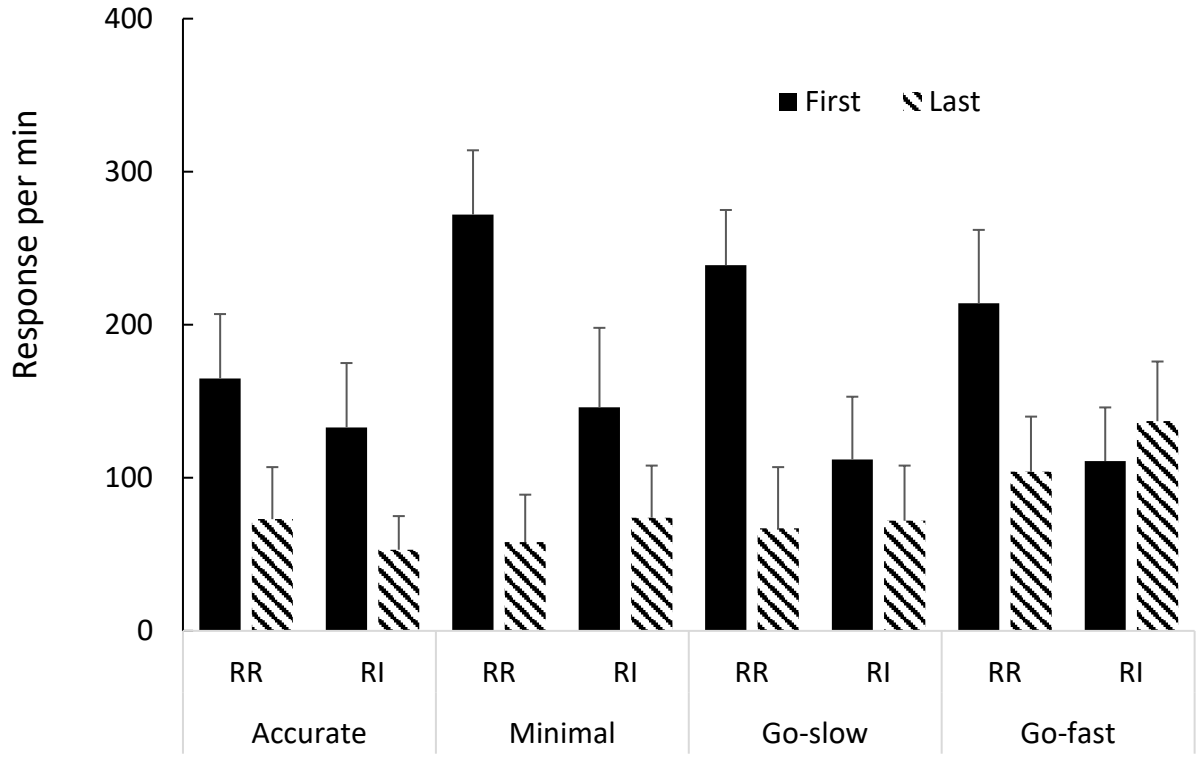
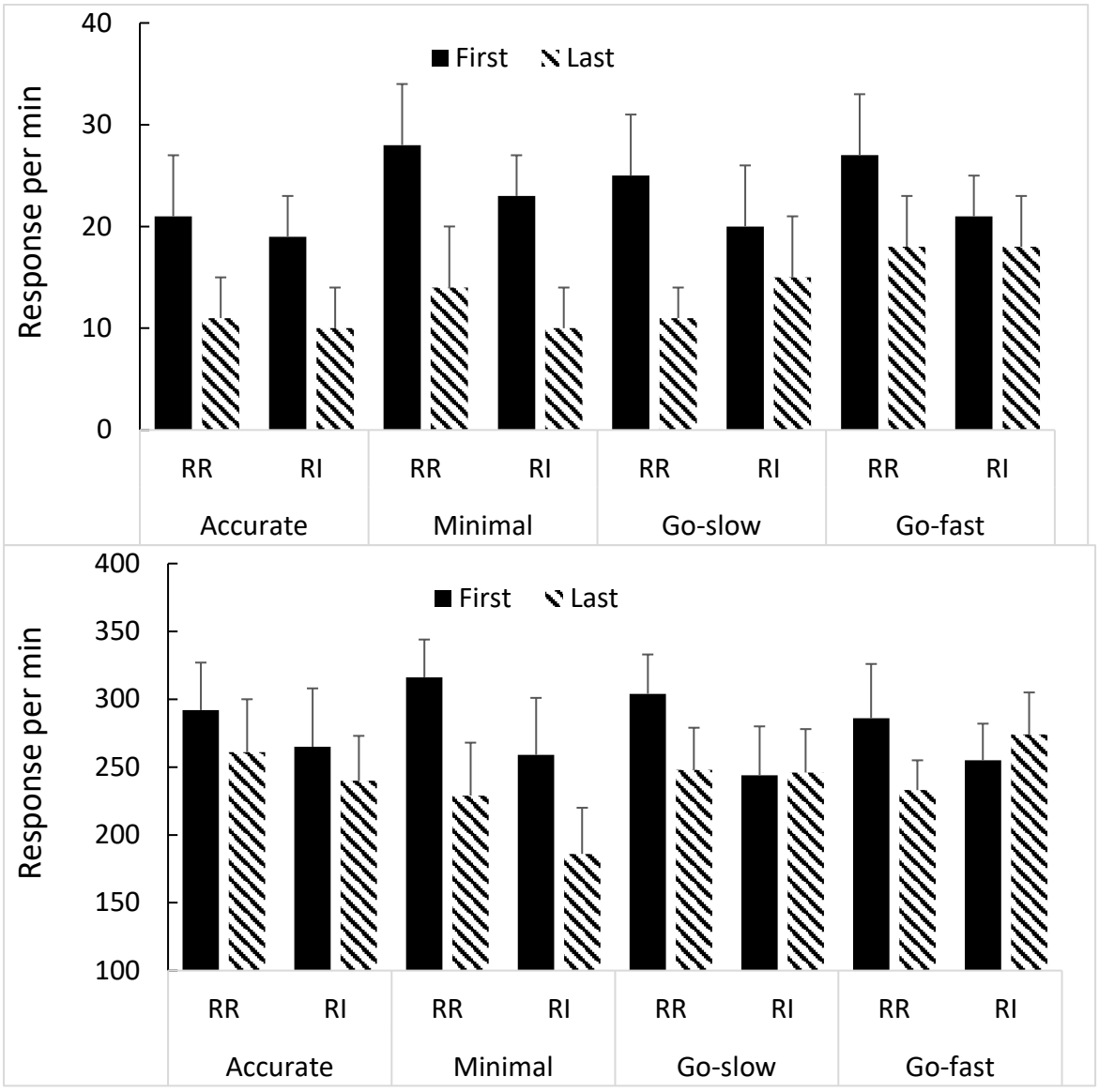


Figure 7: Experiment 3: Group mean bout-initiation (top panel) and within-bout (bottom panel) response rates for RR and RI schedules, for all groups (accurate, minimal, go-slow and go-fast groups) on the first and last extinction trials, using the cut-off method. Error bars = 95% confidence intervals.



Supplementary Materials

The cut-off approach to analysing the micro-structure of responding makes assumptions about which responses should be regarded as bout-initiating and within-bout. The alternative 'survivor' method turns into logs the percentage of IRTs emitted in a particular time-bin of all responses not emitted in shorter IRT bins. The slope of a resulting log survivor plot is an indicator of the response rate: the steeper the slope, the higher the rate of responding. The slope of log survival plots is not uniform, but comprises an initially steep slope (bout-initiations), followed by a shallow slope (within-bout), indicating the presence of two different types of responding (see Shull, 2011). A double exponential equation can be fitted to these data; where the equation fits the two distributions of IRTs (i.e., those prior to the 'break', taken to represent response initiations; and those after the break, taken to represent within-bout responses. This equation takes the form: Ppred = a*exp(-bt)+(1-a)*e(-dt), where b and d represent the rates of within-bout and bout-initiation, respectively. However, the log survivor method requires certain assumptions to be made about the distribution of the data, which may or may not be present, and which may be a relatively poor fit to the data (Reed, 2020). Thus, both approaches have different shortcomings (Reed, 2015), and it is unclear which would be best suited to explore the current set of questions.

Experiment 1

Micro-structure (survivor method)

Figure 1: Experiment 1: Mean overall response rates for RR and RI schedules both groups (Accurate group and minimal group) on all trials, using the log survivor method. Top panel = response initiation rates. Bottom panel = within-bout rates. Error bars = 95% confidence intervals.

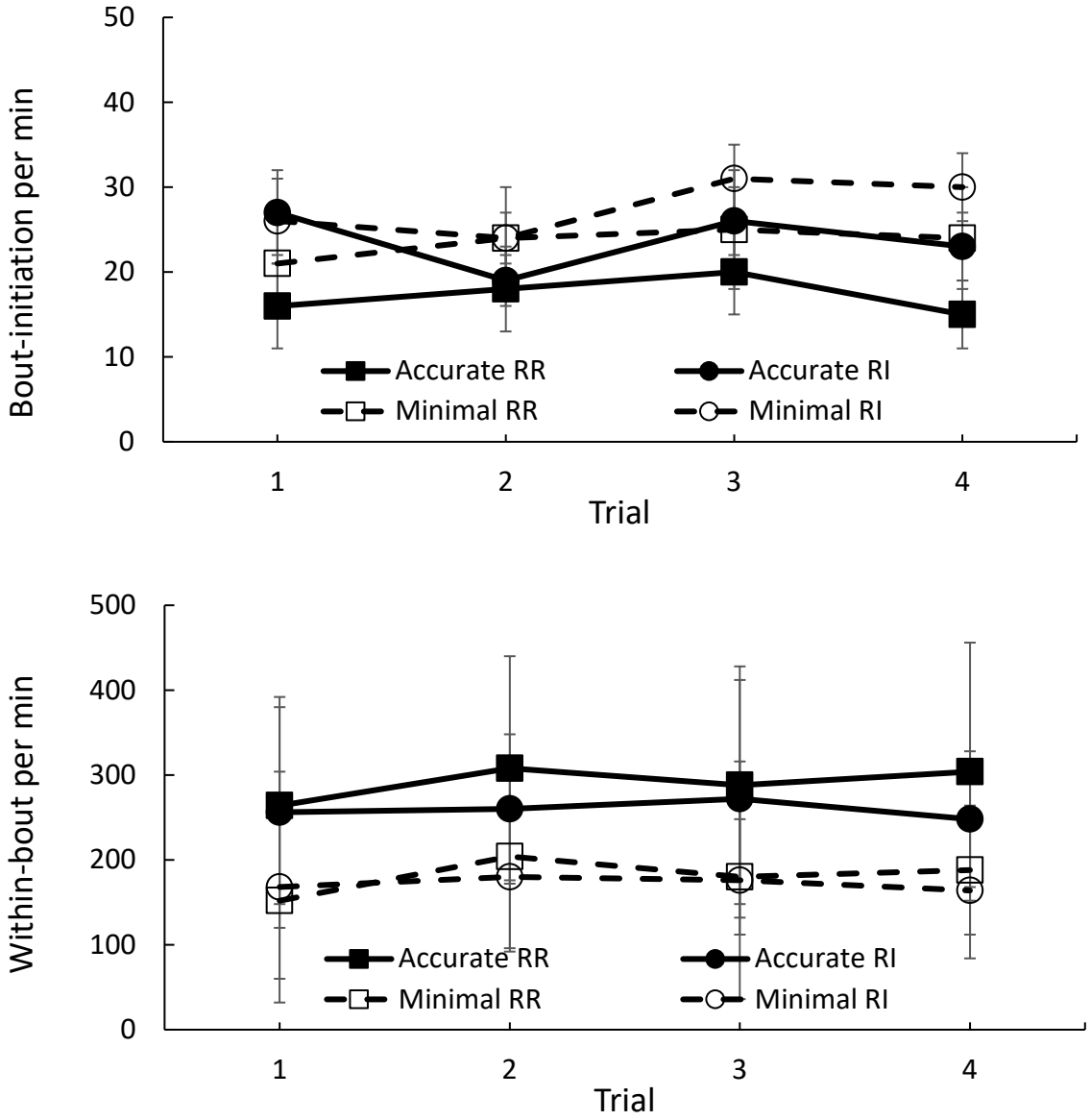


Figure 1 shows the group-mean bout-initiation response rates (top panel) and within-bout responses rates (bottom panel) for two schedules, across the four trials, for both groups using the survivor analysis. There was no difference between RR and RI bout-initiation rates (top panel), and no impact of instructions. A three-factor mixed-model ANOVA (group x

schedule x trial) revealed only a significant main effect of trial, $F(3,219)=4.56$, $p<.005$, $\eta^2_p=.059[.007:.118]$, $pH_1/D=.999$. There were no main effects of group, $F(1,73)=1.12$, $p=.294$, $\eta^2_p=.015[.000:.108]$, $pH_0/D=.633$, or schedule, $F(1,73)=2.29$, $p=.134$, $\eta^2_p=.030[.000:.139]$, $pH_0/D=.989$, and no significant interactions: schedule and trial, $F(3,219)=1.42$, $p=.237$, $\eta^2_p=.019[.000:.057]$, $pH_0/D=.637$; schedule and group, $F<1$, $\eta^2_p=.013[.000:.104]$, $pH_0/D=.998$; trial and group, $F<1$, $\eta^2_p=.004[.000:.021]$, $pH_0/D=.998$; three-way: $F(3,219)=.45$, $p=.718$, $\eta^2_p=.006[.000:.028]$, $pH_0/D=.997$.

There were higher within-bout rates for accurate group compared to the minimal group, and numerically higher RR rates compared to RI rates for the accurate group (four-trial mean 291 versus 259), compared to the minimal group (180 versus 175). A three-factor mixed-model ANOVA (group x schedule x trial) revealed a statistically significant main effect of group, $F(1,73)=14.63$, $p<.001$, $\eta^2_p=.167[.09:.248]$, $pH_1/D=.972$, but not of schedule, $F<1$, $\eta^2_p=.001[.000:.004]$, $pH_0/D=.999$, or trial, $F<1$, $\eta^2_p=.008[.000:.021]$, $pH_0/D=.999$. There was a significant two-way interaction between schedule and trial, $F(3,219)=7.23$, $p<.001$, $\eta^2_p=.090[.004:.243]$, $pH_1/D=.913$, but not between schedule and group, $F(1,73)=2.21$, $p=.141$, $\eta^2_p=.029[.000:.073]$, $pH_0/D=.854$, or group and trial, $F<1$, $\eta^2_p=.002[.000:.005]$, $pH_0/D=.999$. There was a significant three-way interaction, $F(3,219)=2.82$, p=.040, $\eta^2_p=.037[.003:.203]$, $pH_1/D=.811$.

A two-factor mixed-model ANOVA (group x schedule) was conducted for the first and last blocking of training. On the first trial, there were main effects of group, $F(1,73)=11.05$, $p<.001$, $\eta^2_p=.131[.024:.309]$, $pH_1/D=.976$, and schedule, $F(1,73)=12.53$, $p<.001$, $\eta^2_p=.147[.043:.292]$, $pH_1/D=.915$, but no group and schedule interaction, $F(1,73)=1.32$, $p=.253$, $\eta^2_p=.018[.000:.102]$, $pH_0/D=.945$. On the last trial, there were main effects of group, $F(1,73)=6.60$, $p= 012$, $\eta^2_p=.084[.006:.202]$, $pH_1/D=.976$, and schedule,

$F(1,73)=7.75$, $p=.007$, $\eta^2_p=.096[.033:.245]$, $pH_1/D=.919$, but no interaction, $F(1,73)=1.84$, $p<.179$, $\eta^2_p=.025[.000:.087]$, $pH_0/D=.893$.

However, while this effect was statistically reliable when using the cut-off method, it was only numerically present using the survivor method, which may reflect the moderate fit of the data using the latter method. The mean variance accounted for (VAC) for the survivor method for this experiment (across all participants and schedules) was 35.34% (± 15.74; range = 2 – 85), which was a moderate fit.

Experiment 2

Micro-structure (survivor method)

Figure 2: Experiment 2: Mean response rates for RR and RI schedules for the four groups (accurate, minimal, go-slow and go-fast groups) on the first and last trials, as calculated using the survivor method. Top panel = bout-initiation rates. Bottom panel = within-bout rates. Error bars = 95% confidence intervals.

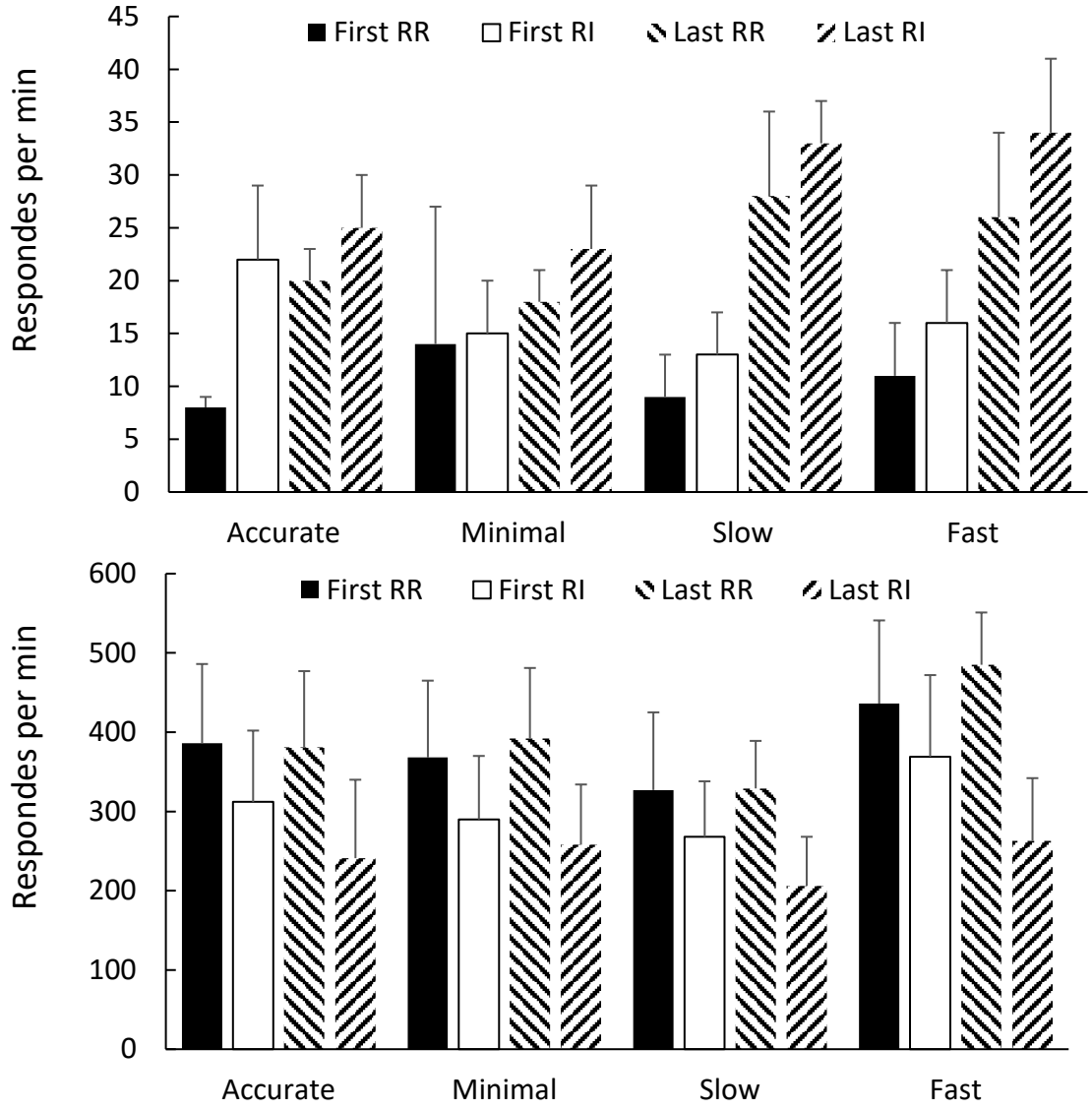


Figure 2 shows the group-mean bout-initiation (top panel) and within-bout (bottom panel) rates of responding for two schedules, on the first and last trials, using the survivor method. There was little effect of instructions on bout-initiation responding; response rates

tended to be higher for the RI than the RR schedule, and higher on the last than the first trial (especially for the go-slow and go-fast groups). A three-factor mixed–model ANOVA (group x schedule x trial) revealed significant main effects of schedule, $F(1,95)=28.75$, $p<.001$, $\eta^2_p=.231[.097:.363]$, $pH_1/D=.999$, and trial, $F(1,95)=28.57$, $p<.001$, $\eta^2_p=.316[.168:.443]$, $pH_1/D=.999$, and a significant interaction between trial and group, $F(3,95)=3.05$, $p=.032$, $\eta^2_p=.088[.000:.186]$, $pH_1/D=.879$. There was no main effect of group, $F(3,95)=1.07$, $p>.30$, $\eta^2_p=.058[.0000:.145]$, $pH_0/D=.995$, or interaction between schedule and group, $F<1$, $\eta^2_p=.001[.000:.009]$, $pH_0/D=.999$, trial and group, $F(3,95)=1.30$, $p=.278$, $\eta^2_p=.039[.000:.114]$, $pH_0/D=.992$, or the three factors, $F(3,95)=1.56$, $p=.205$, $\eta^2_p=.047[.000:.127]$, $pH_0/D=.989$.

There was a higher within-bout rate for RR compared to RI schedule responding, which was more pronounced on the last trial than on the first trial. There was little other consistent difference in responding. A three-factor ANOVA (group x schedule x trial) revealed a significant main effect of schedule, $F(1,95)=52.41$, $p<.001$, $\eta^2_p=.356[.206:.479]$, $pH_1/D=.999$, and a significant schedule and trial interaction, $F(1,95)=5.31$, $p=.023$, $\eta^2_p=.053[.003:.159]$, $pH_1/D=.999$. There was no main effect of trial, $F<1$, $\eta^2_p=.007[000:.076]$, $pH_0/D=.870$, or group, $F(3,95)=2.21$, $p=.093$, $\eta^2_p=.065[.000:.155]$, $pH_0/D=.972$, and no interaction between schedule and group, $F(3,95)=1.26$, $p=.293$, $\eta^2_p=.038[.000:.112]$, $pH_0/D=.993$, trial and group, $F<1$, $\eta^2_p=.005[.000:.034]$, $pH_0/D=.909$, or all three factors, $F<1$, $\eta^2_p=.004[.000:.030]$, $pH_0/D=.999$.

However, this effect was, again, not noted using the survivor method, where there was little clear impact of instructions on within-bout responding. The reasons for the differences between the results when using different methods of micro-structure analyses are not clear. However, it may be the relatively moderate fit of the survivor method may paly or role.

The mean variance accounted for (VAC) for the survivor method for this experiment (across all participants and schedules) was 27.26% (± 21.45; range = 3 – 82) – a moderate fit.

Experiment 3

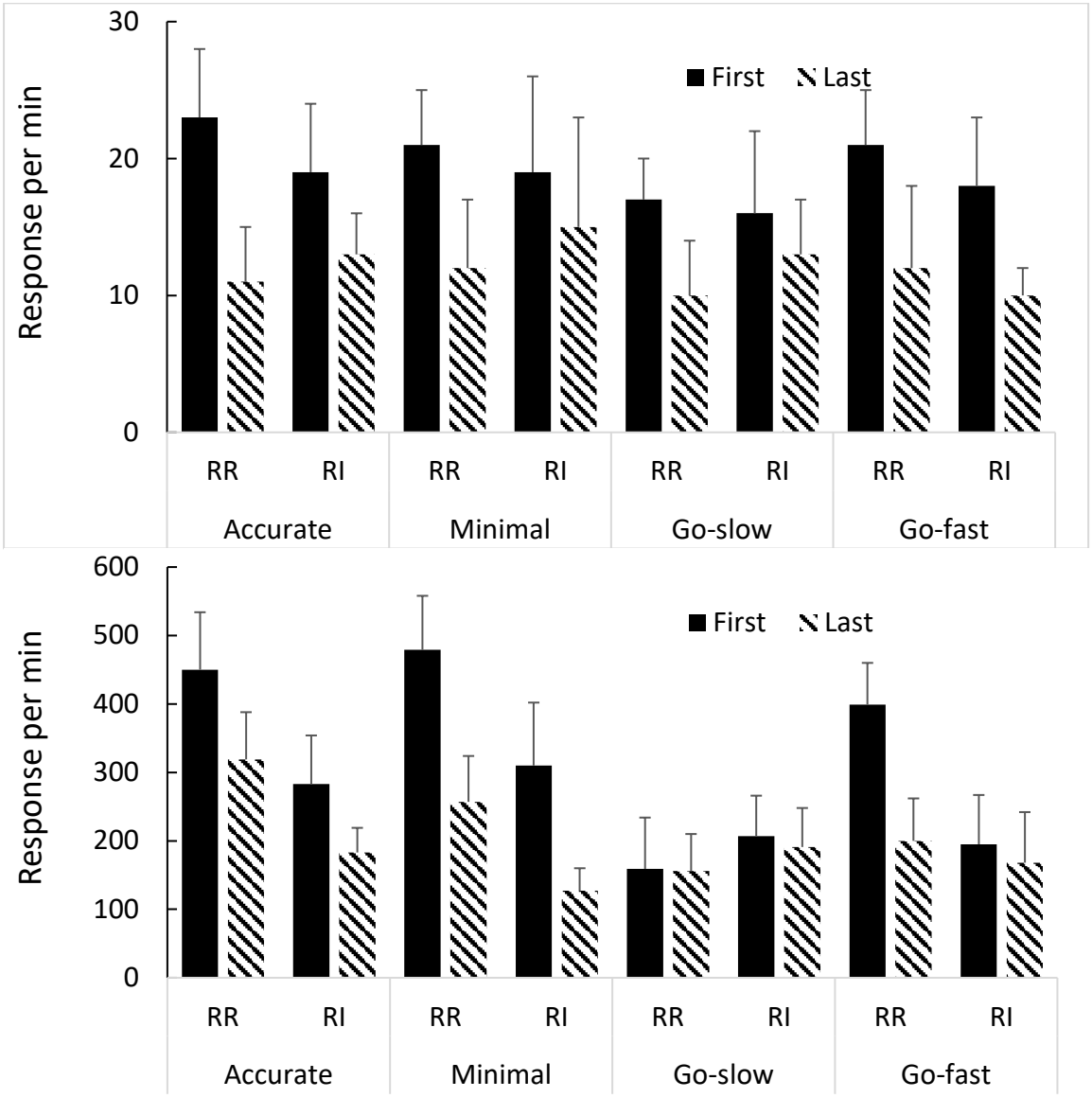
Micro-structure (survivor plot method)

Table1: Group-mean (standard deviation) response rates per minute for bout-initiation and within-bout determined by survivor methods, for the two schedules for the four instruction groups on the last block of training.

	Accurate		**Minimal**		**Go-slow**		**Go-fast**	
	RR	RI	RR	RI	RR	RI	RR	RI
Bout-initiation (survivor)	25.78 (9.93)	31.16 (10.82)	27.83 (12.53)	30.37 (18.18)	26.99 (13.87)	36.63 (20.41)	35.44 (20.70)	40.11 (16.76)
Within-bout (survivor)	400.36 (220.41)	225.49 (222.47)	375.09 (123.23)	291.82 (183.25)	233.29 (247.69)	76.23 (118.89)	407.24 (189.95)	178.98 (208.09)

There was an advantage for the RI schedule for bout-initiation rates, as determined by the log survivor method. A mixed-model ANOVA (schedule x group) revealed a significant effect of schedule $F(1,93)=9.32$, $p=.003$, $\eta^2_p=.091[.011:.212]$, $pH_0/D=.825$, but not of group, $F(3,93)=2.49$, $p=.065$, $\eta^2_p=.074[.000:.169]$, $pH_1/D=.995$, and no interaction, $F<1$, $\eta^2_p=.018[.000:.071]$, $pH_0/D=.997$. In contrast, there was a higher within-bout rate for the RR than the RI schedule, with higher rates in the go-fast group. A mixed-model ANOVA (schedule x group) revealed significant main effects of schedule $F(1,93) = 34.12$, $p < .001$, $\eta^2_p = .256[.116:.388]$, $pH_1/D = .999$, and group, $F(3,93)=8.79$, $p<.001$, $\eta^2_p=.056[.000:.142]$, $pH_1/D=.996$, but no interaction, $F(3,93)=1.02$, $p>.30$, $\eta^2_p=.072[.000:.165]$, $pH_0/D=.999$.

Figure 3: Experiment 3: Group mean bout-initiation (top panel) and within-bout (bottom panel) response rates for RR and RI schedules, for all groups (accurate, minimal, go-slow and go-fast groups) on the first and last extinction trials, using the survivor method. Error bars = 95% confidence intervals.



The mean variance accounted for (VAC) for the survivor method for this experiment (across all participants and schedules) was 30.04% (± 15.73; range = 5 – 79), which was a moderate fit, but with great variation. Figure 3 shows the group-mean bout-initiation (top panel) and within-bout (bottom panel) response rates for two schedules across the first and last extinction trials, using the survivor analysis. Bout-initiation rates (top panel Figure 3) decreased over extinction, but there was little impact of schedule or instructions. A three-factor mixed-model ANOVA (group x schedule x trial) showed a significant main effect of

trial, $F(1,93)=39.74$, $p<.001$, $\eta^2_p=.299[.152:.429]$, $pH_1/D=.999$. There were no effects of schedule, $F<1$, $\eta^2=.004[.000:.063]$, $pH_0/D=.999$, or group, $F<1$, $\eta^2_p=.009[.000:.079]$, $pH_0/D=.999$, and no interactions: trial and schedule, $F(1,93)=2.39$, $p=.125$, $\eta^2_p=.025[.000:.115]$, $pH_0/D=.998$; trial and group, $F<1$, $\eta^2_p=.019[.000:.073]$, $pH_0/D=.999$; schedule and group, $F<1$, $\eta^2_p=.028[.000:.094]$, $pH_0/D=.999$; all three factors, $F<1$, $\eta^2_p=.012[.000:.056]$, $pH_0/D=.990$.

Within-bout rates decreased over extinction, more so for the RR than the RI schedule, and more so for the accurate and minimal groups. A three-factor mixed-model ANOVA (group x schedule x trial) showed a statistically significant main effect of trial, $F(1,93)=63.19$, $p<.001$, $\eta^2_p=.405[.253:.523]$, $pH_1/D=.999$, and schedule, $F(1,93)=52.84$, $p<.001$, $\eta^2_p=.362[.211:.486]$, $pH_1/D=.975$, and group, $F(3,93)=3.93$, $p=.011$, $\eta^2_p=.113[.007:.219]$, $pH_1/D=.973$. There was a significant interaction between trial and schedule, $F(1,93)=14.06$, $p<.001$, $\eta^2_p=.131[.030:.260]$, $pH_1/D=.519$, but not for trial and group, $F(3,93)=2.20$, $p=.093$, $\eta^2_p=.066[.000:.153]$, $pH_1/D=.293$, schedule and group, $F(3,93)=2.36$, $p=.076$, $\eta^2_p=.071[.000:.164]$, $pH_1/D=.369$, or all three factors, $F(3,92)=1.86$, $p=.141$, $\eta^2_p=.057[.000:.143]$, $pH_0/D=.982$.

Separate two-factor ANOVAs (schedule x trial) were performed for each instruction group. For the accurate instruction group there were main effects of trial, $F(1,25)=12.76$, $p<.001$, $\eta^2_p=.338[.063:.549]$, $pH_1/D=.999$, and schedule, $F(1,25)=25.11$, $p<.001$, $\eta^2_p=.501[.198:.668]$, $pH_1/D=.999$, but no interaction $F<1$, $\eta^2_p=.012[.000:.186]$, $pH_0/D=.999$. For the minimal instruction group there were significant main effects of trial, $F(1,19)=34.60$, $p<.001$, $\eta^2_p=.646[.320:.777]$, $pH_1/D=.999$, and schedule, $F(1,19)=39.89$, $p=.117$, $\eta^2_p=.677[.366:.797]$, $pH_1/D=.723$, but no interaction $F<1$, $\eta^2=.045[.000:.289]$, $pH_0/D=.999$. For the go-slow instruction group there were significant main effects of trial, $F(1,19)=7.43$, $p=.013$, $\eta^2_p=.281[.013:.527]$, $pH_1/D=.876$, and schedule, $F(1,19)=4.67$, $p=.0744$,

η^2_p=.198[.000:.458], pH_1/D=.902, and a significant interaction $F(1,19)=12.93$, p=.002, η^2_p=.405[.074:.618], pH_1/D=.970 (indicating a drop in the RR, but not RI, schedule rate). For the go-fast instruction group there were significant main effects of trial, $F(1,30)=14.47$, $p<.001$, η^2_p=.325[.074:.526], pH_1/D=.991, and schedule, $F(1,30)=10.68$, p=.003, η^2_p=.263[.038:.474], pH_0/D=.964, and a significant interaction $F(1,30)=11.22$, p=.002, η^2_p=.272[.043:.482], pH_1/D=.964 (indicating a decrease in RR, but not RI, rate).