Demonstrating and Investigating Resurgence with Human Participants in Laboratory Research

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Abstract

Resurgence is the recurrence of a previously extinguished behaviour. Resurgence, a behavioural phenomenon, is of increased interest in animal and clinical human research. Three recent accounts have explained the resurgence effect. Recent studies have also investigated factors successful in affecting the extent of resurgence. Yet limited work citing resurgence with human participants in laboratory research is concerning. These works investigating resurgence with humans presented challenges that questioned experimental control of behaviour. Furthermore, these procedures included lengthy sessions, complex responses, and rule-following behaviours. A methodology, using elements of a pursuit-tracking task and general descriptive instructions, was created. The methodology first addressed the challenges by achieving good experimental control of behaviour. It then continued to demonstrate resurgence in both four- and three-phase procedure. Three experiments conducted demonstrated resurgence in a manner like those of the animal literature. Replication of findings from previous research also proved the methodology robust in investigating resurgence. Consideration of potential implications, and further use and future development were discussed.

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Literature Review of Resurgence

Resurgence is the recurrence of a previously reinforced behaviour (Redner, 2012; Sweeney & Shahan, 2013; Winterbauer & Bouton, 2010). In an operant research setting, two behaviours (Behaviour A and B) are used to study resurgence. Behaviour A is first reinforced, then reinforcement for Behaviour A is removed (extinction). Next, Behaviour B is reinforced while Behaviour A remains unreinforced. Then, reinforcement for Behaviour B is removed. When Behaviour A is observed to recur, that recurrence of Behaviour A is termed resurgence (Reed & Morgan, 2007; Winterbauer & Bouton, 2010).

The first account proposed by Shahan and Sweeney (2011) argues that the resurgence effect is based on Behavioural Momentum Theory (BMT). The account provides a quantitative model of resurgence. The model suggests that Behaviour A resists extinction as the stimulus-reinforcer relation remains present in the context of training Behaviour B. If the stimulus for Behaviour A remains present during the training of Behaviour B, then the stimulus-reinforcer relation of Behaviour A is further increased. This increased stimulus-reinforcer relation contributes to the resistance to extinction and the strength of Behaviour A when it recurs. Thus, the model predicts that resurgence can decrease as time in extinction of Behaviour A plus exposure to Behaviour B increases. Yet resurgence would nonetheless be observed.

This resurgence account was also demonstrated by Sweeney and Shahan (2013) with pigeons, they conducted two experiments using a variable-interval (VI) 60-s for Behaviour A and 30-s schedule of reinforcement for Behaviour B across two conditions. One condition with constant alternative reinforcement, and other with alternative reinforcement removed three times. The data indicated that

an increased exposure to extinction of Behaviour A plus training of Behaviour B can be a successful strategy for reducing resurgence. Yet their findings suggested that resurgence cannot be eliminated completely.

Podlesnik and Shahan (2010) used BMT in their argument and it corresponds with Shahan and Sweeney's (2011) account. They argued the decrease in responding seen during the extinction of Behaviour A terminates only the response-reinforcer relation. The stimulus-reinforcer relation however, is not terminated and remains present. They also suggested that the training of Behaviour B has a disruptive effect on Behaviour A while Behaviour A remains in extinction. The disruptive effect accounts for the reduction of Behaviour A during resurgence testing. Yet, Behaviour A is still observed when Behaviour B is no longer reinforced. They concluded that the disruptive effect of Behaviour B during training is unable to eliminate Behaviour A from recurring. Hence, BMT provides a good framework to account for the existing resurgence data in the literature (e.g., Epstein, 1983; Reed & Morgan, 2007; Reed & Clark, 2011; Wacker et al., 2011; Winterbauer & Bouton, 2010).

The second account focuses on the persistence of Behaviour A and the difficulty in sustaining behaviour change (Bouton, 2014). The absence of resurgence is defined as Behaviour B persists and when Behaviour A fails to recur. But the recurrence of Behaviour A has always been observed in several studies (Reed & Clark, 2011; Sweeney and Shahan, 2013; Winterbauer & Bouton, 2010). Bouton and Schepers (2014) suggested that the extinction of Behaviour A is not erasure or unlearning, but a form of behavioural inhibition that leaves Behaviour A susceptible to relapse. Therefore, resurgence is robust, like any other post-extinction phenomenon (renewal & spontaneous recovery), cannot be prevented.

Winterbauer et. al., (2013) previously tested the conclusion about resurgence as robust with rats in their second experiment. The experiment, in the second phase, used a random ratio (RR) schedule as opposed to variable interval (VI). They hypothesized that a RR schedule would generate higher response rates from the rats. The results showed that resurgence survived extensive (36 sessions) response elimination training. The higher response rate generated in the RR schedule did nothing to decrease the magnitude of resurgence. The magnitude of resurgence remained unchanged beyond what was observed after four sessions. Their findings correspond with the second account that resurgence is robust. Behaviour A will always be susceptible to recur even after prolonged extinction plus alternative treatment.

The final account by Winterbauer and Bouton (2010; 2012) and Bouton (2014) focuses on resurgence seen as the renewal effect. The account describes Behaviour A recurring when it returned to the original training context. Winterbauer and Bouton (2010) conducted four experiments with rats demonstrating the renewal effect. They trained the rats to leverpress under three different context-phases in all experiments. The experiments showed that Behaviour A recurred with changes made in each context-phase. Changes included the adjustment in the rate of reward delivery, and schedules of reinforcement. Even a small change was enough to create a new context, allowing for Behaviour A to recur. The experiments provided a clear demonstration of resurgence as the renewal effect.

Winterbauer and Bouton (2012) predicted that thinning the rates of reinforcement can reduce the extent of resurgence. The procedure in their experiment was similar to their 2010 study but a change was made in the delivery

of Behaviour B reinforcement. The rate of delivery went through a gradual decrease before resurgence testing. The results showed a reduction in the resurgence effect. Likewise, Bouton (2014) also proposed that the generalization of Behaviour B to other contexts encouraged the reduction the magnitude of resurgence. For instance, if the training of Behaviour B occurred in the original training context of Behaviour A (where resurgence is likely observed), then the magnitude of resurgence will reduce. Hence, resurgence can be minimized, but not eliminated.

Recent studies have also investigated several factors affecting the extent of the resurgence. The literature review found several factors showing a pronounced effect on the resurgence. The following subsections of this review focuses on these factors.

Factors: Previous response rate, history of reinforcement of Behaviour A

Winterbauer and Bouton (2010) investigated factors modulating resurgence with rats who were taught to leverpress. Of interest in their third experiment was the effect of the history of reinforcement of Behaviour A on the magnitude of resurgence. The experiment compared resurgence of lever-pressing in rats between two groups. One with an initial history of Behaviour A while the other without an initial history. Their results indicated the group with the initial history showed more pronounced resurgence (recurrence of Behaviour A) as compared to the group without the initial history.

Doughty, Cash, Finch, Holloway and Wallington (2010) also assessed the effects of a lengthier training history on the magnitude of resurgence. Their procedure included a matching-to-sample methodology and the experiment was conducted with humans. Participants were exposed to a three-phase resurgence

procedure in one session (700 discrete trials) across two conditions. One condition had 50 more trials of conditioning while the other did not. Their results, like Winterbauer and Bouton (2010), showed similar findings. A greater magnitude of resurgence was observed in the condition with more training than the condition without.

Reed and Morgan (2007) examined the effects of the response rate of Behaviour A during training on the magnitude of resurgence. The study in Experiment 1 split rats into two groups who were taught to leverpress. The first group of rats were exposed to a random ratio (RR) schedule while other were exposed to a random interval (RI) schedule. They predicted that the group exposed to the RR schedule would generate a higher response rate and hypothesized to show greater resurgence. The study also controlled for the reinforcement rates so that they are equal to isolate only the response rates. The results indicated that the groups on the RR schedule came to generate a higher response rate and showed greater resurgence relative to those of the RI schedule.

The same study (Reed & Morgan, 2007) in Experiment 2 also found similar findings. Another set of rats split into two groups and taught to lever-press. One group exposed to a differential reinforcement of high rate (DRH) schedule while the other to a different reinforcement of low rate (DRL) schedule. They found that the group exposed to the DRH schedule achieved higher response rates. And consequently, showed a more pronounced resurgence effect. Additionally, Behaviour A nonetheless recurred the least for the group on the DRL schedule even though the response rates were low. The authors concluded that resurgence is a robust effect, incapable of being eliminated.

Winterbauer, Lucke, and Bouton (2013) examined the impact of several

variables on resurgence. Of interest in their first experiment was the final rate of response of Behaviour A during training on the extent of resurgence. The study taught rats to leverpress and split them into two groups. The first group received a ratio schedule while the other received a yoked variable interval schedule. The experiment controlled for the reinforcement rates between the two schedules equal. The authors predicted that response rates would be higher for the group on the ratio schedule. The findings showed that the group on the ratio schedule produced more responding when tested for resurgence. It also appeared that the final rate of response was a better indicator of the strength of resurgence.

Factors: Increased training of Behaviour B

Reed and Clark (2011) examined the degree of resurgence based on differences in training periods (Behaviour B) during Phase 2. 24 children diagnosed with Autism Spectrum Disorder (ASD) were split into four different groups and taught different play sequences in Phase 2. The play sequences varied in terms of time exposed to schedules of reinforcement and the ratios of the schedules. They were then examined in relation to their effect on resurgence. Both groups (VR-4 60 mins and VR-2 30 mins) displayed less resurgence than did on the other group (VR-4 30 mins). The findings indicated that a longer conditioning of Behaviour B had a pronounced effect which reduces the extent of resurgence.

Winterbauer, Lucke, and Bouton (2013) examined the role of the training of Behaviour B on the extent of resurgence. Like their first experiment, Behaviour A received 12 sessions of training at first. They then split the rats into three groups and each group received 4, 12 or 36 sessions of Behaviour B training. The findings indicated that resurgence was more profound in the group with 4 sessions as compared to the group with 12 and 36 sessions. But there were no differences

in the magnitude between the group with 12 and 36 sessions. Resurgence stayed the same. The authors concluded that extending the training of Behaviour B has its limits in reducing resurgence.

Factors: The role of extinction in Behaviour A and repeated extinction testing

Sweeney and Shahan (2013) examined the effects of time in extinction of Behaviour A on the magnitude of resurgence. Their study used pigeons taught to key peck on illuminated keys and these pecks were identified as behaviour of interest for their investigation of resurgence. The results of the first experiment successfully demonstrated that resurgence decreased as the time in extinction of Behaviour A plus exposure to training of Behaviour B increased. Their second experiment used a variant from their first experiment of extending the time spent in extinction of Behaviour A plus time in training of Behaviour B. This variant consisted of repeated resurgence test in which Phase 2 and 3 were repeated twice and was used to investigate its effect on resurgence. A decrease in the recurrence of Behaviour A was also observed.

Wacker et al. (2013) also examined the role of time in extinction for Behaviour A on the magnitude of resurgence. Their experiment was conducted with children using Functional Communication Training (FCT). The procedure was similar to Sweeney and Shahan's (2013) but the results were different to those reported by Sweeney and Shahan (2013). Behaviour A continued to recur during the return to the conditions of extinction and minimal differences were observed during the final extinction condition relative to the initial extinction condition.

The literature revealed several interesting findings. It had been well established that the three accounts have explained the resurgence effect. The review also provided evidence for the factors that have a pronounced effect on

resurgence. In particular, the higher response rates, and longer history of reinforcement of Behaviour A have been consistently shown to reduce the extent of resurgence. Hence, there isn't a real need to examine these factors further in this thesis.

Winterbauer and Bouton (2013) talked about resurgence as the renewal effect. They mentioned that resurgence contained the element of having associative features. Studies (Winterbauer & Bouton, 2010; 2012; Bouton, 2014) were concerned with changes in the each phase during their investigation. These changes included adjustments in reinforcement delivery, and schedules of reinforcement between phases to create new contexts. It was found that a small change in the context was sufficient for Behaviour A to recur. Yet no studies investigating resurgence have used two different behaviours to create different contexts. Using two different behaviours meant that the topography changes while they remain functionally equivalent. Perhaps a change in topography might be enough to create new contexts, and subsequently for Behaviour A to recur. This might be worthwhile investigating in this thesis.

The review showed differences in findings with the role of time in extinction of Behaviour A on the magnitude of resurgence. Sweeney and Shahan (2013) found a reduction in resurgence while Wacker et. al., (2013) found minimal differences. A further exploration revealed a procedural difference in their investigation of resurgence during the extinction of Behaviour A and training of Behaviour B. The three-phase procedure places Behaviour A on extinction while concurrently trains Behaviour B (Bouton & Schepers, 2014; Doughty et al., 2010; Reed & Morgan, 2007; Sweeney & Shahan, 2013; Winterbauer & Bouton, 2012). The four-phase procedure first places Behaviour A on extinction, then

trains Behaviour B (Reed & Clark, 2011; Wacker et al., 2011; Wacker et al., 2013). Additionally, Wacker et. al., (2013) study had some methodological issues. Hence, there is a need to clarify the difference in the use of a four- and three-phase procedure for investigating resurgence. The effects of time in extinction of Behaviour A on the extent of resurgence can also be resolved by the clarification.

Other research have also examined the introduction of a negative 'abstinence' contingency during the training of Behaviour B. Bouton and Schepers (2014) looked into how its introduction affected the extent of resurgence. They imposed a 'time-out' contingency for their first experiment with rats. The rats had to abstain from Behaviour A responding for a period of time until Behaviour B can be reinforced. Their results showed a reduction in resurgence. But they suggested it wasn't the negative contingency that contributed to the reduction. Instead, introducing the contingency made reinforcers harder to earn and more widely spaced. This resembled thinning the delivery of reinforcers like Winterbauer and Bouton (2012) suggested. It would be interesting to see how these findings generalised to human laboratory research.

McHugh, Proctor, Herzog, Schock, and Reed (2012) examined the effects of a mindfulness task on extinction and resurgence. The study looked into how mindfulness could suppress verbal rules in responding. It was also argued that humans are insensitive to contingencies in laboratory settings. The authors predicted that using mindfulness could make people respond to the contingencies. Their findings however, showed that new verbal rules were generated instead of being more responsive to the contingencies. Participants did not become more sensitive to the task contingencies as predicted. Participants were found to respond based on rule-following as opposed to the arranged contingencies.

McHugh's (2012) demonstration of resurgence was a product of verbal rules rather than a result of changes in the arranged contingencies. This is problematic as major resurgence theories assume behaviour is under contingency control. Hence, it is worthwhile to acknowledge the influence of verbal rules on responding with humans in laboratory settings.

Addressing the Challenges in Investigating Resurgence with Human Participants in Laboratory Research

Introduction

Most recent studies investigating resurgence have been conducted in two settings. The first setting is in laboratories with animals (Winterbauer et al., 2013; Sweeney & Shahan, 2013) manipulating variables like schedules of reinforcement. The other is with humans treating problem behaviours in an applied setting (Wacker et al., 2011; Wacker et al., 2013). Yet resurgence could also be investigated with humans in laboratory settings. A lack of work citing resurgence in that setting is concerning as only two recent attempts were found.

In one of these, McHugh et. al., (2012) in their second experiment, examined the effects of training history and a mindfulness induction phase on extinction and resurgence. People gained points by clicking on a computer screen. They first found that the rate of clicking increased for participants with training history. Then the participants without the mindfulness phase progressed showing greater degree of resurgence, and those with the mindfulness phase reduced the extent of resurgence. The study reported that the mindfulness phase removed the training history, and reduced resurgence. They concluded the mindfulness task made participants more sensitive to the change in contingencies.

One question here is how much of the control over responding seen during training and extinction was a product of the various experimental contingencies and how much was the product of instruction following. The participants were told to click either quickly or slowly to earn points. As the authors (McHugh et. al., 2012) pointed out that in many such experiments, participants have been shown to develop rules they then follow. Thus they might not be responsive to the

contingencies presented in the task. The clicking, then, could be verbally regulated rather than related to the arranged contingencies. Consequently, resurgence seen in the control group could be the result of previous rule-following rather than a result of the past contingencies. This in turn, might explain the lack of resurgence effect for the mindfulness group. The lack of resurgence could be a result of disruption of their verbal-control rather than of their sensitivity to the present contingencies. Although the data collected for the control group may reflect resurgence in appearance, it remains unclear if the arranged contingencies were responsible. This is problematic as the major resurgence theories assume that behaviour is under contingency control.

In the second study, Doughty et al. (2010) assessed the effects of training history on resurgence of responding. Three college students were exposed to one session with four-choice arbitrary-matching-to-sample tasks in each of two components of a multiple schedule. In which, each component across participants were asked to match the sample to one of four comparison stimuli. Over two of the conditions one of the correct matching stimuli was introduced for this stimulus in both components and extinction was introduced for this stimulus in the same components. There was some indication of reoccurrence of the earlier correct responses during extinction (i.e., resurgence).

Doughty's task was also quite complex and the data showed latencies to responding on some comparison to be around of 2 to 3-s. These long latencies slowed responding and produced low reinforcement rates which are said to reflect insensitivity to the contingencies of the task. This insensitivity was seen in the persistence of responding despite changes in the contingencies (LeFrancois & Metzger, 1993; Shimoff, Catania, & Matthews, 1981). Such insensitivity was

observed in Doughty et al., (2010) study. They reported there was considerable resistance to extinction of the previously correct response. Participants continued to respond in the same way as they had in the prior reinforcement condition (Condition 3) when extinction was introduced (Condition 4). Although there were initial changes in the data when the stimulus was changed in Condition 3 (extinction) to suggest sensitivity to contingencies, the later finding of persistence of responding and resistance to extinction during resurgence testing questions how much experimental control they had over behaviour. Thus it is not clear if responding was based on the contingencies or if there was another source of control. Once again, this is problematic as major resurgence theories assume that behaviour is under contingency control.

These challenges make it difficult to isolate and manipulate variables to achieve good experimental control of behaviour. Good experimental control is crucial in investigating resurgence with humans in laboratory research. A methodology that might address the problem of experimental control over participants' behaviour could include elements from a pursuit tracking task, such as that used by Bourbon and colleagues (1990). The task required participants to hold a handle to keep a cursor on a target presented on a computer screen. The cursor was programmed to move off target and at varying rates (termed the disturbances). Participants had to compensate for the disturbances by manipulating the handle so as to keep the cursor on the target (Bourbon et. al., 1990). Results showed a strong correlation between behaviour (i.e., manipulating the handle) and consequence (i.e., being on target). It appears that this pursuit tracking task allowed the use of a single simple response that, when it resulted in instantaneous and continuous feedback from the environment, was very

responsive to its consequences. Most importantly, it could be argued that the task showed control by contingencies not by verbal rules.

The pursuit-tracking task corresponds with procedures used in resurgence studies with animals. Animal studies used a short simple behaviour such as a key peck which allows for responding at a high frequency. These short simple responses were controlled by the arranged contingencies and have provided clear indication of the effects of changes in these contingencies on behaviour. It is possible that, with humans, a procedure similar to the pursuit-tracking task might result in behaviour that is responsive to changes in its effect as are key pecks with birds, and so may allow greater control of experimental behaviour than seen in studies by McHugh et. al., (2012) and Doughty etl. al., (2010).

Another issue that needed addressing is the instructions given to participants. The study by McHugh et. al., (2012) gave participants explicit instructions on what behaviour was required. The explicit instruction may have provided a rule. Petrie (2012) argued that a general descriptive instruction about the task may not do this. General instructions require participants to adapt their response to the arranged contingencies rather than rule-follow. Adaptation of responses might give a clearer sign of the effect of a reinforcer, instead of the rule, on the behaviour. The use of less specific instructions could help resolve the confound between whether it is a rule or a consequence that is driving behaviour change.

Thus, it is possible that the use of the pursuit-tracking task and general descriptive instructions could resolve some of the challenges and human participants might alter the way they respond in a laboratory setting. Achieving good experiment control could potentially help demonstrate resurgence better and

the methodology could then serve as the basis for investigations of its implications and generality.

The proposed task for this first experiment incorporated elements of the pursuit-tracking task and used general descriptive instructions. Participants were asked to maintain the water level in a tank drawn on a computer screen. Buttons on the screen were presented for participants. Click on these was the behaviour of interest. The clicks produced a decrease in the water level. Varied drip rates from a tap above the tank served as the disturbances that increased the water level. The water level provided continuous and instantaneous feedback on the effects of clicking and so was the consequence. The task allowed for conditions in which the buttons could become ineffective (extinction) and other buttons could be provided (alternative responses). These objects and events on screen can be arranged in a number of ways, thus enabling multiple conditions and phases.

Experiment 1 aimed to test if the task would provide a methodology that achieved good experimental control of behaviour. Three requirements were set out to show good experimental control of participants' behaviour. The first required participants to complete the entire experiment. The second required a match in responses between the behaviour and contingencies of the task during the training of the behaviours. The third required participants to keep within the goal of the task in Phase 1 to move on to Phase 2. If the methodology achieved good experimental control, then it should demonstrate resurgence better.

Method

Participants

Participants were 14 undergraduate and postgraduate psychology students from the University of Waikato who could earn course credits in specified

Psychology courses. Participants in courses which did not allow course credit went into the draw to win a supermarket voucher of $50 as a token of appreciation for their participation. No other demographics were obtained.

Recruitment

The initial five participants were recruited for achieving experimental control over behaviour and were tested for resurgence at a time of 30-s. The time in extinction of Behaviour A was set at 15-s. The next nine participants recruited were tested under a 60-s resurgence testing phase. The extinction time of Behaviour A remained at 15-s.

Ethics

The research project was approved by the School of Psychology Sub-committee of the University of Waikato Human Research Ethics Committee.

Apparatus

A computer laboratory, containing a workstation used by the participants to complete the computer-simulated task, was the location of the experiment. The laboratory was a small room with no windows. The door was closed when the computer-simulated task was running. The workstation consisted of a keyboard, mouse, the computer with windows operating system, and a monitor. The computer software used to run the computer-simulated task was called Drip v3.0, created by software author Rob Baker.

Procedure

Instructions. Following informed consent, and general introduction to the study, participants were directed to both the monitor, and printed instructions. The full instructions script can be found in Appendix A. After the participants had read

the instructions and all their questions have been answered, the experimenter left the room and the participants were left alone to complete the computer task.

Stimulus. Appendix B displays the screen which participants saw. Participants were presented with a large water tank with two red reference lines situated at 10% and 15% of its capacity. A tap on top of the tank dripped water into the tank at various rates. At the bottom of the tank there was an opening through which water was released to leave the tank. Flowers were also placed around the surroundings of the tank. A black button was already presented at the start of the task. The yellow button appeared later. At the start of the experiment, the water level was filled at 5% of its total capacity.

The task is outlined in Figure 1 and consisted of four phases. In Phase 1, participants were initially presented with only a black button on the screen to click. A click on the black button released a drop of water out of the bottom of the tank and decreased the water level by 2%. The drips from the tap above the tank increases the water level by 1% for each drip. The click compensated for any drips and participants could click at any rate to keep the water level between the two reference lines. Clicking elsewhere had no effect on the water level or the rate of drips. The rate of drips followed a constant oscillating pattern (sine-wave) with each crest and trough at the same level (low to high to low). The task was to keep the water level between the two reference lines for at least 60-s before the participants moved on to Phase 2. If participants were unable to meet the criterion after 300-s, then the experiment would be terminated and participants were debriefed.

In Phase 2, the black button remained present but stopped working. A click on the black button no longer released the water at the bottom of the tank.

All participants in Phase 2 experienced 15-s of this ‘extinction’ condition. The drips from the tap continued to leak from the tap and the water rose continuously. Any clicks had no effect on the water level. The criterion to move on to Phase 3 was the elapsed time of 15-s.

A yellow button appeared in Phase 3 while the black button remained ineffective. Participants could click on the yellow button to release the water from the tank to keep the water level between the two reference lines again. The length of time in Phase 3 depended on the time spent in Phase 1 plus the extinction time in Phase 2. The time in Phase 2 varied across participants as some participants might spend a longer time in Phase 1. The extinction time was included for the participants to compensate for the increase in water level during Phase 2. This inclusion allowed the participants to return the water level to the reference lines. Once the time had elapsed in Phase 3, Phase 4 started.

Both the yellow and black button became ineffective in Phase 4. They remained ineffective for the rest of the experiment. Any click had no effect on the water level. The length of this phase was set at 30-s for the first five participants and 60-s for the other nine participants. Once the time had elapsed, the experiment ended and participants were debriefed. The duration of the experiment lasted less than 15 minutes.

These four phases were identical to a four-phase procedure investigating resurgence like those seen in the literature Wacker et al., 2011; Wacker et al., 2013; Reed & Clark, 2011). In Phase 1, Behaviour A is reinforced. In Phase 2, Behaviour A is placed under the condition of extinction. In Phase 3, Behaviour A remains on extinction while Behaviour B is reinforced. In Phase 4, both

Behaviour A and B remain on extinction for resurgence testing.

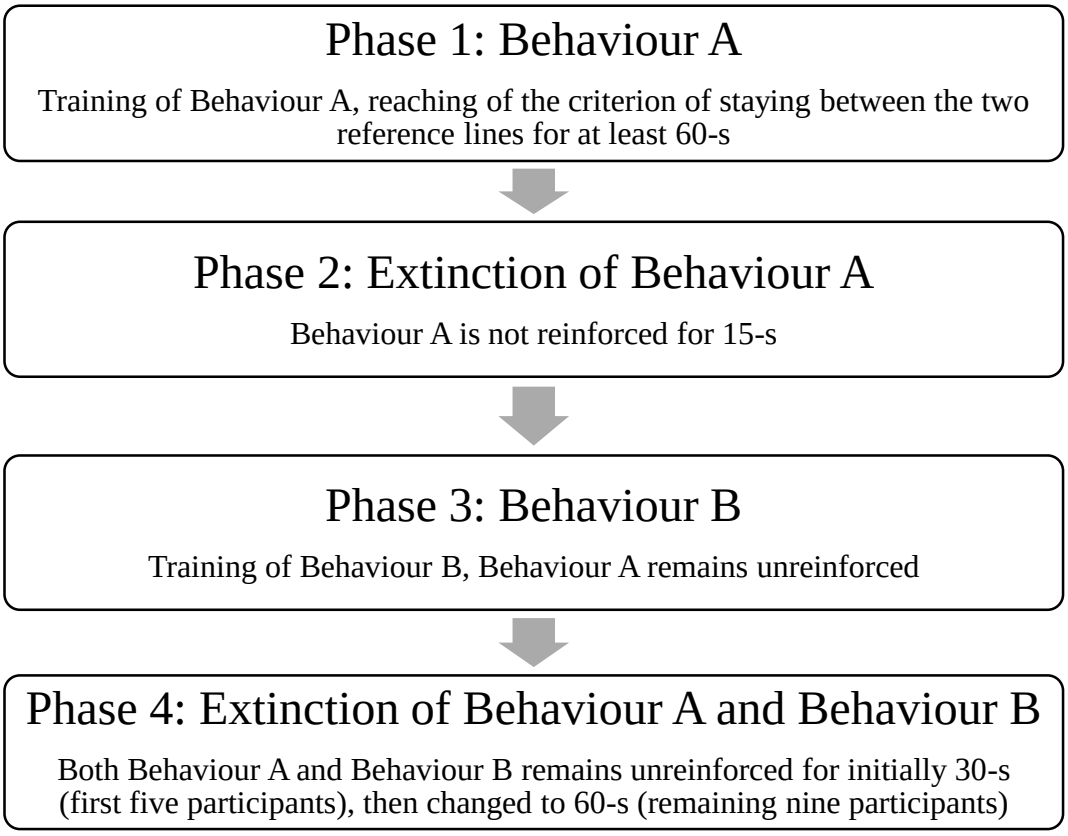


Figure 1. An overview of the basic experimental procedure of Experiment 1.

Data Analysis

The time associated with each click and its corresponding water level was recorded. The buttons (black and yellow) clicked were also recorded and so were the coordinates of any click on the screen. Any other clicks and keyboard presses were recorded, but were labelled as 'Invalid'. The time of each drip was also recorded.

These recordings resulted in four derivations to illustrate experimental control of behaviour and the demonstration of resurgence. The first derivation was the drip rates and was derived from the number of drips. The drip rates were calculated based on the number of drips per interval. Each interval started off with a low rate of drip, then an increase to a high rate, followed by an eventual

decrease to a low rate. As a result, the drip rates followed an oscillating pattern and remained unchanged across phases for all participants. The second derivation also converted the number of clicks into click rates. The click rates were calculated in the same manner as the drip rates. The clicks rates were then presented in each associated drip interval.

The third derivation used the corresponding water level of each click. It shows how the water level tracked against each drip rate, and click rate against the goal of the task. The last derivation converted each click into response rates. The response rates were expressed by the number of clicks per minute. It was calculated by taking the difference in time between the current and previous click, divided by 60-s. Finally, the number of clicks on the black and yellow button in Phase 4 were recorded and analysed to quantify the magnitude of resurgence.

Appendix C illustrates a variety of LOESS smoothing curves. LOESS smoothing curves were used to illustrate the four derivations for experimental control and the demonstration of resurgence. Figure 16 contains a range of sampling proportion (0.0 to 0.3) and polynomial degree (1 to 2). The setting of sampling proportion of 0.1 and polynomial degree of 2 (1st graph on the right) was chosen. The illustration matches the oscillating pattern for the drip and click rate as well as a start point of 0. This setting provided the best illustration for graphical representation and analysis of the result.

Results

Figure 2 illustrates the control aspect of participants' behaviour. On the y-axis, the click and drip rates, and the water level were plotted. While on the x-axis, time up to 500-s was plotted. Two short-dotted horizontal lines signified the reference lines in which the water level needed to remain to meet the goal of the

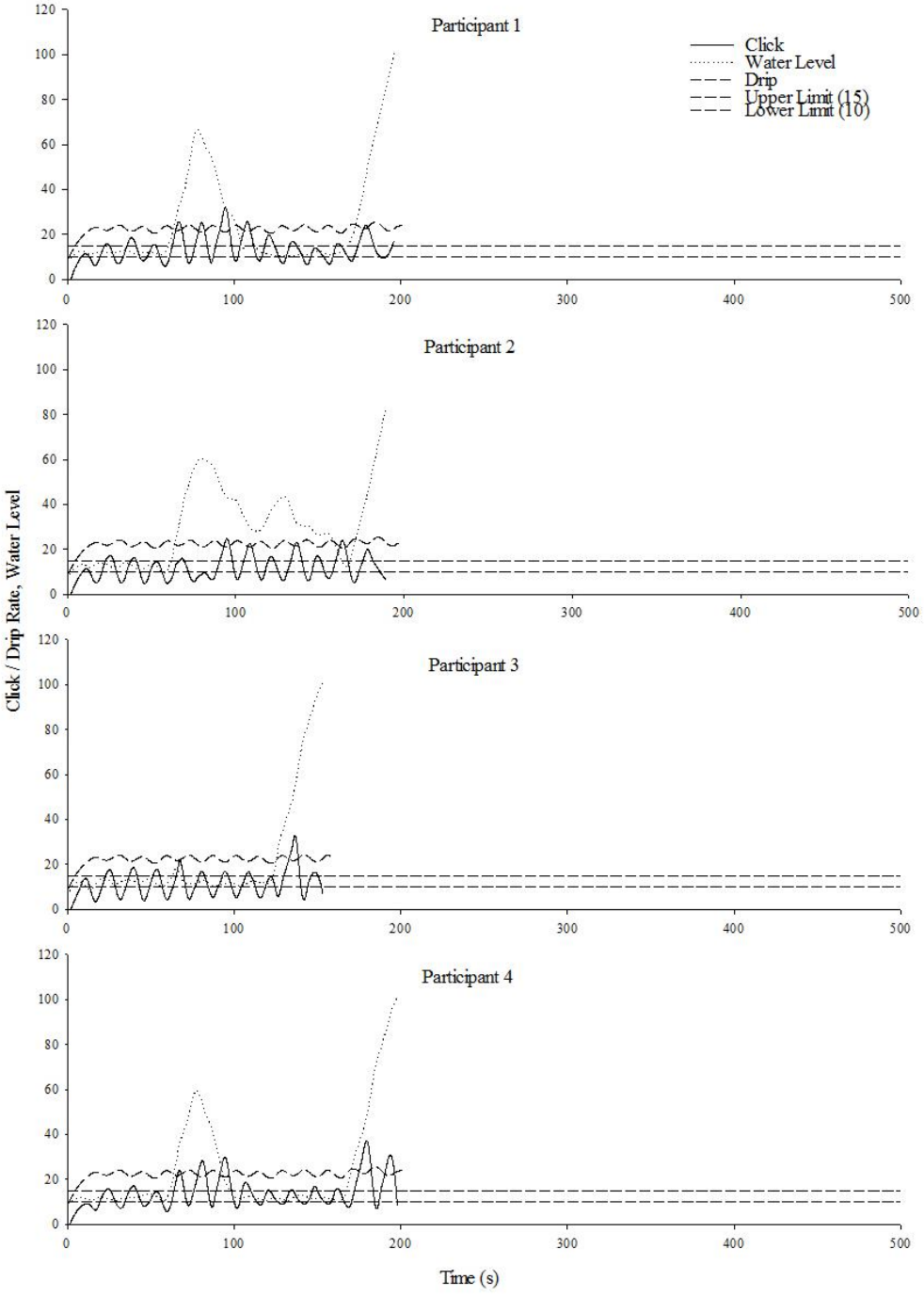
task. Figure 2 also shows the solid line as click rates. The short-dotted line represents the water level and the medium-dotted line represents the drip rates.

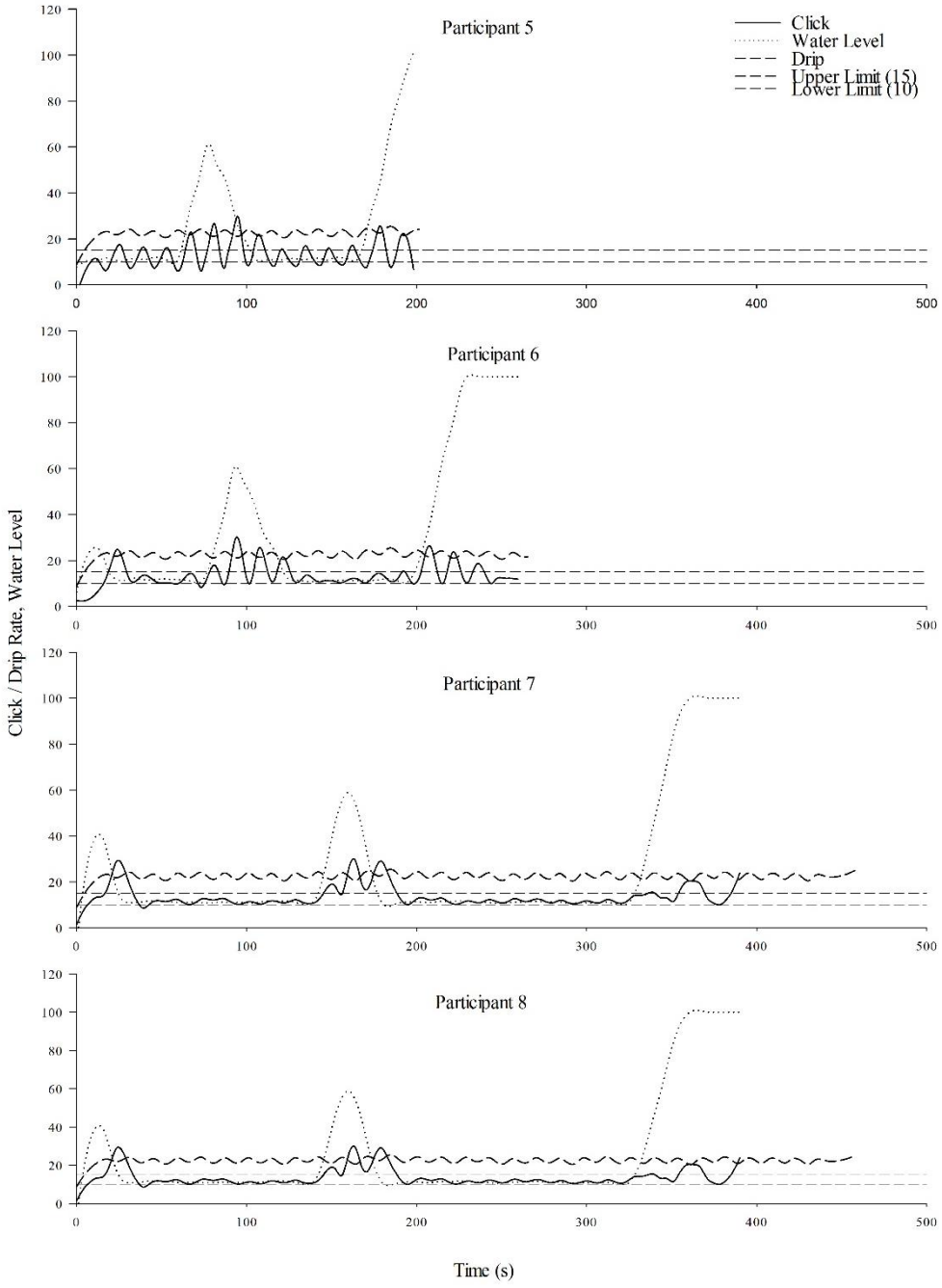
The click and drip rates, and water level determined if participants met the three requirements. These requirements were taken as indicators of good experimental control. The first requirement that the participants completed the entire experiment. The second requirement was the match in the pattern of clicks and drips during the training of Behaviour A and Behaviour B while the last requirement was for participants to keep the water level within the goal of the task.

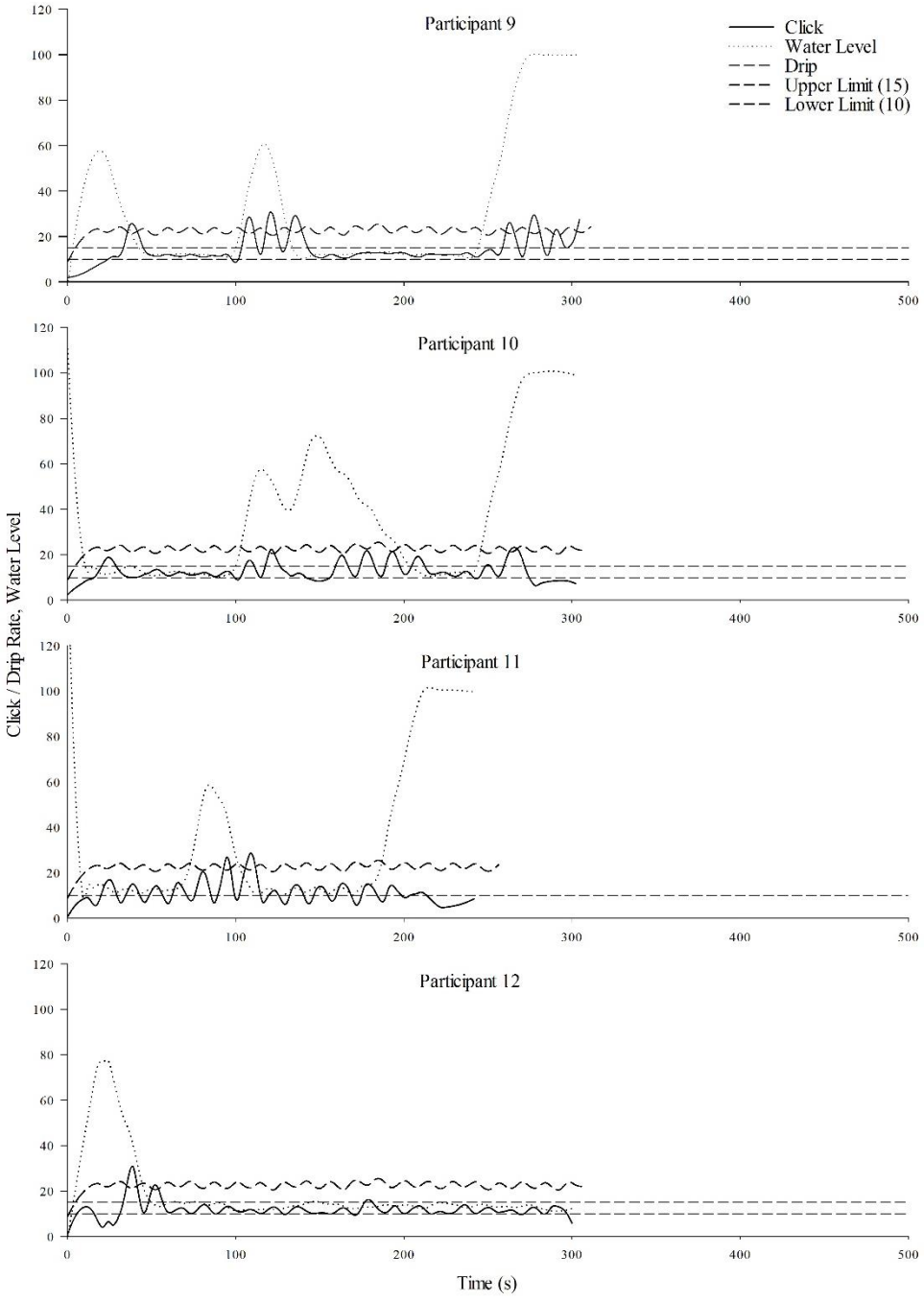
In both Phase 1 and 3, the solid lines oscillated at a varied rate in the crest and trough across all participants. Some participants had high and low crest and trough respectively while others remained flat. The solid line increased for all participants when the water level (short-dotted lines) increased. Participants 7, 8, 9, 12, 13, and 14 also had an increase in the solid line at the start of the experiment. The medium-dotted lines (drip rates) showed a constant oscillating pattern with no variability for all participants. The crest and trough were similar in size for each drip interval.

The short-dotted lines remained between the reference lines during the training of Behaviour A and B for most participants. Except for Participant 12, the short-dotted line at times went beyond the reference lines. Other times when the water levels went beyond at the start of the experiment for some participants, and in Phase 2 and Phase 4 for all participants. Participants 8, 9, 12, 13 and 14 first had their short-dotted line increased, and decreased at the start of the task. It then remained within the reference lines for the rest of the training of Behaviour A. A sharp increase and decrease in the water level were also observed in Phase 2 for all participants except Participant 12. In Phase 4, all participants' short-dotted line

increased sharply to 100% and remained at 100% for the rest of the experiment. Only Participant 12's short-dotted line did not show that.




Participant 5
Participant 6
Participant 7
Participant 8
Click
Water Level
Drip
Upper Limit (15)
Lower Limit (10)
Click / Drip Rate, Water Level
Time (s)
0
20
40
60
80
100
120
0
100
200
300
400
500


Participant 9
Participant 10
Participant 11
Participant 12
Click
Water Level
Drip
Upper Limit (15)
Lower Limit (10)
Click / Drip Rate, Water Level
Time (s)
0
20
40
60
80
100
120
0
100
200
300
400
500

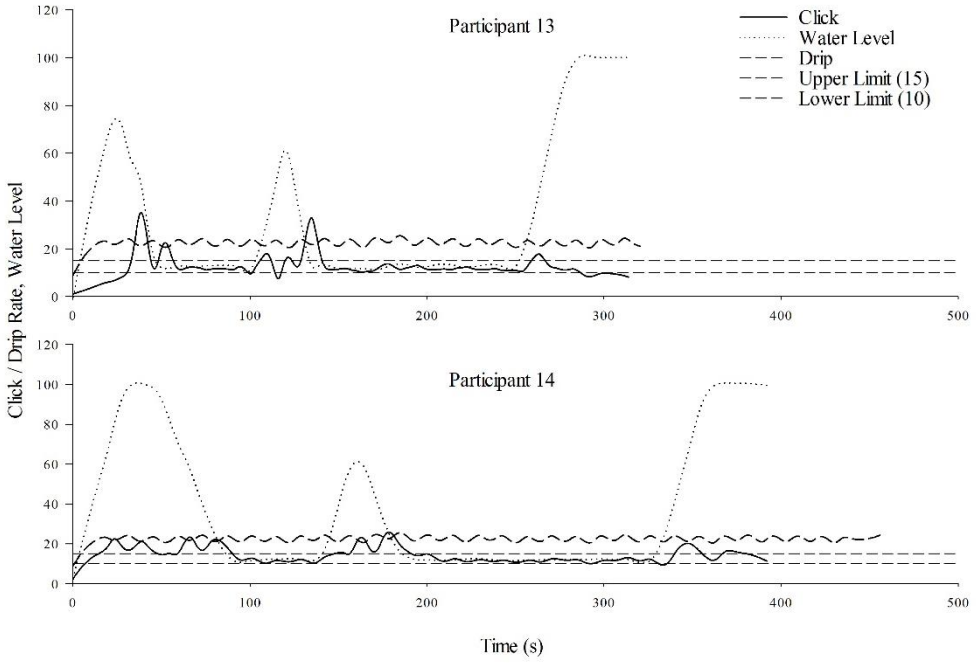


Figure 2. The graphs depict the experimental control aspect for 14 participants of Experiment 1.

Figure 3 illustrates the responses rates of participants in this present experiment and the hypothetical resurgence data by Doughty and Oken (2008). The response rates were divided into four phases in Experiment 1, and into three phases for the hypothetical resurgence data. For this experiment, response rates were plotted up to 300 responses per minute on the y-axis while time up to 500-s was plotted on the x-axis. The solid line represents Behaviour A while the short-dotted line represents Behaviour B. The vertical medium dotted-lines represent a phase change. For the hypothetical resurgence data, sessions were plotted on the x-axis while response rates were on the y-axis. Solid vertical lines showed a phase change. Circular markers with solid lines represent Behaviour A while triangular markers with solid lines represent Behaviour B.

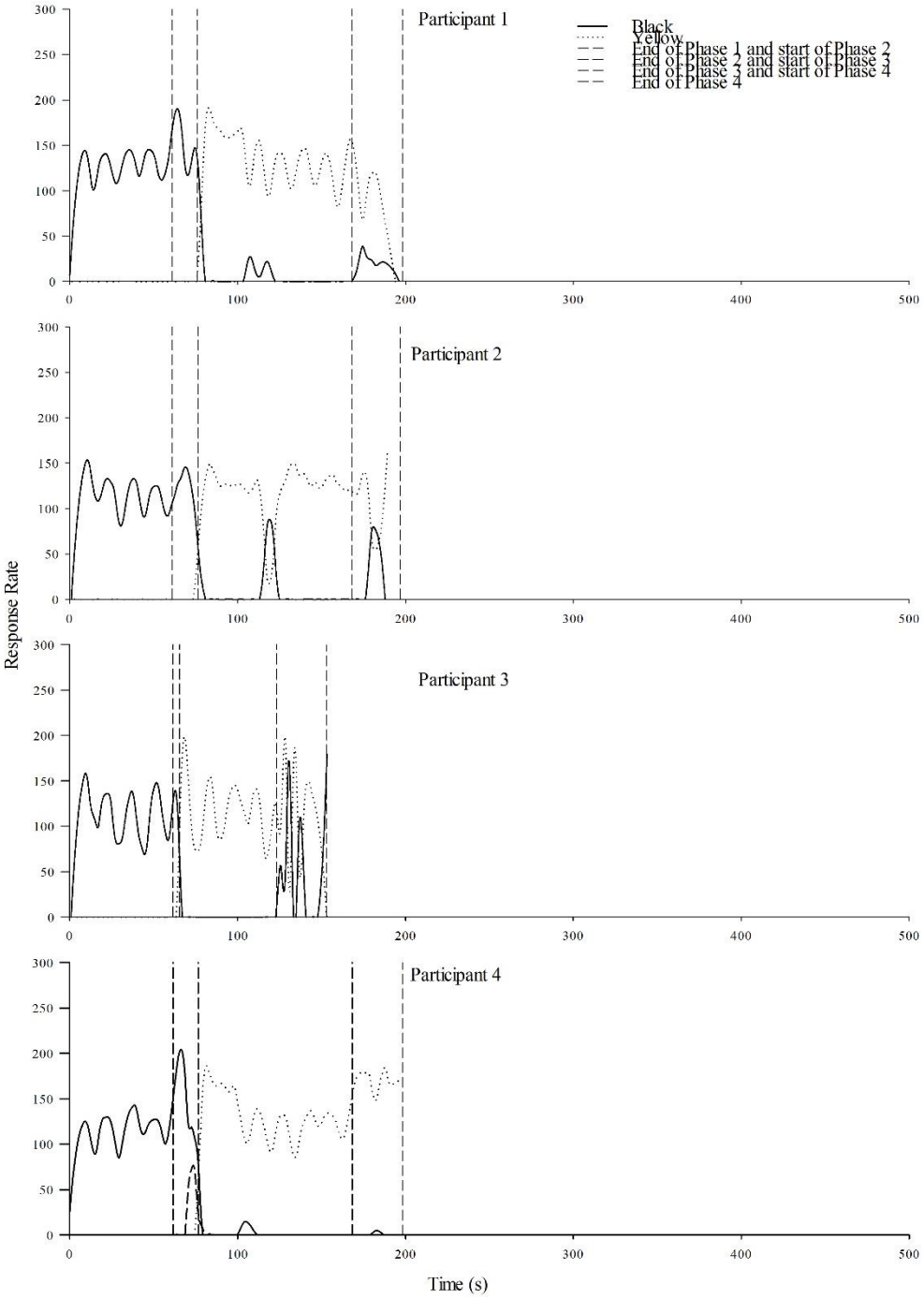
In Phase 1 for both data, the individual lines increased sharply for all participants. The lines remained stable but had some variability in the crest and trough for all participants. The lines for Behaviour B remained flat.

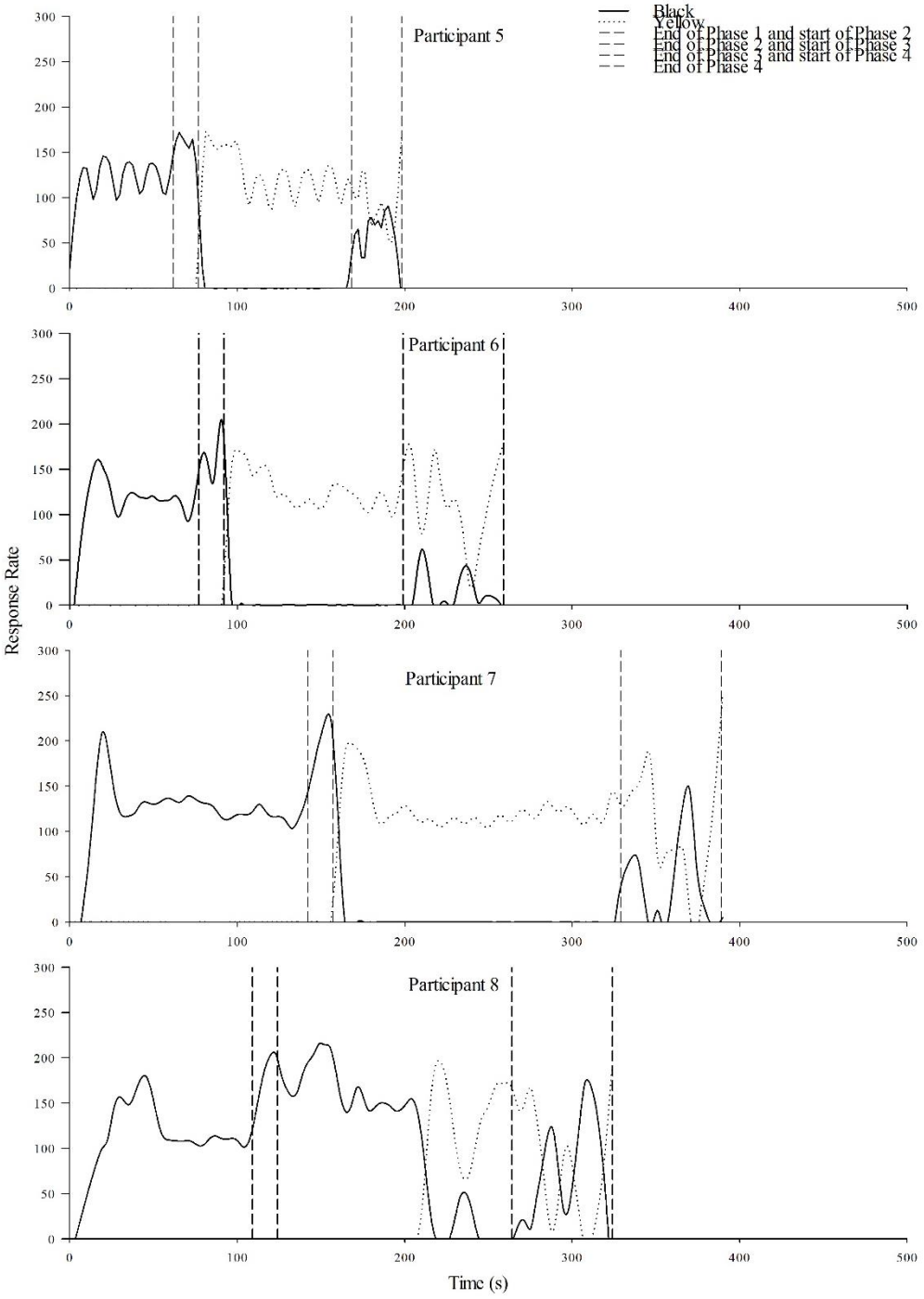
Phase 2 in the hypothetical resurgence data is a combination of Phase 2 and 3 of this present experiment. Doughty and Oken's (2008) shows the line for Behaviour A decreasing sharply till near-zero while the line for Behaviour B increasing sharply and remains stable. In Phase 2 for participants in this present experiment, the solid lines increased sharply. The line for Behaviour B remains to be seen. In Phase 3, the solid lines decreased sharply till near-zero for most participants except for Participant 8 showing a gradual decrease. The solid line was also observed to increase and decrease sharply at certain points for Participants 1, 2, 4, 8 and 10. The short-dotted lines were seen to increase sharply and remained stable with slight variability among participants.

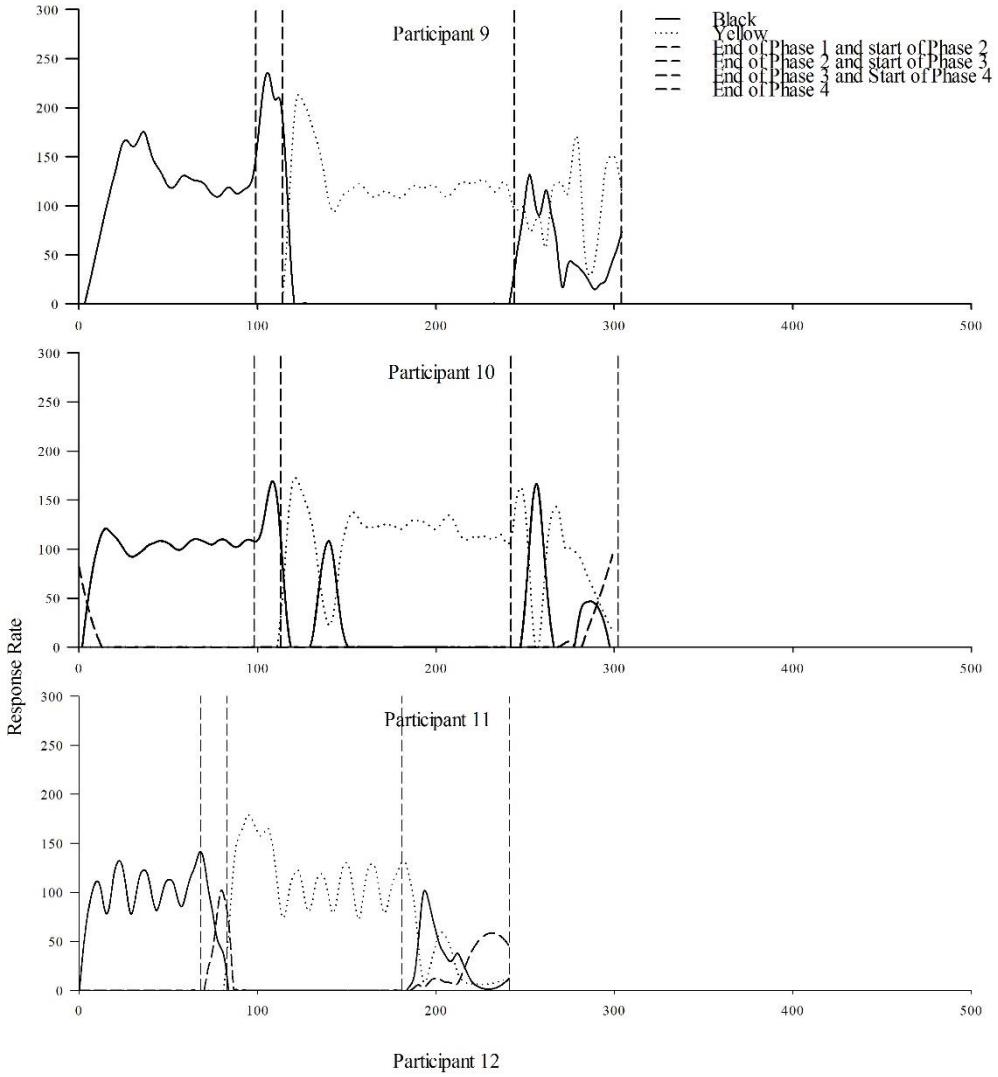
The short-dotted lines for five participants in the 30-s condition of Phase 4 remained stable with a slight reduction. The short-dotted lines did not decrease to near-zero towards the end of the task. The solid lines were observed to both increase and decrease slightly except for Participant 3 whose solid lines increase and decreased sharply. The solid lines appear to reach near-zero for most participants except Participant 3. The remaining nine participants' solid lines were like the initial five participants. But the short-dotted lines were different as it was shown to decrease more for most participants. It was not to near-zero but the decrease was greater than the initial five participants.

Phase 3 of the hypothetical resurgence data represents Phase 4 of the present experiment. The graph shows Behaviour A first increasing sharply at first to a level below the baseline of training. It then decreased to near-zero towards the

end of the session. Behaviour B had a sharp decrease at first, then gradual to near-zero towards the end.




Black
Yellow
End of Phase 1 and start of Phase 2
End of Phase 2 and start of Phase 3
End of Phase 3 and start of Phase 4
End of Phase 4
Participant 5
Participant 6
Participant 7
Participant 8
Response Rate
Time (s)
0
50
100
150
200
250
300
400
500



Participant 12

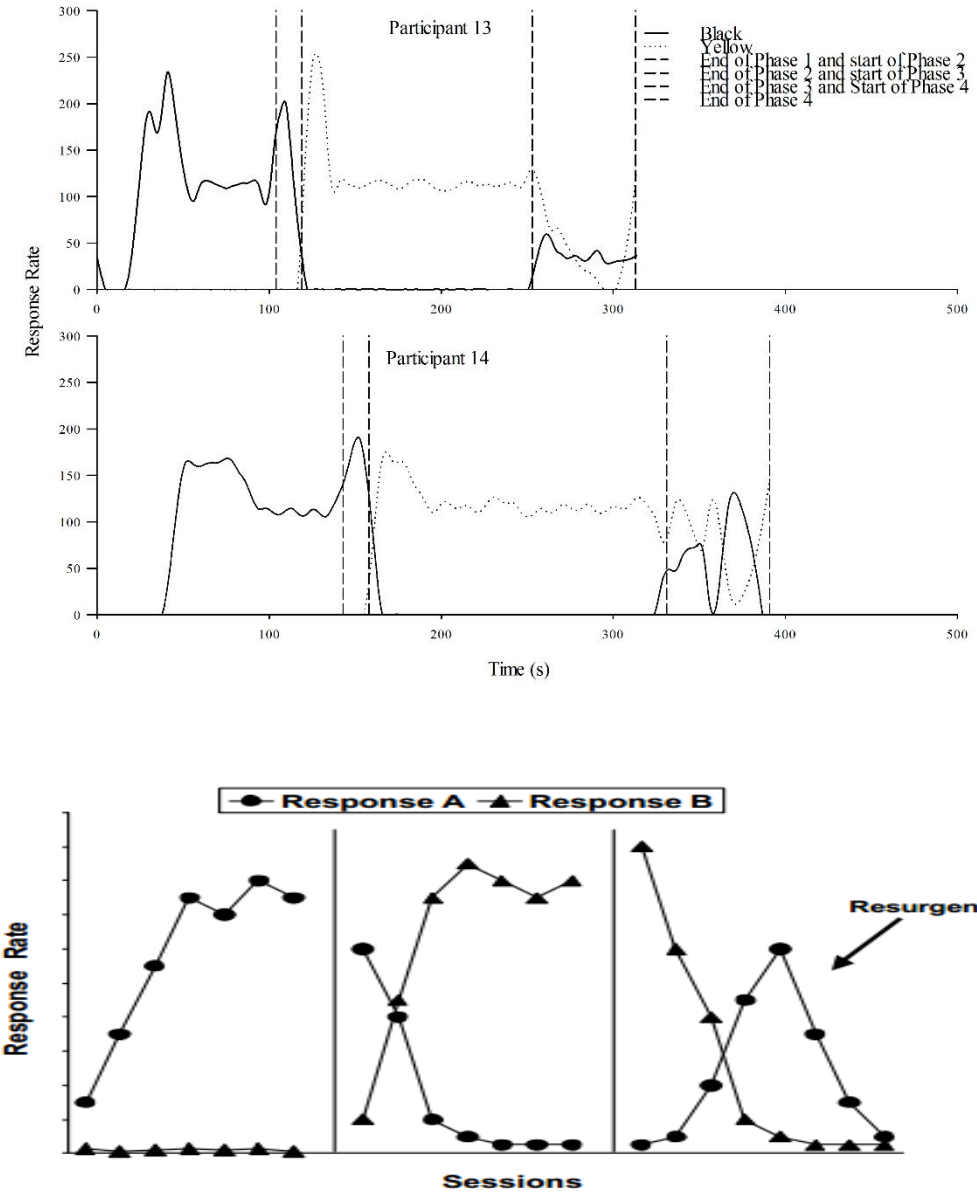


Figure 3. The graphs depict the response rates for 14 participants of Experiment 1. Participant 12's data was excluded due to the failure to move on to Phase 2, and subsequently did not demonstrate resurgence. The hypothetical resurgence data by Doughty and Oken (2008) is also presented on the lower panel.

Discussion

Experiment 1 aimed to test if the task provided a methodology that achieved good experimental control. The task incorporated elements of a pursuit-tracking task and general descriptive instructions. Also, if the methodology achieved good experimental control, then resurgence could be demonstrated better

in a manner consistent with the animal literature. The data of Experiment 1 suggested that the methodology provided by the task had accomplished the aim.

Thirteen out of the fourteen participants completed the entire experiment to which they fulfilled the first requirement for good experimental control. Only Participant 12 did not complete the entire experiment and the reason being Participant 12 also did not fulfil the third requirement to move on to Phase 2. As a result, Participant 12 did not move on to complete the experiment, and subsequently demonstrate resurgence. It appeared that fulfilling the first requirement was dependent on meeting the third requirement. It was concluded Participant 12 did not achieve good experimental control of behaviour.

The oscillating patterns for the click and drip rates were similar for the thirteen remaining participants. It was observed that the click rates occurred slightly later than the drip rates. But this can be accounted for by lag as participants had to react to the drips. The amount of lag was shown to be minute. This suggested that participants were very responsive to changes in consequences like those in the pursuit-tracking task. Thus, the participants met the second requirement indicating good experimental control. The third requirement was also fulfilled. The remaining participants kept the water level within the goal of the task in Phase 1 to move on to Phase 2. The task appeared to have provided a methodology that achieved good experiment control of behaviour.

The results suggested that participants shifted their responding according to a change in contingency rather than rule-follow. Participants shifted their responding when the black button became ineffective. Likewise, responding shifted away from the yellow button when it became ineffective. During resurgence testing of 60-s, the rate of Behaviour A recurred lower than the rate in

Phase 1. The rates of Behaviour A and Behaviour B were also observed to decrease towards the end of the task. These adjustments provided a clear indication that responses were controlled by the arranged contingencies. This also proved that responses were not verbally-regulated. If participants were rule-following (i.e., "Be Alert and Vigilant"), then responding would remain unchanged during the conditions of extinction. Yet participants' responses were observed to occur at a lower rate and decrease. But the response rates for most participants during the initial extinction condition (15-s) were deemed problematic. They responded at a much higher rate than baseline training. A possible explanation could be insufficient time exposed to the contingencies of extinction and this was discussed later. The data suggested the methodology, using elements of a pursuit-tracking task and general descriptive instructions, achieved good experimental control.

Because major resurgence theories assume that behaviour comes under contingency control, achieving good experimental control allowed for the demonstration of resurgence. Experiment 1 also aimed to demonstrate resurgence like those seen in animal research. Yet no animal research have investigated resurgence using a four-phase resurgence procedure. They only used a three-phase procedure. So, the present findings were compared to Doughty and Oken (2008) hypothetical resurgence data. Participant 3's data was excluded in the analysis of resurgence citing experimenter's error. An incorrect extinction time of 5-s was used instead of 15-s. Participant 12's data was also excluded as he did not move on to Phase 2 to show resurgence.

The results of Experiment 1 indicated that participants in the 60-s resurgence test condition provided the best demonstration of resurgence. The rates

of Behaviour A and Behaviour B resembled those of the hypothetical resurgence data better. The rate of Behaviour A was shown to first increase, then decrease later. The rate of Behaviour B also gradually reduced for participants in the 60-s test condition. The rate of Behaviour B, for participants in the 30-s test condition however, did not decrease. Instead, the rate persisted at a rate similar to baseline training. Although there was a slight decrease in the rate of Behaviour B towards the end, the decrease was not greater than participants in the 60-s test condition.

The response rates of Behaviour A and Behaviour B also resembled previous research findings. The present findings showed similar response patterns to Wacker et. al., (2011) study investigating the effects of FCT on resurgence with children. Behaviour A in their study recurred at a lower rate than baseline training. Behaviour B was also observed to decrease. Similar response patterns were also noted in McHugh et. al, (2012) and Doughty et. al., (2010) studies investigating factors affecting resurgence with humans in a laboratory setting. They found that in their control group, the recurrence of Behaviour A occurred much lower than the rate initially trained. The rate of Behaviour B did not persist and went through a gradual decline. The comparison with previous research gave evidence that participants in the 60-s test condition provided the best demonstration of resurgence.

Participant 12's data revealed that good experimental control could have been achieved. Further analysis suggested that he remained responsive to changes in the consequence. Participant 12 reacted to the drips enough that it did not move beyond the reference lines by a large amount. The lag also stayed minute. Yet Participant 12 did not move on to Phase 2 because of an individual difference in maintaining the water level. Participant 12 maintained the water level at the edge

of the reference line while other participants maintained the water level between the two reference lines. So when there was an upsurge of drips, Participant 12 did not have enough time to react to the high rate of drips. As a result, the drips were not compensated and the water level went beyond the goal. Participant 12 failed to continuously keep the water level between the lines for 60s to move on to Phase 2. This led to the conclusion that Participant 12 did not achieve good experimental control.

However, the first and third requirements appeared problematic as indicators of experimental control. Only the second requirement acted as a good indicator for experimental control. The two requirements do not seem to contribute to good experimental control. Instead, they hinder good experimental control and needed an evaluation of its inclusion. Suggestions included removing or altering the two requirements in future experiments. The first suggestion was to increase the intended ranges to 10% to 17%. The second included a 1% allowance from the upper and lower limits. The last suggestion allowed participants to move on to Phase 2 after 300-s instead of terminating the experiment.

An issue with the findings was the rate of Behaviour A during the initial condition of extinction. Most participants increased their rate of response when the black button became ineffective. The response rates seen in the present data do not reflect extinction in the literature. The response rate of participants undergoing extinction should result in an eventual decrease (Miltenberger, 2012). Initially it was assumed that participants might be operating under the rule "Be Alert and Vigilant!". That meant participants persisted with their responding because responses were verbally-regulated rather than related to the arranged contingencies of the task.

But the higher response rates seen during extinction could be better explained without the rule-following argument. Participants might have responded at a rate like that of what is termed extinction burst. It is the sudden temporary increase in behaviour during the beginning of extinction (Miltenberger, 2012). So it was not the rule that the participants' behaviours were governed by but the insufficient time exposed to the arranged contingencies of extinction. It would explain why the response rates occurred at a higher rate during the initial stages of extinction. Earlier, a longer resurgence test condition was concluded to provide the best demonstration of resurgence. If participants could spend more time in extinction, then they might be sufficiently exposed to the arranged contingencies of extinction. As a result, their response rate might resemble those of extinction. So in future experiments, the length of time spent in extinction could be increased to 60-s.

The data from Experiment 1 appeared to have accomplished the aims. The task, using elements of a pursuit-tracking task and general descriptive instructions, have provided a methodology that achieved good experimental control. Furthermore, the methodology demonstrated resurgence like those seen in the literature. Although limitations were evident in the methodology, suggestions offered could potentially resolve these issues. The suggestions could strengthen experimental control and resolve the issues with higher response rates seen in extinction. The accomplishment nonetheless established justification for using the methodology in future experiments in an attempt to test the generality of the methodology. Replication of findings from previous research could also increase the strength of the methodology.

The Effects of Time in Extinction on the Magnitude of Resurgence

Introduction

This second experiment was an extension of the first to determine if the methodology could replicate the findings relating to the extent of resurgence. The literature review suggested that the role of time in extinction of Behaviour A needed further clarification. Clarifying the role of time in extinction of Behaviour A was also compatible with another aim. That aim is to resolve the issue of higher response rates seen during extinction. Hence, Experiment 2 was conducted to clarify the role of time in extinction of Behaviour A on the magnitude of resurgence and resolve the issue of higher response rates seen in extinction.

Sweeney and Shahan (2013) previously studied the effects of time in extinction on resurgence with pigeons. They found that the recurrence of Behaviour A decreased as the time in extinction increased. The authors concluded that increasing the exposure to extinction may be a successful strategy to reduce the extent of resurgence. Winterbauer et. al., (2013) investigated the same with rats but found marginal differences in the extent of resurgence after four sessions of Phase 2 training and extinction. Although Behaviour A recurred less for rats for the groups with 12 and 36 sessions of Behaviour B training, the extent of resurgence did not differ between the two groups. They concluded that resurgence is a robust effect and extending the exposure to extinction plus alternative treatment may not be effective in reducing resurgence. Wacker et al. (2013) studied the effect of time in extinction with children using FCT. Their result indicated that participants' destructive behaviour recurred with only minimal difference across extinction conditions. The findings indicated that the extent of resurgence was related to the final response rate during the initial extinction

condition. An increased exposure to extinction during the training of Behaviour B (i.e., FCT) did nothing to reduce resurgence.

These studies (Sweeney & Shahan, 2013; Winterbauer et. al., 2013; Wacker et. al., 2013) have failed to replicate the effects of time in extinction consistently. Further evaluation of the data revealed differences in their experimental procedures investigating resurgence. Sweeney and Shahan (2013) and Winterbauer et. al., (2013) investigated resurgence using a three-phase procedure. Wacker et. al., (2013) used a four-phase procedure. In a three-phase procedure, time in extinction occurs concurrent with exposure to alternative training. It is not possible to separate and investigate the two factors affecting resurgence. But isolating the variable, time in extinction, can be implemented in a four-phase procedure. This corresponded with the aims of Experiment 2.

Further evaluation of Wacker et. al., (2013) study revealed methodological limitations. Their experiment included an earlier extinction condition probe and introduced an extended treatment phase (training of Behaviour B). The inclusion of both factors led to uncertainty of the results (i.e., reduction of resurgence) by a single factor, or both. That is if it was extinction of Behaviour A or the lengthy treatment phase that was responsible for lowering the extent of resurgence. Also, Wacker et. al., (2013) study could not account for variables beyond their control. Although they accounted for the renewal effect by conducting the treatment phase in the original training context of the problem behaviour, the authors remained uncertain what occurred outside of sessions. Ongoing reinforcement of the problem behaviour might have maintained the problem behaviour. As a result, what affected the magnitude of resurgence remained even more unclear. Thus,

Experiment 2 aimed to clarify if only increasing the time in extinction of Behaviour A could reduce the extent of resurgence.

Participants in Experiment 1 were responding in an extinction burst-like manner during extinction. It was concluded that the time in extinction was too short and participants were not sufficiently exposed to the changes in contingency. Suggestions were made to increase the length of time spent in extinction of Behaviour A to 60-s. Experiment 2 predicted that by increasing the length of time, participants would be given more exposure to the change in contingency. As a result, the response rates would resemble those of extinction.

Experiment 2 also continued to with the use of the three requirements as indicators to achieve good experimental control. The requirements remained unchanged as changing the requirements might produce differences in responding. The differences could create uncertainty to whether a reduction of resurgence was due to an increased time in extinction or changes in the requirements. Thus, participants in this present experiment were tested under the same conditions as participants in Experiment 1.

Method

Participants

Participants were eight undergraduate and postgraduate psychology students from the University of Waikato who were recruited under the same conditions as participants in Experiment 1.

Apparatus

The apparatus remained unchanged throughout the present experiment like those of in Experiment 1. However, the software was now v3.1.

Procedure

Stimulus. The stimulus remained unchanged like those of in Experiment 1.

Task. The task remained the almost identical like those of Experiment 1. The difference was the increase in the extinction time of Behaviour A to 60-s.

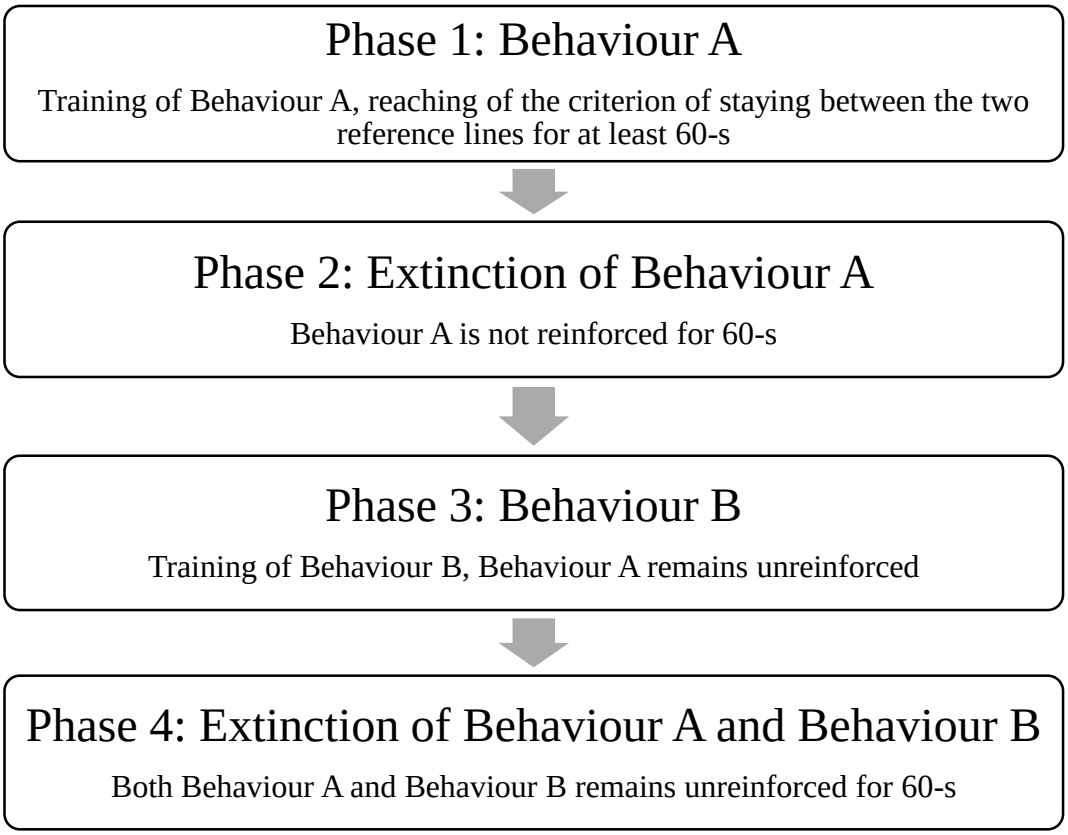


Figure 4. An overview of the basic experimental procedure of Experiment 2.

Data Analysis

The data analysis remained unchanged throughout this experiment like those of Experiment 1.

Results

Figure 5 illustrates the experimental control aspect of participants' behaviour in Experiment 2. Of substantial difference from Experiment 1 was the change in the water level. The change was most observable during Phase 2 (extinction of Behaviour A). The water level for all participants increased to a 100% and stayed at 100% for a longer period of time. After which, the pattern of the

water level decreasing remained the same. There were minimal differences beyond observed for the rest of the data.

Figure 5 presented and analysed the rest of the data like those of Experiment 1. The data plotted on the x and y-axis remained unchanged. Click and drips rates, and the water level were plotted on the y-axis while the time up to 500-s was plotted on the x-axis. The participants' data occurred like those seen in Experiment 1. Patterns and extent of clicks remained unchanged. Drip rates remained the same. Drip patterns continued to follow an oscillating pattern for all participants across conditions. The water level for the rest of the experiment did not differ from those of Experiment 1.

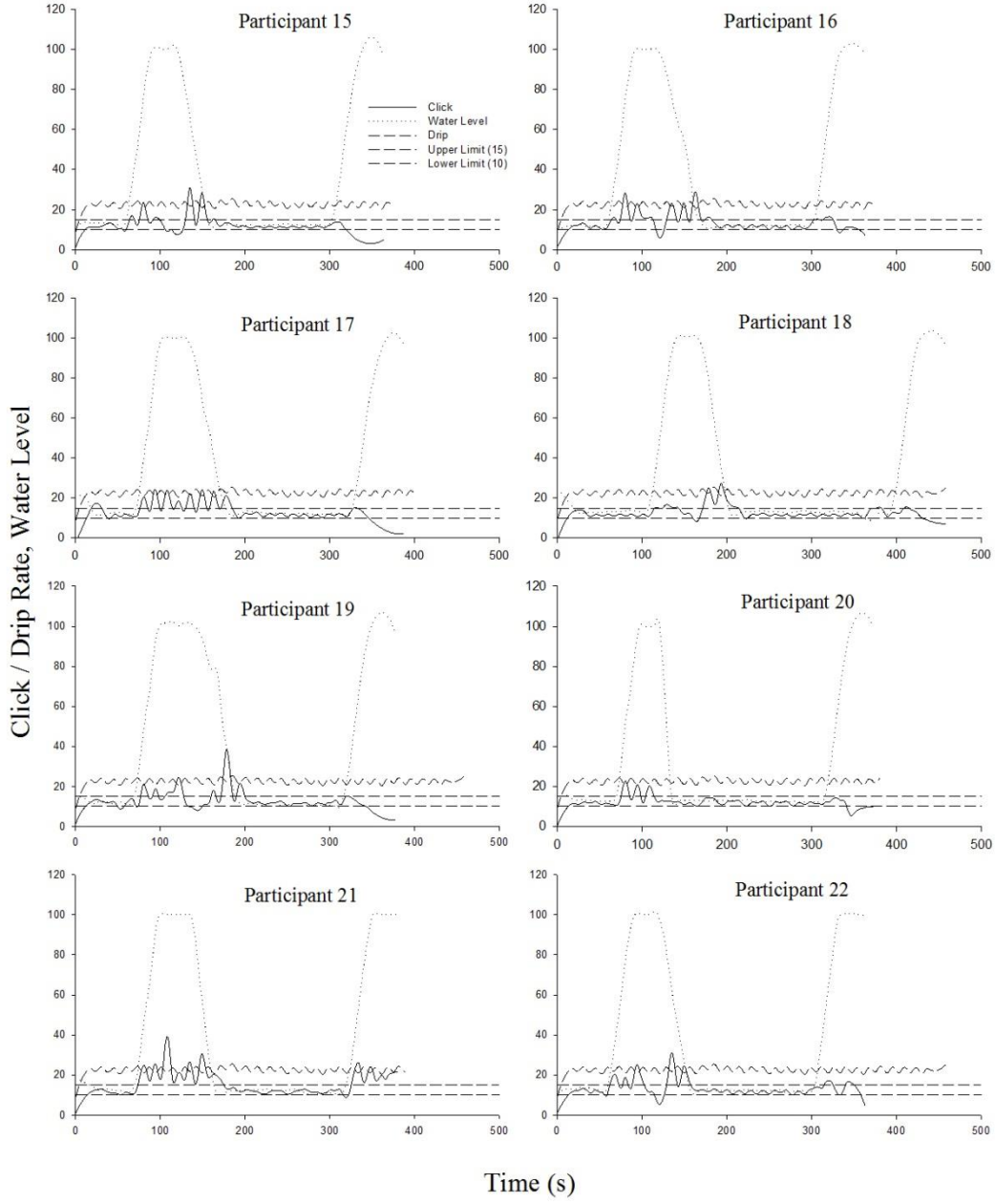


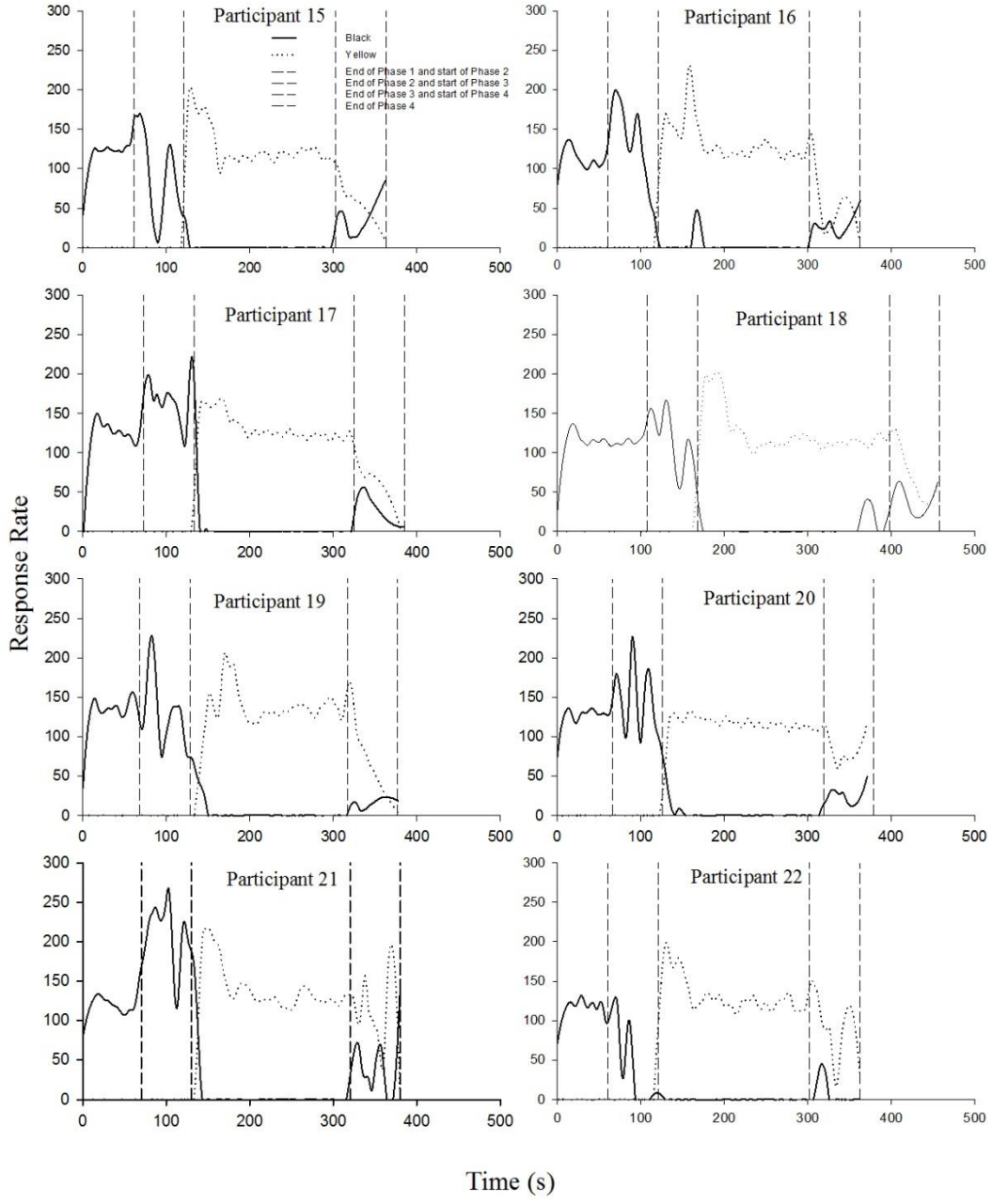
Figure 5. The graphs depict the experimental control aspect for eight participants of Experiment 2.

Figure 6 illustrates the response rate of participants in Experiment 2. Of difference as compared to those in Experiment 1 were the response rates during extinction and resurgence testing. Experiment 2 increased the time in extinction to 60-s. The solid lines (Behaviour A) was seen to increase sharply at first for all participants. Only Participant 22 decreased responding to near-zero towards the

end of extinction. The rest of the participants either gradually reduced their responding to below the baseline rate or till baseline rate.

The time (60-s) in resurgence testing remained unchanged. The rate of Behaviour A (solid line) increased to a rate well below the rate of baseline training. The rate was no larger than half of the rate during baseline training. Then the solid lines decreased and remained within the low rate for the rest of the test condition. Some participants' rates increased slightly towards the end of resurgence test. Behaviour B (short-dotted lines) decreased gradually to near-zero for most participants. Only Participant 20 and 21 continued to respond but at a lower rate.

Figure 6 presented and analysed the rest of the data like those of Experiment 1. The data were also compared to the hypothetical resurgence data by Doughty and Oken (2008). The data plotted on the x and y-axis remained unchanged. Time up to 500-s was plotted on the x-axis while response rate up to 300 clicks per minute was plotted on the y-axis. The data on Figure 6 shows the rest of the data remained unchanged like those in Experiment 1. Likewise, the hypothetical resurgence data by Doughty and Oken (2008) in the lower panel of Figure 6 remained unchanged.


Participant 15
Participant 16
Participant 17
Participant 18
Participant 19
Participant 20
Participant 21
Participant 22
Black
Yellow
End of Phase 1 and start of Phase 2
End of Phase 2 and start of Phase 3
End of Phase 3 and start of Phase 4
End of Phase 4
Response Rate
Time (s)

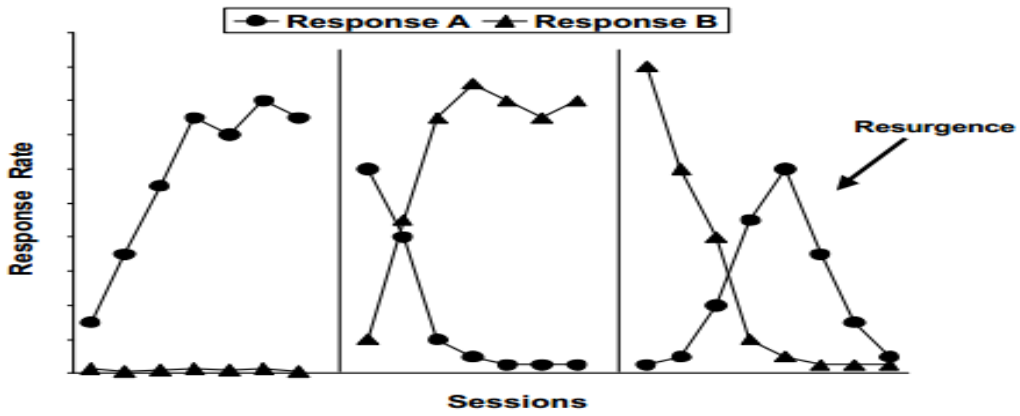

Response A
Response B
Response Rate
Resurgence
Sessions

Figure 6. The graphs depict the response rates for eight participants of Experiment 2. The hypothetical resurgence data by Doughty and Oken (2008) is also presented on the lower panel.

Figure 7 presents the mean number of black clicks in Phase 4 of participants in the 15-s and 60-s condition. Figure 8 shows the mean number of yellow clicks in Phase 4 of participants in the 15-s and 60-s condition. The mean number of black clicks of participants in the 15s condition (15s EXT M = 33.86) was more than twice as high as the mean number of black clicks of participants in the 60s condition (60s EXT M = 16.00). The increased time in extinction had an effect on the number of black clicks during resurgence. This significant effect was verified using a between-groups t-test ($t(10.57) = 2.76$, $p < 0.05$) showing a reduction in the extent of resurgence in the group with a lengthier extinction time, 60-s. The mean number of yellow clicks of participants in the 15-s condition (15s EXT M = 62.88) was slightly higher than those in the 60-s condition (60s EXT M = 51.50). However, the between-groups t-test showed no significant differences between the two groups ($t(14) = 9.17$, $p > 0.05$).

Figure 9 and 10 represent all individual responses of the black and yellow button clicks during resurgence testing. Figure 9 represents the data of participants in the 15-s extinction condition while Figure 10 represents the data of participants in the 60-s condition. Cumulative clicks of black and yellow button clicks were recorded in Phase 4 and plotted against the time of 60s on each graph. Clicks on the black button showed a steeper increase for participants in the 15-s extinction condition as compared to participants in the 60-s extinction condition. Also, clicks on the black button had a clustered pattern of clicks for participants in the 15-s extinction condition while participants in the 60-s extinction condition had more spread out button clicks. Participants in the 60-s extinction condition also had a lower number of cumulative black and yellow clicks as compared to participants

in the 15-s extinction condition.

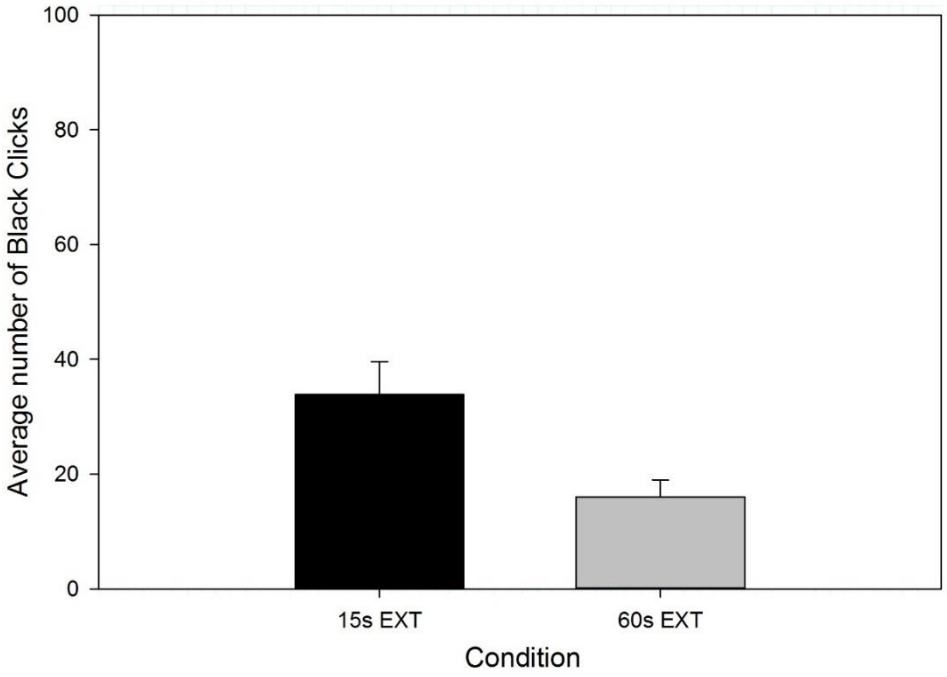


Figure 7. The mean number of black button clicks across all participants in the 15-s EXT and 60-s EXT condition during resurgence testing.

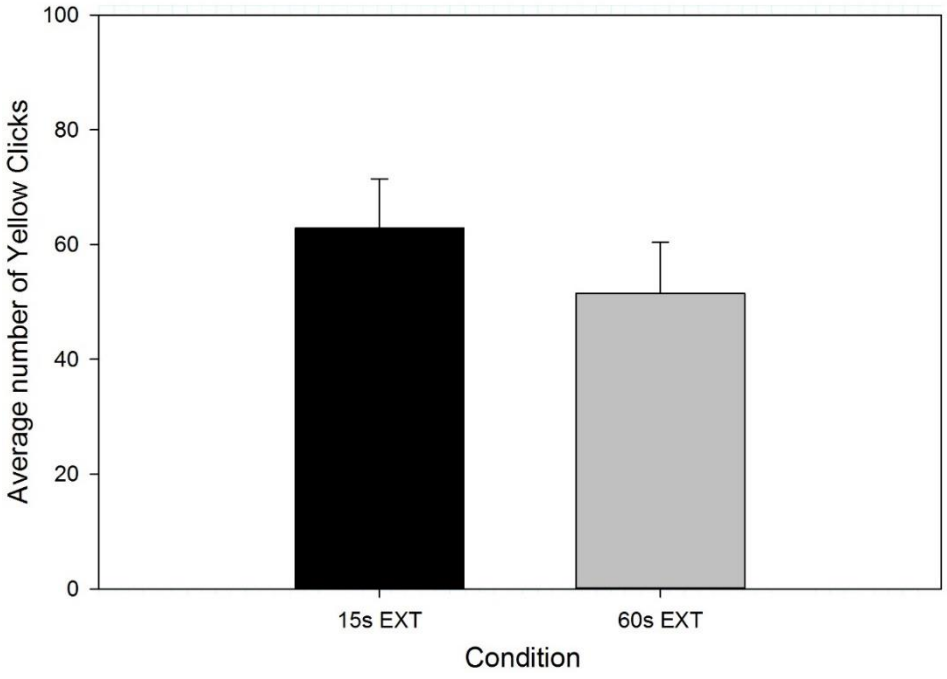


Figure 8. The mean number of yellow button clicks across all participants in the 15-s EXT and 60-s EXT condition during resurgence testing

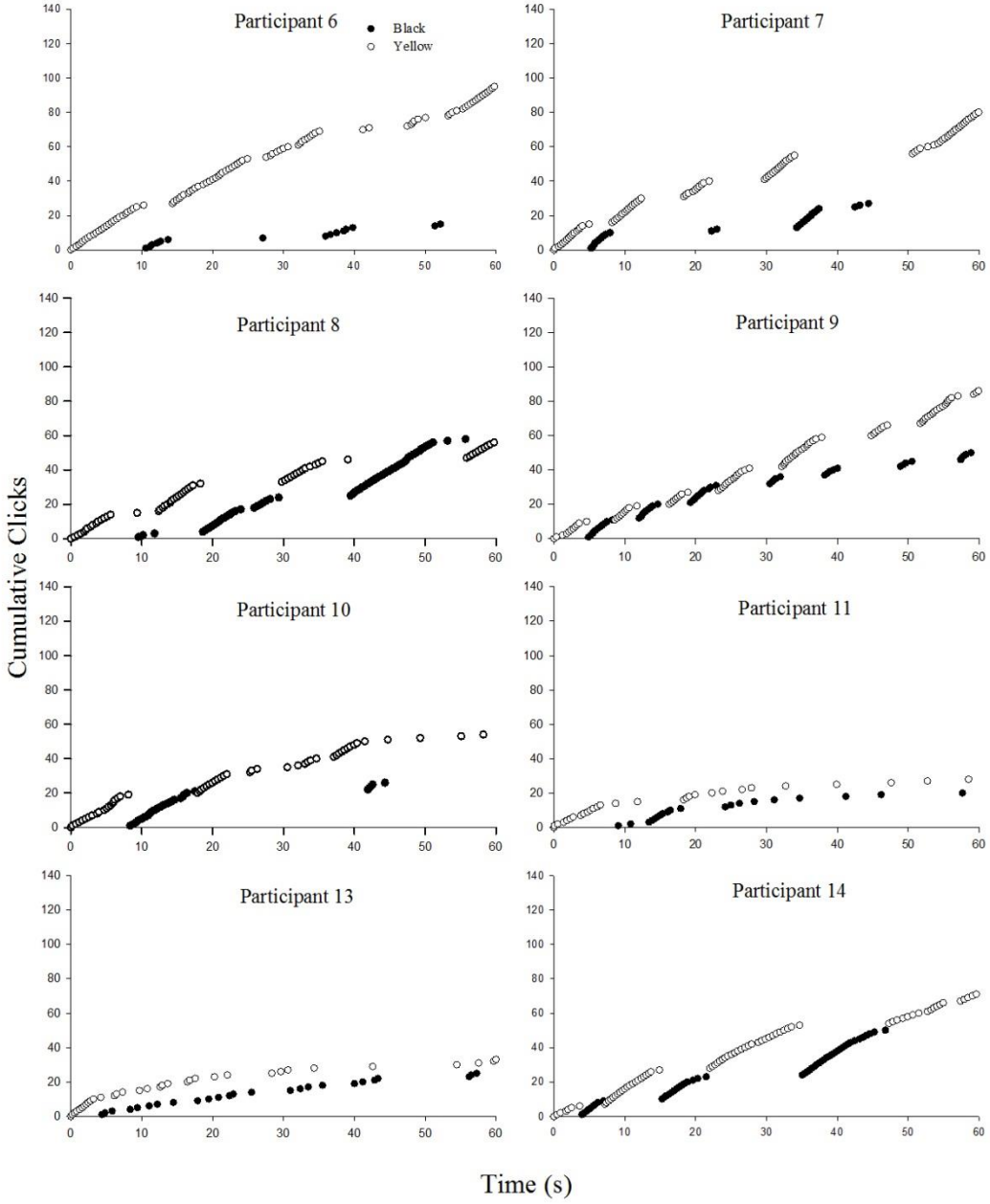


Figure 9. Cumulative number of black and yellow button clicks of each participant in the 15-s EXT condition of Experiment 1.

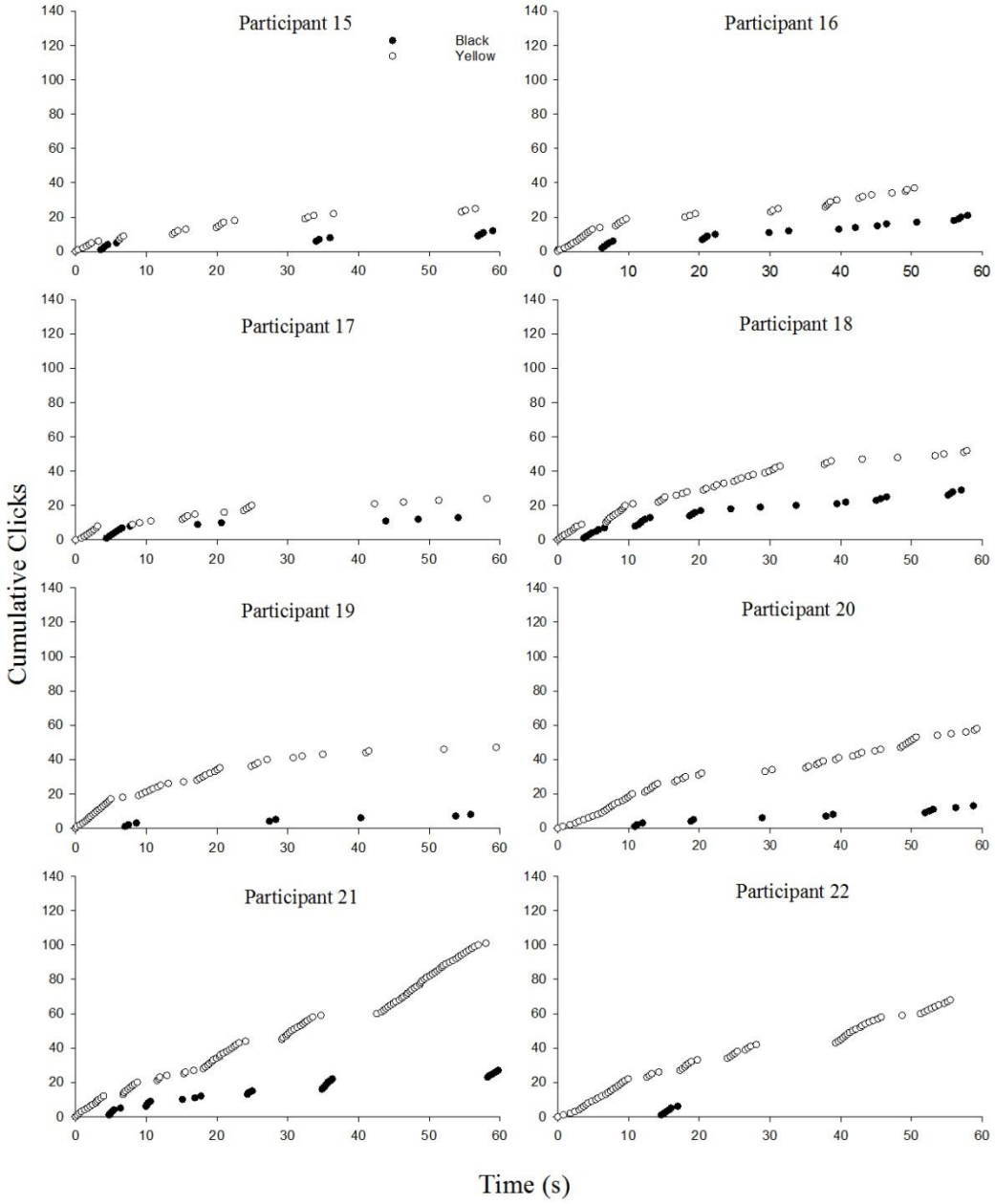


Figure 10. Cumulative number of black and yellow button clicks of each participant in the 60-s EXT condition of Experiment 2.

Discussion

The findings suggested that Experiment 2 continued to achieve good experimental control of behaviour. Although the requirements remained unchanged, all eight participants achieved good experimental control. Experiment 2 also demonstrated resurgence in a manner like those of Experiment 1. Furthermore, increasing the time in extinction also provided a better

representation of extinction and the extent of resurgence decreased as time in extinction increased. The data achieved the aims of Experiment 2 and proved the methodology robust in investigating resurgence.

The methodology, using elements of a pursuit-tracking task and general descriptive instructions, continued to show good experimental control. Participants remained very responsive to the change in consequence (drip rates). No other effects were noted except for changes in the water level in Phase 2. Also, participants continued to regulate their responses based on the arranged contingencies. Extending the time in extinction increased the participants' exposure to the contingencies of extinction. Although initial responding increased to a rate to higher than the rate of baseline training, the subsequent response rates gradually decreased. As a result, the response rates resembled closer to those of extinction. Hence, Experiment 2 achieved good experimental control and the aim of demonstrating extinction better was also accomplished.

Increasing the time in extinction appeared to have changed the magnitude of resurgence. But the pattern of the resurgence data remained unchanged. The data also indicated that the methodology continued to demonstrate resurgence like those of animal research. The findings of Experiment 2 showed that resurgence reduced when time in extinction increased. The number of black clicks of participants in the 60-s condition were lower than those in the 15-s condition. This reduction was further verified by a significant result of a between-group t-test and was key in clarifying the role of time in extinction on resurgence. The findings in this present experiment corresponded with Sweeney and Shahan (2013) that an increased exposure to extinction may be an effective strategy to reduce resurgence.

The differences in this present findings from Wacker et. al., (2013) study could be due to a tighter control over all variables in the experimental procedures. Participants were not exposed to the unintended effects of inadvertent reinforcement. Furthermore, an extended alternative treatment was not introduced in this present experiment. The exclusion helped separate two variables (i.e., time in extinction of target behaviour and increased exposure to alternative treatment) affecting the extent of resurgence. The significant result of Experiment 2 clarified the role of time in extinction on resurgence and have solidified the methodology as robust in investigating resurgence.

The methodology had provided consistent data from Experiment 1 and 2 that achieved good experimental control of behaviour and demonstrated resurgence like those of animal research. The significant findings of Experiment 2 (i.e., time in extinction reduced the magnitude of resurgence) further increased its strength. The methodology had shown promise in addressing the challenges investigating resurgence with humans in laboratory research. It might therefore be useful to get good experimental control of behaviour and demonstrate resurgence in a three-phase resurgence procedure.

Demonstrating Resurgence in a Three-Phase Procedure

Introduction

The data from both experiments supported the present methodology for investigating resurgence with humans in laboratory research. The third experiment was a further extension to Experiment 1 and 2 by asking again if the methodology could achieve good experimental control and in turn demonstrate resurgence in a three-phase procedure like those seen in the animal literature. Experiment 3 also aimed to resolve the issues in relation to the three requirements in Experiment 1. Furthermore, Experiment 3 queried if extending the time in testing resurgence would produce a better illustration of resurgence.

Good experimental control depended on two aspects. One aspect looked into how participants were responsive to the drip rates while the other examined if participants responded based on the changes in contingencies. Participant 12 was responsive to the drip rates but because he did not move on to Phase 2, it remained unclear if he was under contingency control. To resolve the uncertainty of experiment control, Experiment 3 used the suggestions in Experiment 1 to alter the first and third requirements.

The suggestions were to alter the goal of the task, include an allowance for the upper and lower limit, and allow participants to move to Phase 2 if they failed to meet the third requirement. Experiment 3 changed the intended ranges by increasing to 10% to 17%. Participants were also given 1% allowance for each lower and upper limit. And if participants did not meet the goal of the task after 300-s, the experiment would not be terminated. Instead, participants would move on to Phase 2. These changes attempted to resolve individual differences in maintaining the water level and gave participants a slightly longer time to react to

the upsurge in drip rates. Furthermore, allowing participants to move on to Phase 2 helped examine if participants responded based on changes in contingency.

In Experiment 1 and 2, participants regulated their responses further when exposed longer to changes in contingency. The findings implied that increasing the time in the resurgence phase would provide a better demonstration of resurgence. Experiment 3 first aimed to resolve the issues identified in Experiment 1. Altering the requirements was predicted to resolve the issues and achieve better experimental control of behaviour. The methodology then continued to demonstrate resurgence in a three-phase procedure like those seen in the animal literature. Lastly, Experiment 3 compared two groups of participants with different resurgence testing times. The first group was given a 60-s resurgence condition while the other a 120-s condition. The comparison would be examined to determine if increasing the time would provide a better demonstration of resurgence.

Method

Participants

Participants were 24 undergraduate and postgraduate psychology students from the University of Waikato who were recruited under the same conditions as participants in Experiment 1 and 2.

Recruitment

16 participants were first recruited and tested for resurgence at a time of 60-s. The remaining eight participants were then recruited and tested at a time of 120-s.

Apparatus

The apparatus remained the same throughout the experiment like those in Experiment 1 and 2. However, the software was now v3.2 which signified the use of a three-phase procedure.

Procedure

Instructions. The instructions remained unchanged and the full instructions script can be found in Appendix A.

Stimulus. The stimulus presented remained unchanged and can be found in Appendix B.

Task. The task now consisted of three phases. Phase 2 in the four-phase procedure was no longer present. Phase 2 now consisted of the black button becoming effective with the yellow button simultaneously present.

These three phases resembled a three phase resurgence study used in animal studies and the hypothetical resurgence data by Doughty and Oken (2008). In Phase 1, Behaviour A is reinforced. In Phase 2, Behaviour A is placed on extinction while Behaviour B is reinforced. In Phase 3, both Behaviours are placed on extinction for resurgence testing.

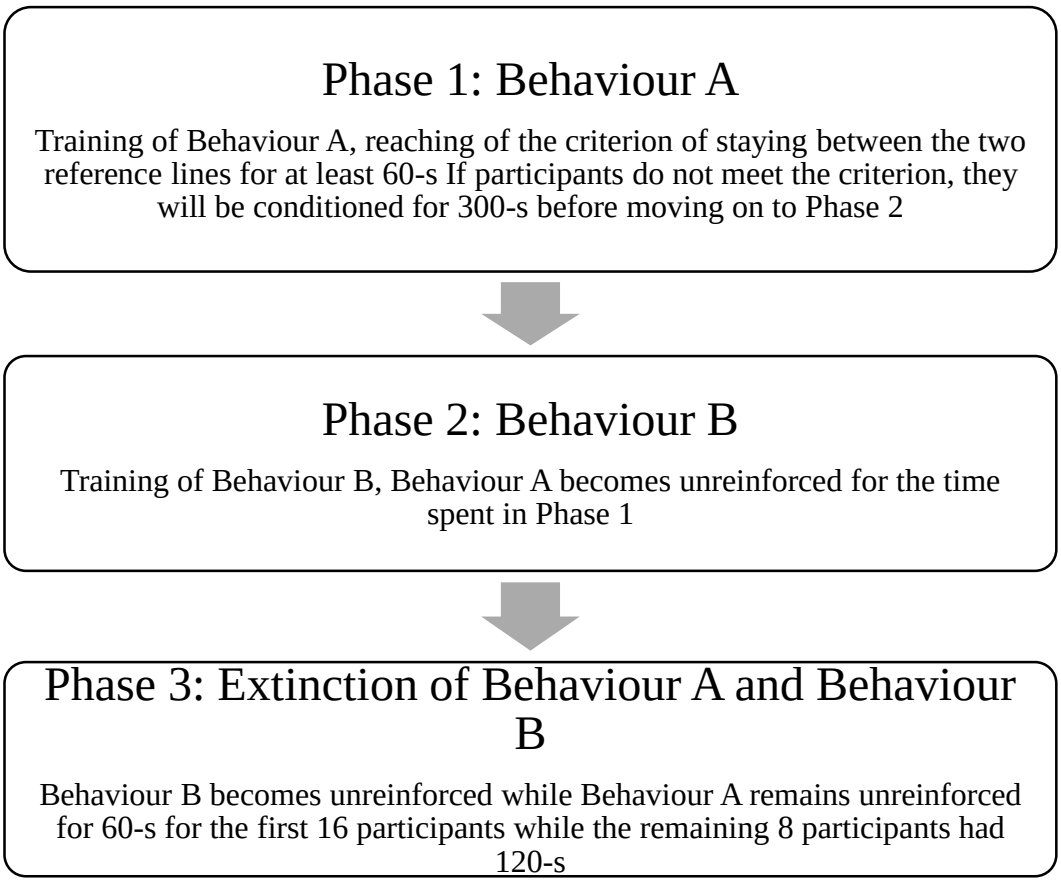


Figure 11. An overview of the basic experimental procedure of Experiment 3.

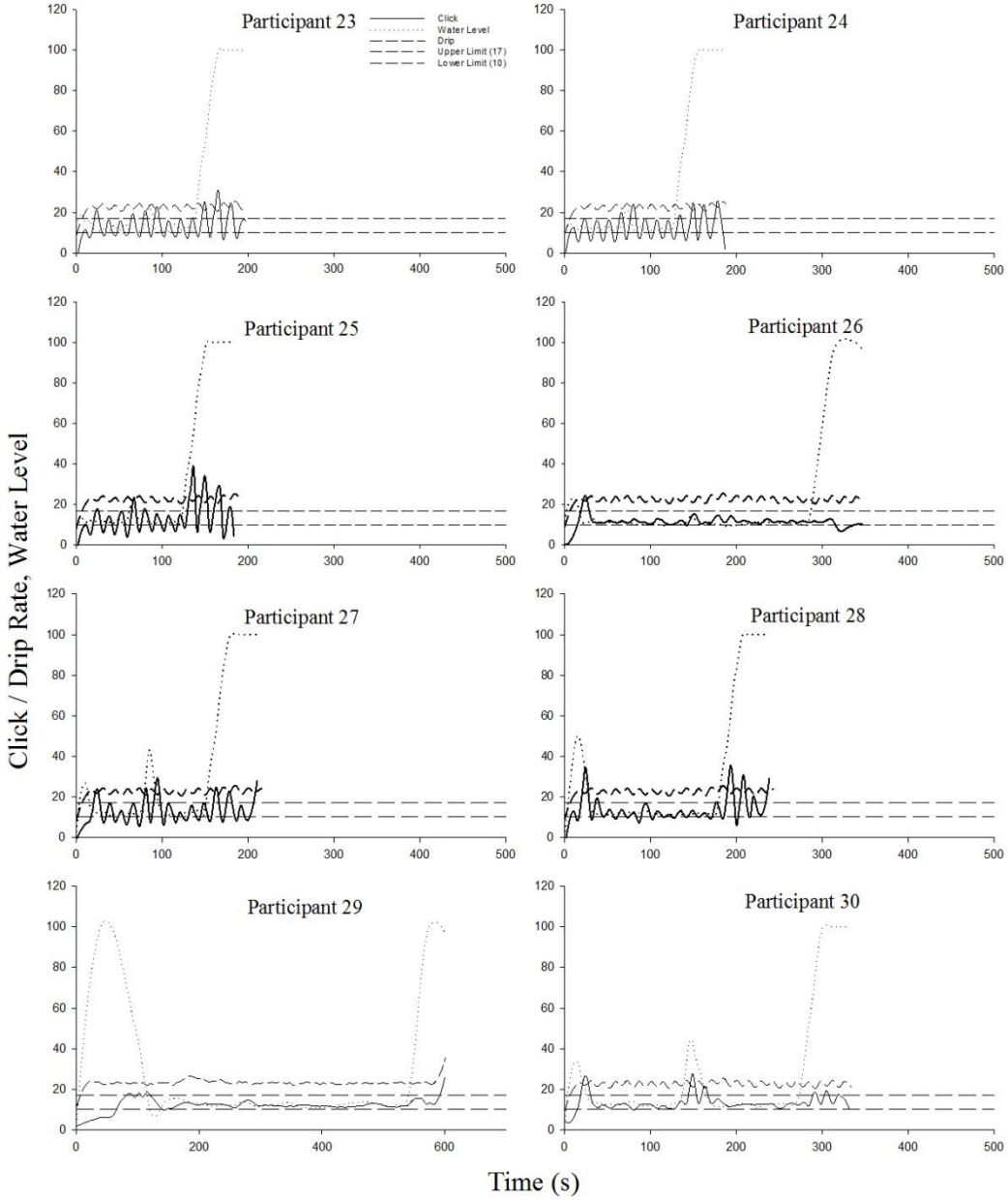
Data Analysis

The data analysis remained the same throughout this experiment as of those in Experiment 1 and Experiment 2.

Results

Figure 12 and 13 illustrate the experimental control aspect of participants in Experiment 3. Participants were tested for resurgence at a time of 60-s and 120-s. Of significance difference was the change in the water level in this present experiment as compared to the findings of Experiment 1 and 2. The short-dotted lines for participants in the 60-s condition remained unchanged. However, the short-dotted lines for those in the 120-s condition remained at 100% for twice as long. Apart from that, the water level for Participant 29, 38 & 44 had a sharp increase, then decrease at the start of the task.

Figure 12 and 13 presented and analysed the rest of the data like those of Experiment 1 and 2. The data plotted on the x and y-axis remained unchanged. Click and drips rates, and the water level were plotted on the y-axis while the time up to 500-s was plotted on the x-axis. The results like Experiment 1 and 2 were not substantially differences. Clicks and drip rates, and the water level remained similar in pattern. As expected, click rates were seen to increase in magnitude when the water level started to increase and decrease. Drip patterns continued to follow an oscillating pattern for all participants across conditions. The water level for the rest of the phases did not differ from those of Experiment 1 and 2.


Participant 23
Participant 24
Participant 25
Participant 26
Participant 27
Participant 28
Participant 29
Participant 30
Click
Water Level
Drip
Upper Limit (17)
Lower Limit (10)
Click / Drip Rate, Water Level
Time (s)

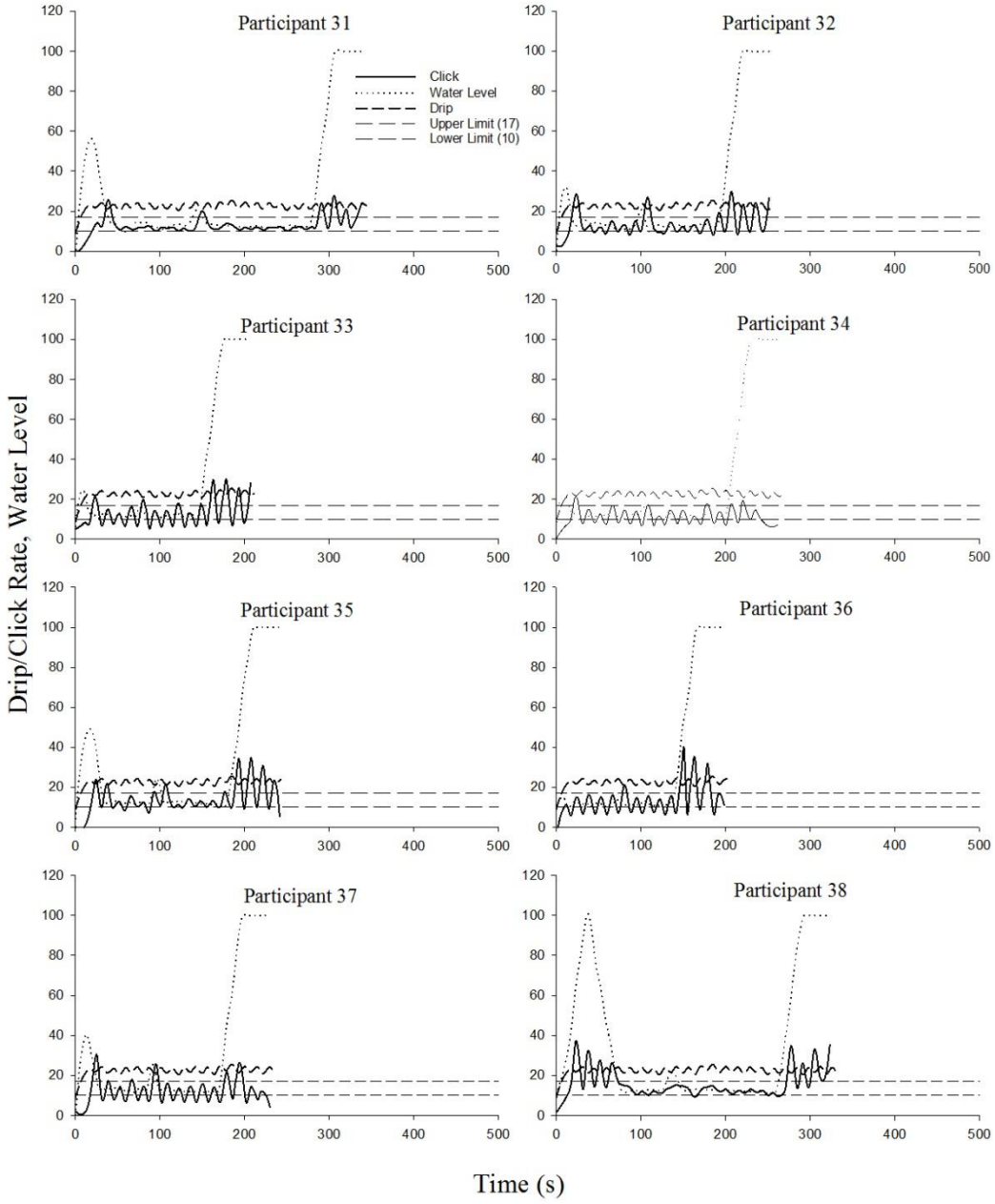


Figure 12. The graph depicts of the control aspect results of Experiment 3 for 16 participants under resurgence testing of 60-s.

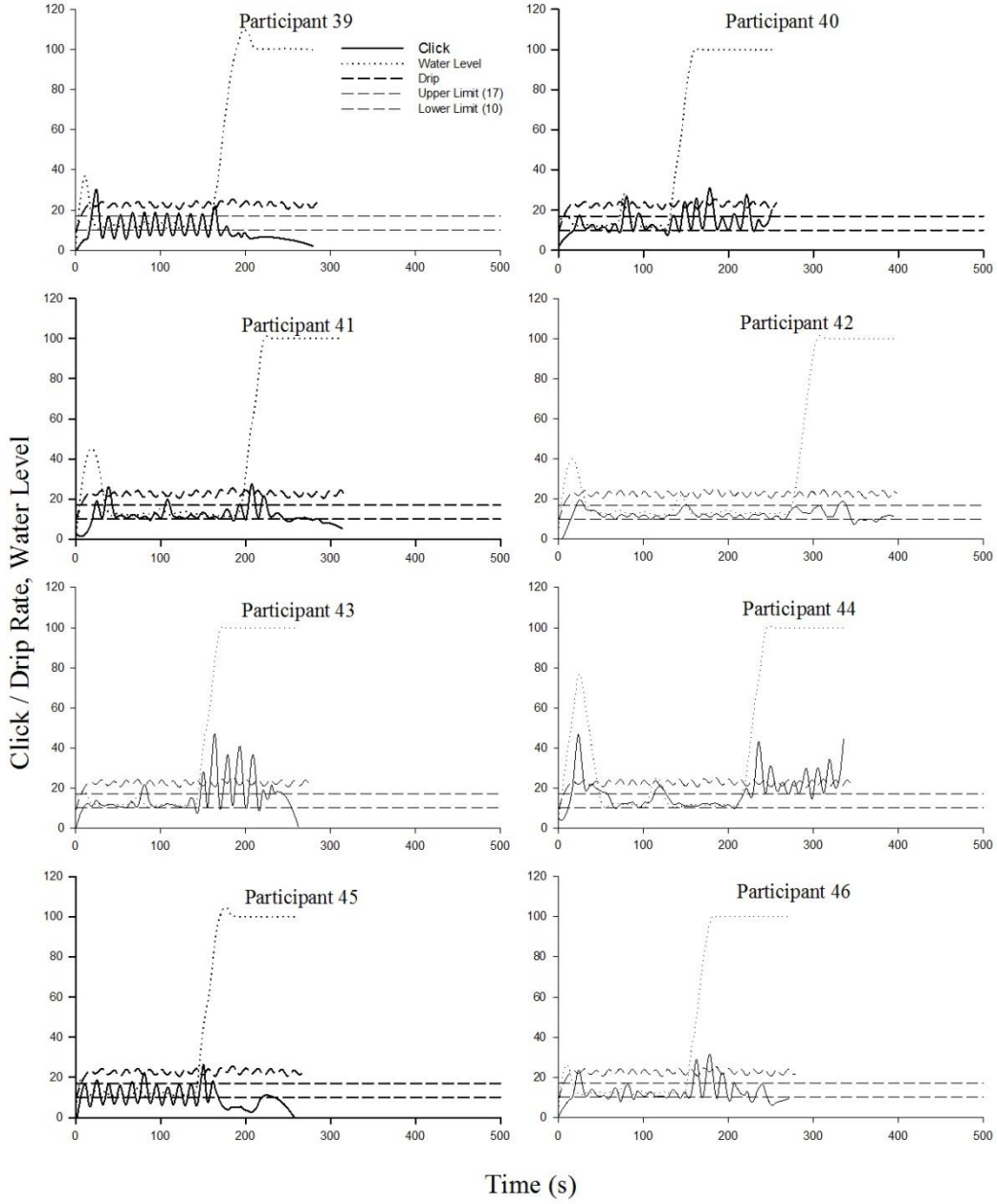


Figure 13. The graph depicts of the control aspect results of Experiment 3 for the remaining eight participants under resurgence testing of 120-s

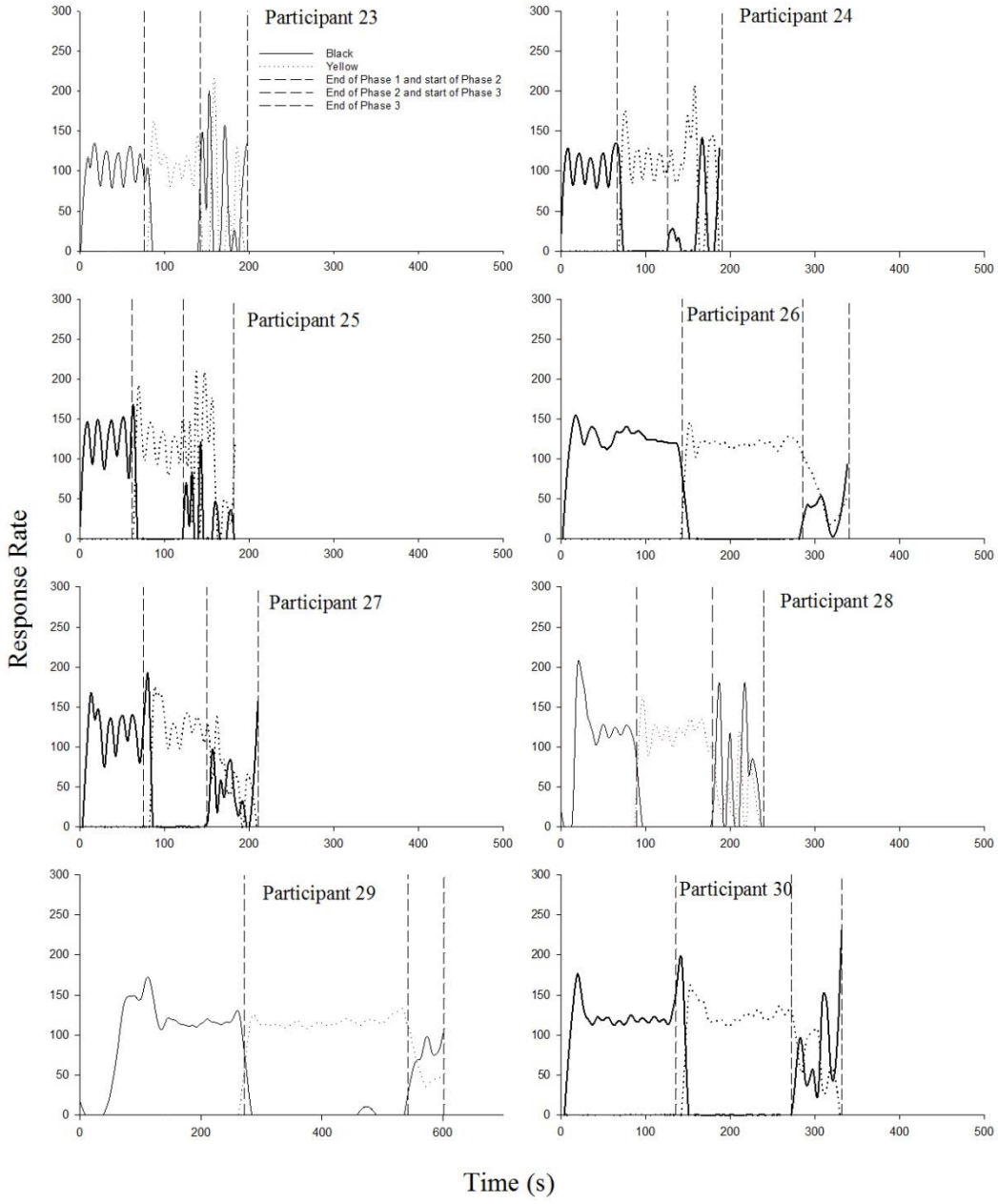
The response rates were also presented and analysed like those of Experiment 1 and 2. The data was compared to the hypothetical resurgence data provided by Doughty and Oken (2008). The hypothetical resurgence data in the lower panel of Figure 15 remained consistent. Figure 14 and 15 illustrate the response rate aspect of participants across two resurgence conditions. 16 participants were tested for resurgence at a time of 60-s while the remaining eight

at a time of 120-s. 3. The data plotted on the x and y-axis remained unchanged. But there are now only three phase change lines displayed instead of four.

The data showed no differences in the response rates of participants during the training of Behaviour A and Behaviour B across both resurgence testing conditions. The extent and patterns of the response rates remained the same like those of Experiment 1 and 2. But the response rates were of noticeable difference during resurgence testing in both conditions.

Figure 14 illustrates the response rates of participants in the 60-s resurgence testing condition. The solid lines (Behaviour A) steadily increased at first to the rate of baseline training for all participants. Then, most participants' response rates were not observed to decrease later except for Participant 25, 28, 32, and 37. Their response rates remained at a high rate. The short-dotted lines for most participants, except Participant 25, 26, 27, 34 and 37, remained at a rate like baseline training. They were not observed to decrease gradually towards the end of the task. The pattern and extent of response rates were also different to the hypothetical resurgence data.

Figure 15 illustrates the response rates of participants in the 120-s resurgence testing condition. The figure shows differences in response rates as compared to those in Figure 14. Behaviour A (solid lines) recurred with an increase in rate initially, but gradually decreased for most participants towards the end of the task. The short-dotted lines (Behaviour B) were also observed to gradually decrease towards the end of the task. Both sets of lines did not remain as high as those seen in Figure 14. The pattern and extent of response rates of participants in the 120-s condition resembled closer to the hypothetical resurgence data.


Participant 23
Participant 24
Participant 25
Participant 26
Participant 27
Participant 28
Participant 29
Participant 30
Black
Yellow
End of Phase 1 and start of Phase 2
End of Phase 2 and start of Phase 3
End of Phase 3
Response Rate
Time (s)

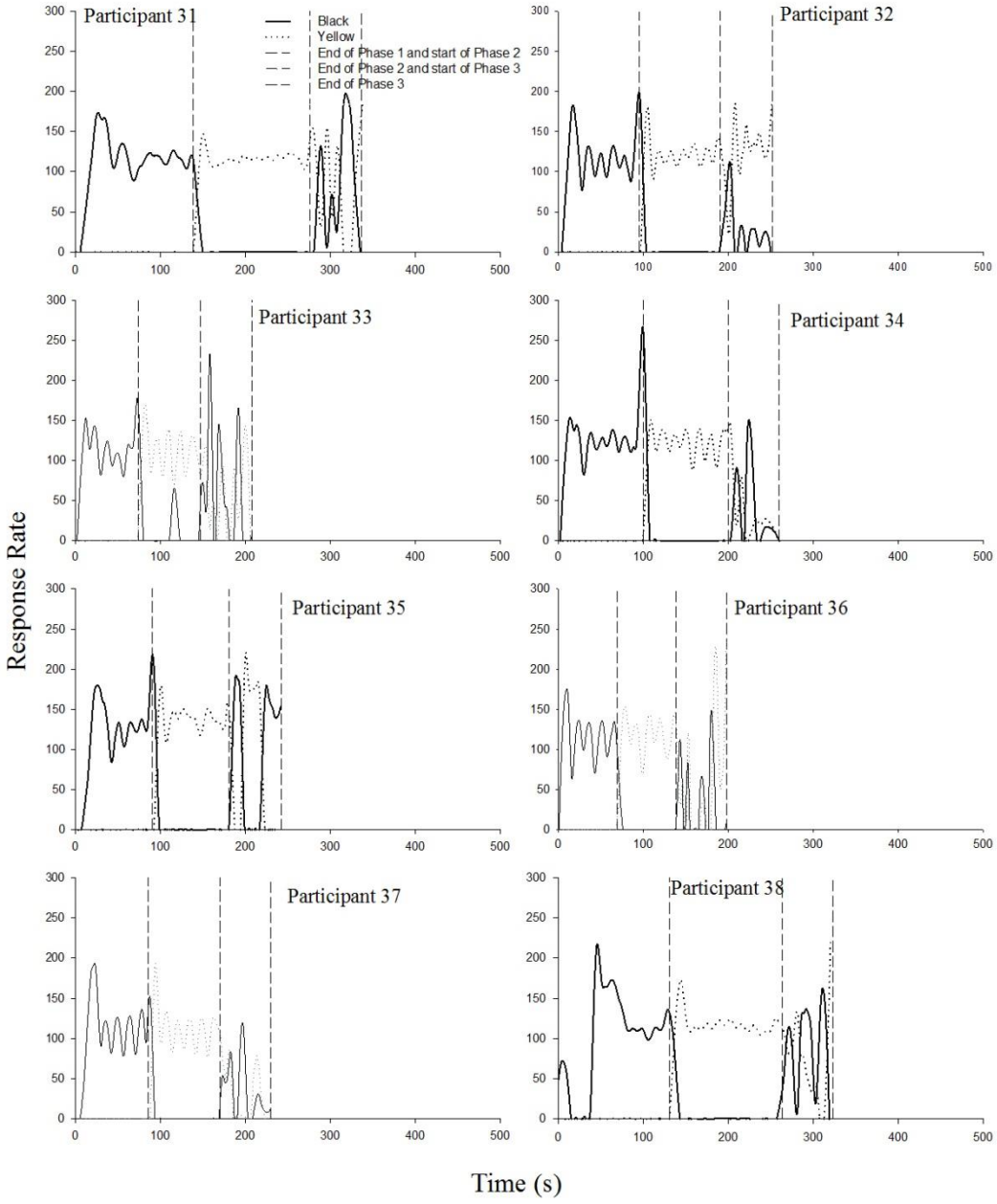
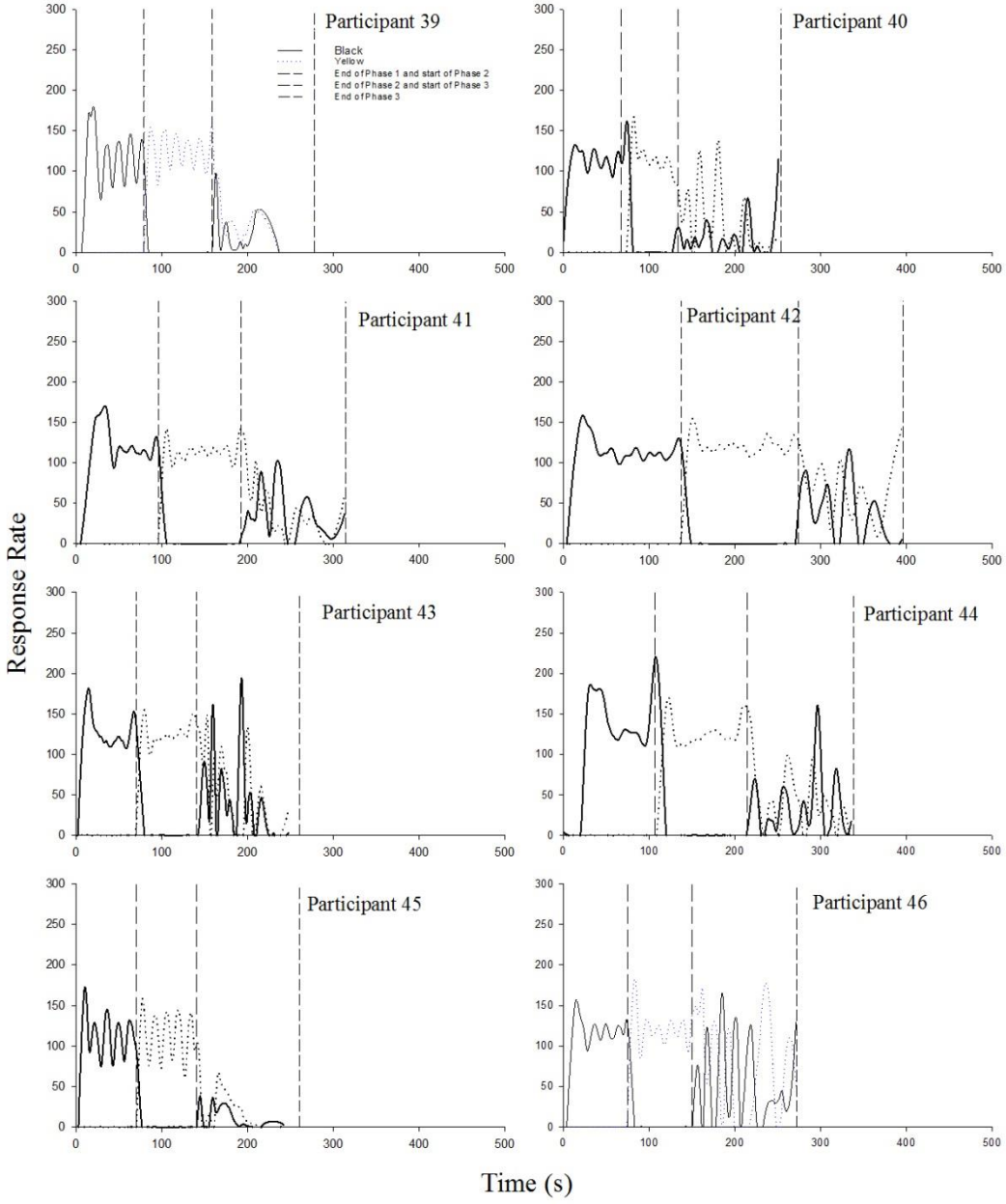


Figure 14. The graph depicts of the response rates of Experiment 3 for 16 participants under resurgence testing of 60-s.



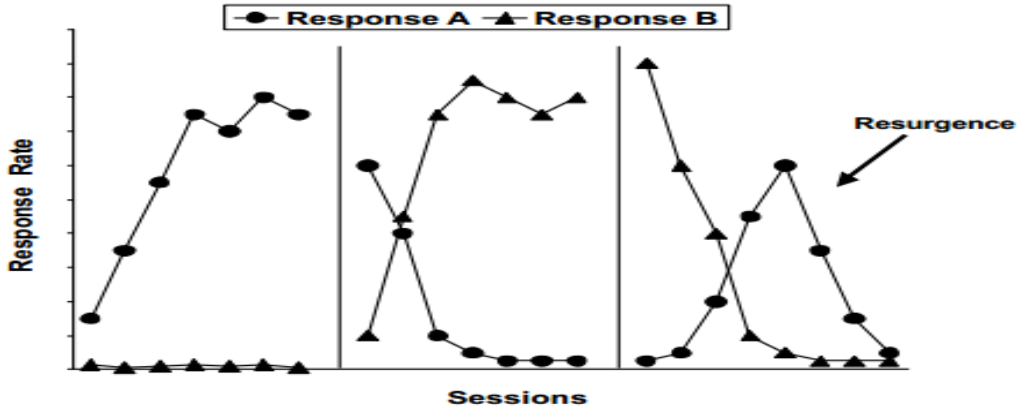


Figure 15. The graph depicts of the response rates of Experiment 3 for the

remaining eight participants under resurgence testing of 120-s. Doughty and Oken (2008) hypothetical resurgence data is also presented on the lower panel.

Discussion

The data of Experiment 3 suggested that the methodology stood up to changes in the procedure and requirements. It appeared to have resolved the issues identified in Experiment 1 and achieved the same degree of experimental control. Furthermore, resurgence was demonstrated with the 120-s condition providing the best illustration like those seen in the animal literature.

Experiment 3 continued to achieve good experimental control despite changes to the requirements and experimental perimeters. All participants fulfilled all three requirements taken as indicators of good experimental control. Also, all participants were able to move on to Phase 2 without using the new proposed change. The change intended for participants to move on after 300-s of being unable to fulfil the goal. But it was not needed in this present experiment. Perhaps changes to the intended ranges (10% to 17%) and including the 1% allowance explained its lack of usage. These change may have made the moving on to Phase 2 easier. Furthermore, they would have resolved the individual differences in responding and gave participants more time to react to the upsurge in drip rates.

The methodology also continued to demonstrate resurgence in a manner consistent with the previous research. Participants in the 120-s condition provided the best demonstration as compared to those in the 60-s condition. The data also indicated that increasing the exposure to the arranged contingencies gave participants more time to regulate their responses. The findings of Experiment 3 proved the methodology robust in achieving good experimental control and demonstrating resurgence in a three-phase procedure.

General Discussion

This thesis first investigated the use of a task, using elements of a pursuit-tracking task and general descriptive instructions, to create a methodology for laboratory research. The methodology is then applied to the challenges in investigating resurgence with humans in a laboratory setting. The results from the three experiments indicated that the challenges were addressed and good experimental control of behaviour was achieved. There were clear indications of responding based on the arranged contingencies rather than rule-following. Resurgence was also demonstrated in both three- and four-phase procedures. Experiment 2 clarified the effects of time in extinction on resurgence and found a significant reduction in the extent of resurgence. That result from Experiment 2 further attested the strength of the research method.

By using a pursuit-tracking task in the present experiments, a single simple click was provided with immediate feedback. Each response was clearly indicated on screen by a decrease in the water level to participants. The consequence provided the behaviour with instantaneous feedback. Participants were not exposed to multiple schedules or choice-making procedures which delayed reinforcement and increased their latency in responding like those seen in Doughty et. al., (2010). Subsequently, the latency in response reduced from 2-s seen in Doughty et. al., (2010) study to almost immediately in the present study. Providing immediate feedback would strengthened the connection between behaviour and consequence.

Past research by Doughty et. al., (2010) have also shown that low rate of responses made the connection between behaviour and consequence weak. The weak connection made participants insensitive to changes in contingencies and

resistant to extinction. This was clearly evident in their study as participants continued responding in the same way as they had during training even though the extinction condition was in place. In the present experiments the drips were set at a pace where participants had to respond at a high rate which meant participants were conditioned more, immediately, and at a higher rate. Increasing the rate of responding would also strengthened the connection between behaviour and consequence. As a result, participants became more sensitive to changes in contingencies and were less resistant to extinction. The findings in all three experiments provided clear evidence that participants were responsive to the arranged contingencies. Participants adjusted their responding much quicker to changes in the contingencies during extinction.

McHugh et. al., (2012) have shown that by giving participants explicit instructions on how to respond, it led to uncertainty whether responding appeared to be verbally regulated or by contingencies. Consequently, in the investigation of resurgence, it was unclear whether results were produced by changes in contingencies or returning to previous rule-following. But by using general descriptive instructions in the present experiments, the uncertainty was resolved. Participants were neither told the contingencies nor the response. Yet the data from all three experiments have shown that behaviours were regulated based on the arranged contingencies. This was clearly evident in the findings of all three experiments as participants regulated their responses according to the contingencies in each of the conditions (i.e., initial training, extinction, alternative training, and resurgence). Because of the absence of specific instructions, responding based on rule-following was discounted. Hence the conclusion that

participants regulated their responses was a direct result of changes in contingencies.

The results not only demonstrated resurgence, but have replicated in Experiment 2 that resurgence decreased as time in extinction increased. The findings in Experiment 2 were consistent with results from Sweeney and Shahan (2013). The group that received a longer time (60-s) in extinction showed visually (and statistically significant) the lowest resurgence as compared to the group that received only 15-s of extinction. Furthermore in Experiment 2, extending the time in extinction (60-s) increased the participants' exposure to the contingencies of extinction. As a result, the response rates resembled closer to those of extinction. Participants in the 60-s extinction condition responded in a manner consistent with extinction than those in 15-s extinction suggesting extinction burst.

The findings from Experiment 1, 2 and 3 can be viewed from the perspective of the three accounts. The three accounts concluded that resurgence is a robust effect that cannot be eliminated, but can be reduced. Bouton and Schepers (2014) also suggested that extinction is not erasure or unlearning, but a form of response inhibition that leaves Behaviour A always susceptible to relapse. The present findings have shown that Behaviour A continued to recur even at low rates. The data from all three experiments corresponded with the three accounts. The results therefore gave us confidence that the method used here is robust for investigating resurgence.

It is worth noting that several participants started off slowly and took longer to figure out a way to reduce the water level. As a result, the water level rose. This created a scenario where participants had to respond at a higher rate initially to compensate for the raised water level. This scenario may have also

contributed to a latent history effect. A latent history effect in humans and higher rates of response like those seen in Doughy et. al., (2008) and Reed and Morgan (2007) can affect the extent of resurgence. Their study showed there was greater resurgence for those with a latent training history and higher rate of responses. This might explain why several participants who took longer to respond in the beginning of the task had a higher magnitude of resurgence.

Thus, response rates during the training of Behaviour A and Behaviour B need to remain consistent. The consistency would eliminate any latent history effect affecting resurgence. It is possible by altering the experimental perimeters in future experiments would resolve the latent history effect. The intended ranges could be increased to around the 20% or 30% mark so that participants had more time to figure out their response. The water level could also started off at 0% instead of 5%. The black button could also be presented 5-s after the task began rather than leaving it present at the start. Anecdotal evidence suggests the black circle did not evoke the behaviour of clicking. Perhaps introducing the black button 5-s start the task began might evoke the clicking behaviour.

There was the possibility that participants might be operating under the rule "Be Alert and Vigilant". This rule was initially pointed out to have unintended effects on the initial extinction time of 15-s. Experiment 2 excluded this possibility by increasing the time in extinction to 60-s and suggested that participants in the 15-s condition were responding at a rate suggesting extinction burst. But it does not remove any uncertainty to whether responding was a product of rule-following or changes in the contingencies. Several participants continued to show high rates of responding during resurgence testing. Others persisted with lower rates of responding and did not reduce to near-zero. Thus, the instructions

could be made more general and less explicit in future experiments. The statement "Be Alert and Vigilant" could be removed while the goal of the task could be altered to only state "Keep the plants alive".

Experiment 2 clarified the effects of time in extinction on the extent of resurgence. The findings in Experiment 2 showed that the number of black clicks significantly reduced when the time in extinction increased from 15-s to 60s. The findings were consistent with the suggestion by Sweeney and Shahan (2013) that an increased exposure in extinction may be an effective strategy for limiting resurgence. The results from Experiment 2 therefore have provided practical applications in clinical settings. These settings include interventions targeting problem behaviour with extensive relapse problems. Individuals who are in treatment could first go through the process of extinction of their problem behaviour. It is then the resurgence of the problem behaviour would be less likely observed.

In conclusion, it would seem that the methodology had address the challenges in investigating resurgence with humans in laboratory research. This has been the purpose of this thesis. This does not mean that the methodology cannot be examined further. The effect of time in extinction plus training of Behaviour B on the extent of resurgence was not examined in this thesis. Future experiments could start off by investigating this. A replication of results from Sweeney and Shahan (2013) would further strengthened the methodology as robust in investigating resurgence. Other new factors (i.e., negative abstinence contingency) could also be examined. Furthermore, the methodology could investigate other behavioural phenomenon such as the renewal effect and stimulus control.

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Appendix A

Instruction for Participants

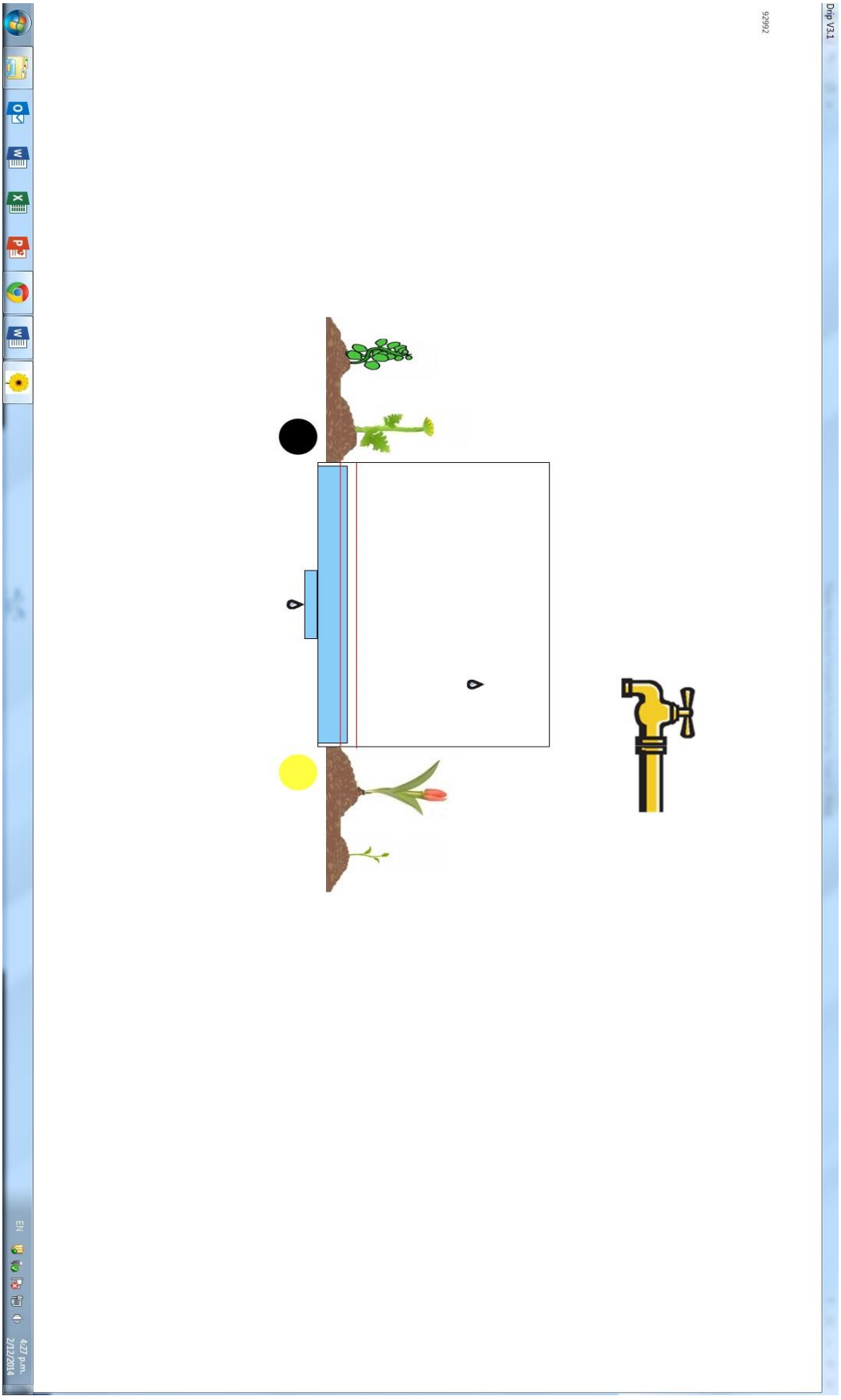
In this task, you will have to keep the water level between the two red lines in order for the flowers to grow. If it goes beyond the range, the flowers will stop growing and they might die. Hence, you have to prevent this by clicking on the screen.

BE ALERT AND VIGILANT!

Once you are ready and have accepted the responsibility, click [START].

The experiment ends when it says "Experiment has ended" on the bottom left of the screen.

Appendix B



Appendix C

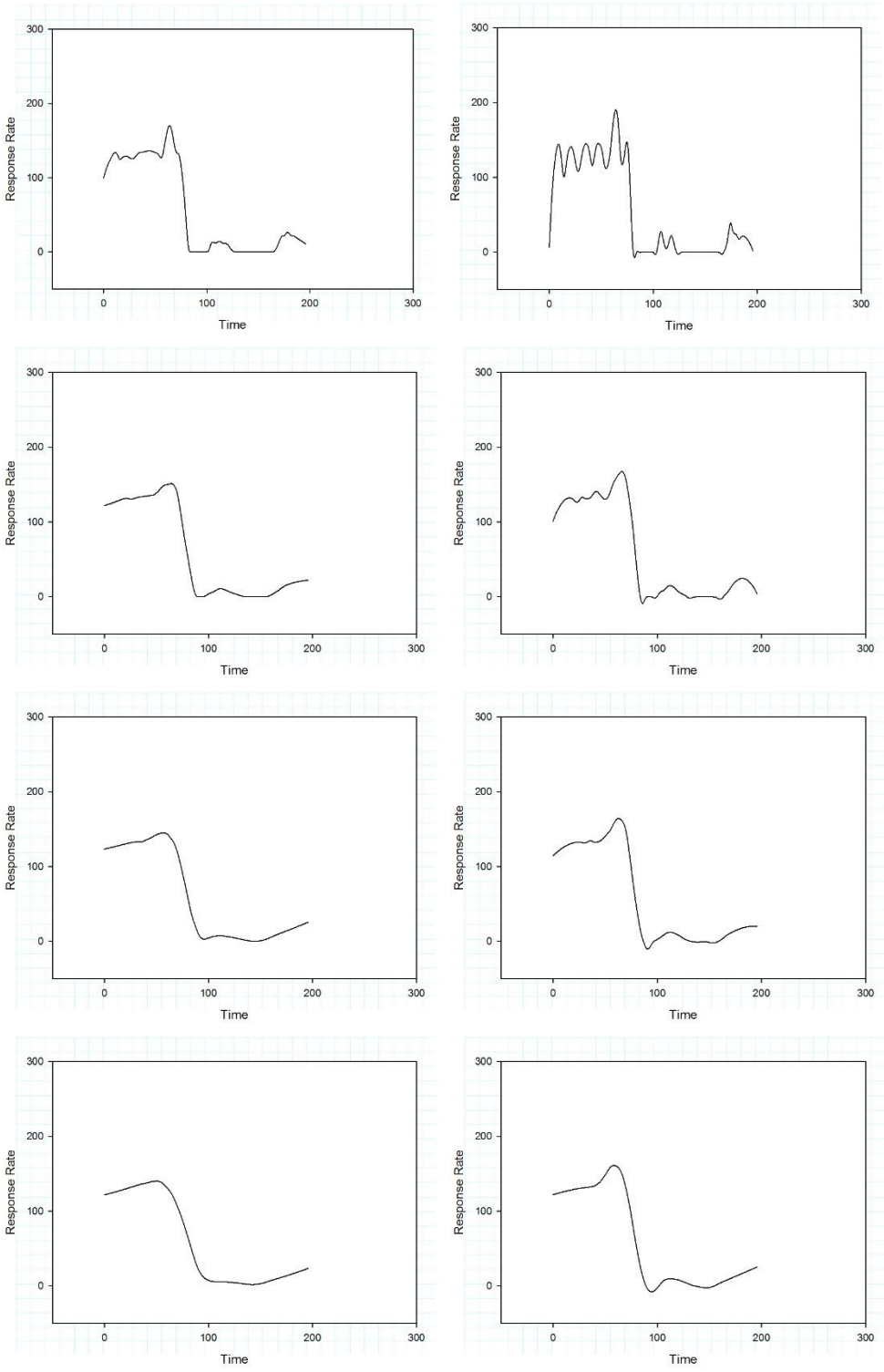


Figure 16. The left panel displays a range of sampling proportions (0.1 to 0.4) with a polynomial degree of 1 while the right panel with a polynomial degree of 2.