Resurgence and Order Effects in Humans

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Abstract

Latent behaviours are learned behaviours that have not been recently observed in an individual's behavioural history. These behaviours can reappear under many different conditions. Resurgence refers to the reappearance of latent behaviour during extinction. Resurgence is one of the behavioural effects which increases behavioural variability during extinction. This increase in behavioural variability contributes to the complex responses produced in problem solving situations. In typical resurgence research there are three phases: a training phase, an alternative reinforcement phase and a resurgence phase. However, in real-life situations, people often have more extensive learning histories and multiple behaviours may reappear when extinction occurs. The aim of this study was to research whether the order that behaviours were acquired in, for either three or four behaviours, would affect their prevalence during extinction. University students were randomly assigned into one of two groups. The first group took part in a four-phase resurgence procedure and learnt three responses sequentially before transitioning to the extinction phase. The second group learnt an additional response before transitioning to the extinction phase. A primacy and recency effect was found in the three response group; the first trained response and the last trained response were the most prevalent trained responses during extinction. This was consistent with previous research. The behaviours of the participants in the second, four-response, group were more idiosyncratic and no order effects were observed. This study contributes to the research of how different aspects of an individual's behavioural history can affect resurgence.

Keywords: Behaviour, Humans, Resurgence, Serial-Position, Order Effects, Primacy, Recency, Problem Solving

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"[T]here is probably no behavioral process which is not relevant to the solving of some problem, an exhaustive analysis of techniques would coincide with an analysis of behavior as a whole" (Skinner, 1969, p.225).

Introduction

Defining Problem Solving

Problem solving has been described as having "a well-earned reputation for being the most chaotic of all identifiable categories of human learning," (Davis, 1966 as cited in Holth, 2008, p. 160). This reputation stems from a cyclical history between research and theory which has led to an array of differing definitions for term problem and subsequently problem solving (Tallman, Leik, Gray & Stafford, 1993). It is from these definitions that the scope of behaviour defined as problem solving behaviours are determined.

Andersen (1980) defines a problem as a state which an organism is not in but desires to be in, a "goal" state, and problem solving as any behaviour to reach that state. Andersen also suggests that all behaviour is purposeful, an act of moving from one state to a "goal" state. Taking both of these points into consideration, this definition defines all behaviour as problem solving (Andersen; Holth, 2008).

Different variables have been added to the definition of problem solving to reduce the scope of behaviour the term encompasses, this includes the addition of obstacles, difficulty, and whether a task is able to be completed immediately (Holth, 2008). These additional variables have their own issues: not all problems have physical or identifiable obstacles, a task may not be able to occur immediately due to constraints that do not constitute a problem like only being

able to hop on a bus when it arrives at the bus stop, and both easy and hard problems exist (Holth; Skinner, 1988).

Skinner (1969) begins a chapter on *An Operant Analysis of Problem Solving* with the statement, "the behavior observed when a man solves a problem is distinguished by the fact it changed another part of his behavior and is strengthened when it does so" (p.133). The first example of a problem Skinner gives involves an individual under food deprivation—a Motivating Operation (MO) for food seeking behaviour—with no response available that has been previously reinforced by food. The problem is solved by changing the environment until a response that is reinforced by food occurs.

However, Skinner (1969) also includes examples that should not be considered a problem, this includes behavioural chains that would likely be under stimulus control. Skinner poses a problem in which a person is asked to identify someone behind them. It is established that the person knows their name. Precurrent behaviour[1], behaviour which precedes the emittance of the terminal behaviour is performed; the person turns to look at the individual behind them before answering the question with their name. Skinner suggests that this precurrent behaviour is problem solving behaviour because it generates the discriminative stimulus needed to emit a response. However, unlike the previous example, there is nothing which prevents the chain of behaviours which evokes the terminal behaviour that results in reinforcement from occurring. Many tasks

[1] Precurrent behaviour is similar to a behavioural chain, but differs in one significant way. Precurrent behaviour creates supplementary discriminative stimuli, rather than become conditioned discriminative stimuli, which increases the probability of a terminal behaviour that will lead to reinforcement.

are comprised of a series of steps—putting on shoes, making a coffee—and behavioural chains are needed to complete them, but this does not necessarily make them a problem. An issue with comparing precurrent behaviours to behavioural chains is that chains of precurrent behaviour are typically novel whereas established behavioural chains are not. Though the behaviours comprising a precurrent chain may be combined in a novel way, the individual units of behaviour, otherwise known as atomic repertoires, are under distinctive stimulus control (Palmer, 2003). There is no problem when all of the relevant behaviours which fulfil the requirements of a schedule of reinforcement are under the control of current stimuli.

A problem occurs when an individual comes into contact with a discriminative stimulus—a stimulus which indicates that a schedule of reinforcement is available—but the individual has no prevailing response that will result in reinforcement (Skinner, 1969; Donahoe & Palmer, 1994; Palmer, 2009; Holth, 2008). Problem solving describes the behavioural event that generates the response, or responses, which manipulate the current environment to occasion a reinforcer (Skinner; Donahoe & Palmer). In order for problem solving to be successful the relevant responses must be in the individual's behavioural repertoire (Donahoe & Palmer; Epstein, 1983; Kieta, Cihon & Abdel-Jalil, 2018).

Mechanisms of Problem Solving

Problem solving is often associated with higher order mental processes and theoretical cognitive constructs ranging from Gestalt's perceptual restructuring of "problem spaces" to technological metaphors based on the latest computer processing models (Donahoe & Palmer, 1994; Holth, 2008; Kieta, Cihon & Abdel-Jalil, 2018). Palmer (2003, 2012) suggests that complex behaviour,

commonly considered cognitive, can be understood from a molecular behavioural perspective. From this approach complex behaviours are not functional units but are comprised of atomic repertories that are arranged in relation to corresponding stimuli (Palmer, 2009, 2012). Atomic repertories are under distinctive stimulus control and are unique to an individual's behavioural history (Palmer).

Atomic repertoires are the building blocks of behaviour and can explain variations in behaviour as well as first instances of behaviour. An individual can ring a friend they have never rung before without error by entering their friend's number found in the phonebook. This behaviour is under multiple sources of control; both from the textual stimuli in the phonebook as well as the stimuli present on the keypad (Palmer, 2012). Novel maths equations can be broken down into smaller, precurrent behaviours that are under direct stimulus control to form a novel, terminal answer. Though these behaviours can be described as novel, having never been observed in an individual's behavioural repertoire, they can be described as formulaic and do not meet the requirements to be problem solving behaviour. The individual units of behaviour needed to form the chain of behaviours required for reinforcement are under stimulus control (Kieta, Cihon & Abdel-Jalil, 2018). Instead, problem solving needs to be considered in terms of latent behaviour, behaviour which is not evoked by the current arrangement of stimuli in the environment, and how this behaviour can be brought to strength.

Response Strength

Response strength is a construct posed by Skinner (1938) to be used as an alternative to probability when measuring on-going behaviour because probability cannot be directly accessed (Epstein,1895). Instead, the strength of a response could be measured by the rate that an individual emits that response and this

measurement of response strength could then be related to probability. Palmer (2009) suggests that response strength, rather than probability, is a useful construct because it makes more sense to discuss the strength of a behaviour which has already been emitted and observed. Palmer also relates response strength to other measures of behaviour including the force or speed that a behaviour was emitted. An individual may yell or whisper a response.

Palmer (2009) suggests that response strength is not only useful when measuring overt behaviour, but also covert and latent behaviour. Overt and covert behaviours are both brought to strength above a "Threshold of Emission" by current variables, and overt behaviours to a strength above a "Threshold of Observability" (Palmer, p.51). Latent behaviour describes behaviours within an individual's repertoire that are below the "Threshold of Emission" and, due to current variables, other competing behaviour is evoked to strength instead (Palmer). However, strength is not a fixed value for the emission of a behaviour but it is also relative to the strength of other competing behaviours. A "weak" behaviour can be emitted if there are no "strong" competing behaviours (Palmer).

Response strength is established through the contiguity of a response with reinforcement (Skinner, 1981; Shahan, 2017). When a response results in reinforcement that response is "strengthened"—this refers to an increase in either the frequency or likelihood of that response occurring under similar conditions in the future (Shahan; Palmer, 2009; Cowie, 2018; Kieta, Cihon & Abdel-Jalil, 2018). Throughout an individual's history of exposure to reinforcement under various environmental conditions different responses are required and through reinforcement they are acquired (Palmer; Kieta, Cihon & Abdel-Jalil). These acquired behaviours are referred to as a behavioural repertoire.

Palmer (2009) uses a flask metaphor to describe the probability and potentiation of latent responses in an individual's repertoire. Within the flask are all responses that exist in an individual's behavioural repertoire. Most responses are at the bottom of the flask with a low probability of occurring. Variables in the environment increase the strength of some behaviours, increasing their probability of occurring, but below the "Threshold of Emission." A bottleneck at the top of the flask represents response competition. Many responses cannot occur simultaneously—an individual can sit or stand but they cannot do both at the same time. Only one behaviour is brought to strength above the "Threshold of Emission" due to environmental variables, this causes the other competing behaviour to be inhibited so that the two behaviours do not blend together (Palmer).

Shahan (2017) criticises the use of reinforcement and response strength in behavioural psychology; explaining that using the term reinforcement—even as a hypothetical explanation—for a process that "strengthens" behaviour is circular. Behaviour increases in strength because it results in reinforcement and reinforcement occurs because it is a result of the behaviour which produces it. Though the procedural definition of reinforcement is problematic, reinforcement is a useful descriptive term for when an increase of behaviour occurs as a result of the functional relationships between the behaviour and consequential events. Shahan suggests that more research needs to be conducted to understand the mechanisms behind these prospective, temporal relations, rather than rely on reinforcement and response strength as implicit explanations. Nevertheless, response strength is a useful concept to understand how different mechanisms contribute to problem solving (Palmer, 2009).

Stimulus Control

Skinner's three-term contingency describes the functional relationship between an antecedent, a response and a consequence, this establishes the role of the antecedent or environment in behaviour (Sidman, 2008). A discriminative stimulus (S^D) is an antecedent which, through a history of reinforcement, signifies that a reinforcer is available when a particular behaviour is performed which increases the probability of that response occurring. A pigeon pecks a lit key which results in food. When this occurs reliably over several sessions, the lit key becomes an S^D which signifies a reinforcer (food) and evokes a behaviour (key pecking). Alternately, a s-delta (S^Δ) signifies that no reinforcement is available; no food is delivered when the key is not lit so no key pecking is evoked which makes an unlit key an S^Δ.

The definition of an S^D is sometimes changed from a stimulus which evokes a behaviour to being a stimulus which occasions or increases the probability of a certain behaviour when that stimulus is present. This is because a behaviour may not always occur in the presence of an S^D. To account for this, Skinner's three-term contingency is often expanded to a four-term contingency to allow for the better prediction of behaviour. Another antecedent is added which is referred to as a Motivating Operation (MO). MOs modify the reinforcing or punishing effectiveness of a consequence which alters the frequency of behaviour correlated to that consequence relevant to the current S^D (Edwards, Lotfizadeh & Poling, 2019). An MO which reduces the effectiveness of a reinforcer can account for a behaviour not occurring in the presence of an S^D. Whereas an MO which increases the effectiveness of a reinforcer means that a behaviour is likely to occur in the presence of an S^D. As suggested by Skinner's (1969) first example, a MO

evokes problem solving behaviour when behaviour correlated with the consequence is unavailable, however, not stated in the example, the behaviours which are evoked are still under the control of the stimuli present in the current environment.

Beyond the four-term contingency are n-term contingencies. Behaviour is typically not controlled only by a single stimulus, but also by wider external and internal environmental cues and stimulus-stimulus relations. N-term contingencies allow for a better prediction of behaviour by considering these additional environmental cues. An example of this is conditional discrimination in which behaviour is under the control of one stimulus when another stimulus is present (Axe, 2008). Conditional discrimination would be established when pecking the lit key is reinforced when a tone is present, whereas when the tone is not present pecking an unlit key will be reinforced (Sidman, 2008). The function of the key, when lit and unlit, is dependent on whether the tone is present or not. A simple maths example is also useful to demonstrate this (Palmer, 2009; Kieta, Cihon & Abdel-Jalil, 2018). When an individual responds with "24" to the equation *12 times 2*, that response was likely within the individual's behavioural repertoire under the control of current stimuli. If the operational symbol *times* was changed to another symbol then a different response would be brought to strength and evoked such as *12 divided by 2* resulting in the response "6".

As stated in the definition of a problem: a problem occurs when an individual comes into contact with a discriminative stimulus, but the individual has no prevailing response that will result in reinforcement. An important factor which contributes to this is novelty. When a stimulus is novel there will be no associated behavioural repertoires for it to evoke which will result in

reinforcement. A stimulus can also be functionally novel, this is when a stimulus varies greatly from the original context that a repertoire was established in that the current stimulus does not evoke that existing repertoire to strength. Conversely, a stimulus which evokes a stereotyped repertoire, due to an extensive history of reinforcement, can prevent variable or novel behaviour which would result in reinforcement.

Novelty

Novelty is an important part of problem solving; both as a component of a problem and the novelty of problem solving responses within the context of an individual (Chase & Bjarnadottir, 1992). However, the term novelty has similar issues as problem solving; its definition determines the range of behaviour that can be qualified as novel. Novelty has been defined in both extremes to encompass all and no behaviour. It is proposed by the Theory of Generativity that since no two behaviours are topographically identical then all behaviour can be considered novel (Epstein, 1991; Shahan & Chase, 2002). Alternatively, an approach which categorises all behaviour into large higher order classes—such as food seeking or rule-governed behaviour—which ignores the variation of behaviour topographies can be used to suggest that no behaviour is novel (Shahan & Chase). Neither approach is appropriate because they cannot be used to further the understanding of behaviour; nor contribute to the analysis of behaviour which allows for prediction and control (Shahan & Chase).

Shahan and Chase (2002) suggest that the analysis of novel behaviour needs to be pragmatic. Instances of novel behaviour can be established by determining the level of variation that is appropriate within a situation, which is important when judging creativity or problem solving behaviour (Shahan & Chase).

Response classes can also be appropriate in other situations by classifying behaviour into smaller, useful classes of behaviour in which topographies vary, Shahan and Chase use the example of distinguishing the first instance of using a tool to get food from other food getting topographies. This does lead to a subjective analysis of novelty, but some subjectivity is unavoidable when studying this phenomenon. Nevertheless, novel behaviour involves the variation of context, response typography, or consequences when those variations observed are deemed important (Shahan & Chase). These variations need to be considered within the context of a subject's learning history.

Context: The Role of Stimuli and Novelty in Problem Solving

Cerutti (1989) suggests that complex responses, including problem solving, can become generalised response classes, using the example that when a child is instructed on how to solve the area of a particular parallelogram they then generalise that response to novel parallelograms. However, this is another example of formulaic behaviour compromised of atomic repertoires under stimulus control. Though the dimensions of a parallelogram can be altered in many different ways, no variation is significant enough that this formulaic behaviour cannot be applied (Kieta, Cihon & Abdel-Jalil, 2018). Instead, problem solving is demonstrated when an individual is presented with a novel shape to solve without being given a formula. Problem solving behaviour may involve applying other repertories to solve that problem such as applying the formula to solve the area of a parallelogram to a novel polygon.

A problem can also occur when a stimulus is functionally novel. This means that the properties of a stimulus deviate enough from the original stimulus that behaviour does not generalise to that stimulus and the relevant behaviour is not

evoked. A problem may be solved when the individual generates the supplementary stimuli needed to evoke the appropriate repertoire. An individual may be asked to calculate the height of a building; they are only told the distance from their position to the building and the angle from the ground to the top of the building at their position. Physically, this situation may resemble no problem that they have encountered before with a three-dimensional building and little additional stimuli. The individual may use covert behaviour to visualise additional stimuli, imagining a line from them to the top of the building. Alternately, an individual may use overt behaviour, using a piece of paper and a pen to draw the stimuli present in the problem as well as those additional lines. This is problem solving behaviour which provides stimuli which may evoke using the formula to calculate the height of a triangle in order to calculate the height of the building.

Differences in both external and internal contextual cues alter the probability of a behaviour occurring. Godden and Baddeley (1975) conducted an experiment on context-dependent memory in which participants, comprised of members of a University diving club, learned a list of items either on land or in the water. They then participated in a free recall test. This test took place either in the environment which matched the context the list was learned in or an environment which did not. Their results showed that when the context of learning and recall did not match the participants recalled fewer items than when the contexts were the same. Similar results have occurred with internal cues. Capaldi and Neath (1995) cite two studies using internal cues in which recall was better when the cues match compared to when they did not match. In one study they cited the participants were either sober or intoxicated during the learning and

recall phases, while another study focused on mood with participants placed in either happy or neutral conditions (Capaldi & Neath).

Functional Fixedness

Functional fixedness is a term used in Gestalt psychology which refers to an inability to repurpose an object for anything other than its original function; this can be redefined as a discriminative stimulus which, through a history of reinforcement, evokes a limited repertoire related to the function of the object. In Maier's Two-String Problem two strings hang from the ceiling in a way that when a person holds one string they cannot hold the other, and an object such as pliers is also in the room (Donahoe & Palmer, 1994). The subject must tie the two strings together, and they can use any of the materials available. The problem is solved by using the pliers as a weight, tying it to the string and swinging it like a pendulum while holding the other string and catching the pliers when they can be reached. In Maier's original study, only 14 of the 61 participants were able to solve the problem with the target solution even after receiving hints such as Maier brushing against the string to set it in a swinging motion and Maier handing the pliers to the participant telling them that they needed to be used to solve the problem (Landrum, 1990).

Birch and Rabinowitz (1951) also researched the impact that previous experience can have on problem solving. They conducted a study with Maier's problem in which two objects that could serve as weights were available: an electrical switch and an electrical relay. They had three groups, a control group, and two experimental groups that went through a pretest training phase before attempting Maier's problem. This phase consisted of either completing an electrical circuit with the switch or completing an identical circuit with the relay.

They found that 17 of the 19 subjects in the experimental groups used the object they did not have pretest training with as the weight to solve the problem. Birch and Rabinowitz concluded in their discussion that stereotyped learning prevented an object from being used in ways other than its function which can prevent successful problem solving and they suggest that "general, broad, nonspecific experience seem[ed] to provide the repertoire of experience essential for [problem solving]" (p.125).

Variability

It has been shown that having multiple repertoires available for a single object can increase an individual's ability to solve a problem when that object needs to be used in a novel way. Brown (1989) and her colleges conducted a study which demonstrates this with 5 and 9 year old children. In their study, children were assigned to a functional fixedness condition or a flexibility condition. Prior to completing a problem solving task, the children took part in a pretest session. For the functional fixedness condition, the pretest session involved drawing on three sheets of paper. For the flexibility condition, the pretest session involved using three sheets of paper for different tasks including drawing, making a plane or a house. None of the tasks for the flexibility group involved the target behaviour to solve the problem. In the test phase the children were given the task of solving the genie problem. For this problem an item, such as marbles, had to be transported from one bottle to another without breaking them or lifting the first bottle. Objects including glue, tape, string, and a sheet of paper were available to solve the problem. The solution for the problem was to roll the paper into a tube to transport the item. The proportion of children able to solve the problem was

higher for flexibility condition than the functional fixedness group for both age groups.

Insight

Insight is a form of problem solving which is often described as the "Aha" moment when a problem is solved abruptly (Shen, Yuan, Lie & Luo, 2015). Insight is an interest in Cognitive Psychology and is associated with higher order processes, memory and intelligence (Taylor, Knaebe & Gray, 2012). Moving away from Cognitive Psychology and to Behavioural studies on the topic, such as Epstein's (1984, 1985a) studies, Insight can be used as an example of how many different behavioural processes can come together for a problem to be solved.

Kohler (1925) conducted a variety of experiments with chimpanzees. These experiments consisted of constructing problems for the chimps which involved obtaining food. This includes an experiment where, in a room, Kohler placed a banana out of reach and a wooden crate a few meters from the banana. The chimpanzees would unsuccessfully jump to try and grab the banana. One of the chimpanzees, Sultan, emitted problem solving behaviour which Kohler attributed to a mental process he labelled "Insight." When Sultan failed to reach the banana, the chimpanzee was observed pacing before—spontaneously—moving the box closer to the banana, climbing on the box and jumping to successfully grab the banana.

In Behaviour Analysis, the term "Insight" has been altered to mean the spontaneous recombination of individual behavioural repertoires to solve a problem (Epstein, 1985a). In a simulation of Kohler's (1925) problem, Epstein (1984) adapted the experiment so that it could be conducted with pigeons. Epstein taught the pigeons two repertoires which were necessary to solve the problem. For

the first repertoire, the pigeons were taught to push a small box to a target. For the second repertoire, the pigeons were taught to climb on a box beneath a plastic banana and then to peck the banana. Flying and jumping to peck the banana was extinguished. Once the pigeons were trained both repertoires, a problem was established by placing the banana out of reach and the box in another corner of the chamber. First, the pigeons reached for the banana and then orientated to the box, then the pigeons were observed pacing back and forth before pushing the box to the banana, climbing on top of the box and pecking the banana.

Epstein (1985a) suggests that several different mechanisms are accountable for "Insight." This includes the following mechanisms. 1) "Multiple controlling stimuli"—the banana controlled the pigeon reaching towards it and the box controlled the pigeon orientating to the box. 2) "Changing dynamics"—alternation between these behaviours was unstable because neither produced reinforcement. Epstein argues that since flying and jumping towards the banana was previously extinguished, then reaching for the banana would extinguish faster than behaviour towards to box. The box then became the controlling stimulus for the pigeon to push. 3)"Functional generalisation"—the pigeon pushed the box to the banana, not because it resembled the target in training, but because pecking the banana had been previously reinforced so it served the same function. 4) "Automatic Chaining"—similar to precurrent behaviour, the behaviours emitted by the pigeon produced stimuli which evoked other behaviour. The bird stopped pushing the box when it was under the banana and the pairing of those stimuli evoked climbing on the box and pecking it.

However, not all problem solving behaviour emitted by pigeons in Epstein's insight experiments met the requirements to be considered "Insight." Epstein

(1985b) used a similar design with a different pigeon; but instead of two repertoires, there were three with banana pecking as a separate repertoire. The performance of the pigeons differed to the pigeons in Epstein's (1984) paper. The pigeons did not look at the banana and did not stop pushing the box when it was under the banana, and not all of the pigeons climbed on the box immediately to peck the banana. A core component of "Insight" is that the behaviours produced are smooth and continuous until the chain of behaviours needed to solve the problem is complete. However, the performance of each behaviour in this experiment appeared to be disjointed and "unrelated" (Epstein, 1985b, p.138). Extinction and resurgence were used to account for the performance of the pigeons in this paper (Epstein, 1985b).

Resurgence is when a previously learned behaviour, not recently observed, reappears during extinction (Epstein, 1983). When the pigeon pushed the box towards the banana, the pigeon did not stop at the banana. Epstein suggests that this is because the box under the banana was not a previously established discriminative stimulus which controlled climbing and pecking, instead the pigeon stopped pushing the box because it was under extinction. Resurgence was used to account for the pigeon climbing on the box. Since both reaching towards the banana and pushing the box had been placed under extinction, the previously reinforced behaviour of climbing was brought to strength and the pigeon climbed on the box.

Resurgence

Latent history effects refer to the way in which previously learned behaviour, not recently observed, can reappear under different circumstances (Lieving & Lattal, 2003; Lattal & Pipkin, 2010; Reed & Morgan, 2006). This

includes reinstatement, renewal, and resurgence. Resurgence refers to the reoccurrence of latent behaviour during extinction. Resurgence is a mechanism which allows for an increase of behavioural variability during extinction by making multiple behavioural repertoires available, this allows for the production of complex response in problem solving situations (Shahan & Chase, 2002; Epstein, 1985). When one behaviour is reduced in strength it allows for another behaviour to occur. Resurgence occurs in conjunction with other variables including generalisation and discrimination. When an individual comes into contact with a problem, the variability of behaviours that occur are not random, but are behaviours which have been previously reinforced in that context or similar contexts (Shahan & Chase, 2002). When a person loses their keys they will look in all the places where they have previously found their keys. When a car does not start an individual may repeatedly turn their keys, put their foot on the accelerator, or perform other behaviours previously reinforced in the car.

A typical resurgence procedure consists of three phases. First, a target response is reinforced which results in an increase, or maintenance, of that response. Second, the target response is no longer reinforced, put under extinction, and an alternative response is reinforced. Last, there is a resurgence phase in which both responses are under extinction. In this phase the target behaviour typically re-emerges. Resurgence can also occur when reinforcement is rapidly reduced from a rich schedule to a lean schedule of reinforcement, or when a reinforcement contingency is changed to a punishment contingency (Lattal & Pipkin; Fontes, Todorov & Shahan, 2018).

The first two phases of a resurgence procedure, the training phase and the alternative reinforcement phase, establish a learning history and repertoire with

the stimulus conditions present in the procedure. By placing the target behaviour under extinction in the alternative reinforcement phase, the response strength of the target behaviour reduces so that it becomes latent behaviour and the competing alternative response is evoked by the current conditions instead. In the resurgence phase, when the alternative behaviour no longer results in reinforcement, the previously reinforced target behaviour is evoked by the change in conditions.

A variation of this procedure includes an explicit extinction phase after the training phase which places the target response on extinction before continuing to the alternative reinforcement phase (Leiving & Lattal, 2003.) This explicit extinction phase attenuates the resurgence of the target behaviour during the final extinction phase.

There are many different history variables that contribute to the way in which latent behaviours occur during resurgence. These variables include stimulus control, the history of reinforcement (the length of reinforcement and the schedules of reinforcement each behaviour was placed under), and the order in which each behaviour was acquired (King & Hayes, 2016; Reed & Morgan, 2006; Mechner & Jones, 2011).

Order Effects

A common paradigm used to test episodic memory—a form of declarative memory—in Cognitive Psychology and Neuropsychology, is to present participants with a list of items which contains enough items to exceed their attention spans (Gavett & Horwitz, 2012). After a learning period, the participants then take part in either an immediate or a delayed recall test. A phenomenon that is often present in this paradigm is a serial-position effect. This term describes the

way in which participants tend to recall items at the beginning of the list and items at the end of the list better than the items presented in the middle; when graphed this forms a U-shaped curve (Mechner & Jones, 2011). Better recall of the items at the beginning of a list is called a primacy effect, and better recall of the items at the end of the list is called a recency effect.

In current behavioural research, the terms primacy and recency have been used to describe a specific history variable; the way in which the order that behaviours are acquired in impact on their prevalence during extinction (Mechner & Jones, 2011). Various methodologies have been used to test this effect including modifying the standard resurgence procedure to include two alternative reinforcement phases (Reed & Morgan, 2006; King & Hayes, 2016). Most of the studies on this topic have reported a primacy and a recency effect in which the first and last behaviours acquired were more prevalent during extinction than the behaviours acquired in between. However, Reed and Morgan cite an unpublished paper from their labs which reported reversion—behaviours reoccurring more in the opposite order than they were acquired in.

Reed and Morgan (2006) conducted a study in which 6 rats were trained to emit three different three-sequence behaviours using left-right lever presses. They used a modified resurgence procedure with a total of five phases; a training phase, two alternative reinforcement phases, and two extinction test phases. The rats were trained to emit each sequence to criterion; at least 80% of all responses emitted over 20 successive sessions were correct. A recency effect was observed during the first extinction phase for all of the rats—the last acquired behaviour occurred the most. A primacy effect—the next most emitted behaviour was the first acquired behaviour—was observed with three of the rats. Two rats emitted

the second acquired behaviour more than the first. One rat emitted behaviours one and two an equal amount of times. Reed and Morgan (2006) concluded that a primacy effect was found. In the second extinction phase, behaviour two occurred more than behaviour one and three. This could be because the behaviour had less contact with extinction so that its response strength was maintained.

Recent applied research into resurgence with human participants has been focused on using multiple alternative behaviours to attenuate the re-emergence of maladaptive or problem behaviours (Purcell, 2018). In applied clinical settings Differential Reinforcement of Alternative Behaviour (DRA) is used to replace maladaptive behaviours with adaptive behaviours. This process is similar to a resurgence procedure. First, the function of the problem behaviour is identified such as attention-reinforced punching. Next an alternative behaviour is taught and is reinforced by the same reinforcer while the problem behaviour is placed under extinction. For example, punching is no longer reinforced and saying "look at me" is reinforced by attention instead. However, due to poor treatment fidelity the alternative behaviour undergoes extinction which results in a resurgence of the problem behaviour.

The target behaviour in studies in which multiple alternative behaviours have been reinforced is either a pre-existing problem behaviour or a recently taught behaviour (Lambert, Bloom, Samaha, Dayton & Rodewald, 2015; Lambert, Bloom, Samaha & Dayton, 2017; Purcell, 2018). In the studies that a taught target behaviour was used, this taught behaviour was trained more extensively than the alternative behaviours (Lambert et al., 2015; Purcell, 2018). In the training phase the target behaviour is placed under extinction and three alternative behaviours are taught sequentially. Once the first alternative behaviour is trained to criterion it is

no longer reinforced and the second behaviour is trained to criterion, then the last behaviour is trained while all previous behaviours are under extinction. Once all behaviours were trained, a resurgence phase was put in place. While all studies found that multiple behaviours did mitigate resurgence of the target behaviour, their results differed (Lambert et al., 2015; Lambert et al., 2017; Purcell, 2018). Purcell (2018) and Lambert et al. (2015) found a recency effect in which the last trained behaviour occurred at a higher rate than all of the other behaviours during extinction, and the other alternative behaviours occurred at a higher rate than the target behaviour. However, Lambert et al. (2017) found a primacy effect as well as a recency effect. This means that most recently trained behaviour and the target behaviour as the first trained behaviour occurred at a higher rate than the other alternative behaviours.

There are many confounding variables that could explain the differing results in these studies. One confounding variable is the topography or form of the behaviours. Peter (2015) writes that topographically different responses are more likely to result in resurgence. Subjects may also have a preference for one behaviour over another (Jones & Mechner, 2015). History of reinforcement is another factor; this encompasses the length of reinforcement and the rate of reinforcement. It has been shown that a behaviour with a high number of prior repetitions is more likely to re-emerge than a behaviour with a lower number of repetitions (Mechner & Jones, 2001). This has implications for the research on already established problem behaviours as it cannot be ascertained whether the problem behaviour re-emerged at a high rate due to its history of reinforcement, a primacy effect, or both.

Mechner and Jones (2011) conducted a series of experiments to establish whether the order that topographically similar behaviours were acquired in would impact participants' preference for an operant class when presented in sets of three or five in a final test. In these experiments, participants learnt a series of operant classes. The operants contained criterial and non-criterial elements constructed from keystroke sequences on a partially covered keyboard. The criterial elements were the first and last three letters in a sequence. The non-criterial elements were six or more letters of the participant's own choice in the middle. Participants began a sequence by pressing "spacebar" and completed a sequence by pressing "enter." This means that each sequence contained at least 14 keystrokes. The criterial elements defined the operant class.

In the first experiment, participants learnt nine operant classes. They learnt one operant class per session and each session was on a different day. Sessions took place on days 1, 2, 3, these were the primacy operants, days 13, 14, 15 were the middle operants, and days 17, 18, 19 were the recency operants. In the final session, participants took a test.

Participants were tested on the sequences they had learnt with the opportunity to earn money for a correct response. They lost money if a response was incorrect. They were presented three of the operant classes to choose from. Of the fourteen participants, seven performed operants from the primacy class the most and five performed operants from the recency class the most. Mechner and Jones conducted five experiments in this study, altering the time between sessions or teaching similar but unrelated operant classes on the days between sessions. Preference for primacy responses or recency responses were found across all experiments. These results were consistent with an earlier study (Mechner &

Jones, 2001) which found that participants tended to re-emit earlier non-criterial sequences and later non-criterial sequences when emitting an operant more than middle sequences.

Order effects were found for the control group in King and Hayes (2016) paper researching the role of discriminative stimuli on resurgence. In this study University students completed a computer-based task. A modified resurgence procedure with four phases was used; one training phase, two alternative reinforcement phases and a resurgence phase. The participants were instructed to enter in a "password" which consisted of a four-response sequence with no repeated characters using the keys available on the keyboard. Only the digits 1, 3, 5, 7, 9 on the number pad and the "Enter" and Delete" keys were available, all other keys were covered and the mouse was disabled. The training phases and the alternative reinforcement phases were designated a unique response sequence. This response sequence was determined by the first response sequence in each phase which met the requirements stated that deviated from any previously designated response sequence. Only the designated response sequence in each phase was placed on a fixed ratio 1 schedule of reinforcement. Any response sequence which differed from the designated response sequence in each phase was not reinforced. Participants were assigned to one of four conditions. For the control group the background for all of the phases was white. The colours in the background of each phase was different across phases for the other three conditions; red for the training phase, blue for alternative reinforcement phase 1, and green for alternative reinforcement phase 2. In the resurgence phase these three groups were allocated to either a red, green or blue background condition. When the background of the phase that a response sequence was obtained

matched the resurgence phase, that behaviour reappeared the most. The results from four of the seven participants in the control showed a recency and primacy effect. One of the participant's results only showed a primacy effect, and another participant's results only showed a recency effect. One participant emitted each response sequence an equal number of times.

Aim and Rationale of Research

The aim of this project is to research whether the order in which behaviours are acquired impacts on their prevalence during extinction when three or four behaviours have been acquired. The experiment used in this study is a replication King and Hayes's (2016) computer-based task. The three-response condition in this study follows the same procedure as the King and Hayes control group as written in their method section. Another alternative reinforcement phase has been added for the four-response condition. It was hypothesised that a primacy and recency effect would be observed in both the three response and four response conditions.

Method

Participants

Ethics approval was granted by the Human Research Ethics committee at Waikato University (HREC2019#17). Participants were recruited through the University of Waikato's intranet, social media and posters displayed around the University's Hamilton Campus (Appendix A). The ten participants who completed this study were Waikato University students, there were six female participants and four male participants. The mean age of these participants was 26.5 years old, the age of participants ranged from 18 years old to 52 years old. An additional three students participated in this study but were withdrawn from this study. One participant was withdrawn due to an issue occurring during the

experiment. The other two participants were withdrawn because they failed to complete phase two of the experiment. All participants were offered either course credit if they were enrolled in an eligible Undergraduate Psychology course or the opportunity to enter into the draw for a $50 supermarket voucher.

An information sheet was provided to all participants prior to the beginning of the experiment (Appendix B). This informed the participants that they would be taking part in a computer-based task, that the experiment would last approximately an hour, and that they could withdraw from the experiment at any time. The information sheet also gave information on who to contact if the participants had any issues with the experiment.

Apparatus

Participants completed a computer-based experiment in a computer lab. The experimental programme was run as an application through Google Chrome which recorded data onto the University of Waikato's server. The experiment was displayed on a 22 inch desktop. The keyboard and mouse of the computer were moved to the left side of the monitor before the experiment began. An Adesso keypad, Model No: AKB-618UD, was modified so that it only had the keys 1, 3, 5, 7, 9, "Backspace" and "Enter".

Response

The operant behaviours used in this experiment were four-response sequences which consisted of four digits of the available keys on the number pad which was proceeded by pressing the "Enter" key. A valid response was made up of four digits with no repeated numbers (ie. 1359). The first valid response in each phase was assigned as the designated response sequence for that phase and would result in reinforcement when entered. Any four-digit sequence entered which

deviated from the response sequence designated in that phase was considered Untrained and did not result in reinforcement. Any incomplete submissions entered, responses that consisted of three or less characters, were not recorded because they were not a proper response sequence.

Procedure

Prior to the beginning of the experiment all participants provided informed written consent (Appendix C). The participants were instructed to turn off all of their electronic devices, such as their cellphones, and place them in their bags to prevent any distractions.

The participants were randomly allocated into one of two conditions. The first condition involved a multiple alternative reinforcement resurgence procedure; the participants in this condition took part in a training phase and two alternative reinforcement phases before undergoing extinction. The second condition involved an additional alternative reinforcement phase before undergoing extinction.

The participants sat at the computer; the initial screen informed the participants of the requirements to perform a valid operant, “Using the keys available enter in a password. A valid password must be 4 characters in length with no repeated characters.” The participants were instructed to press spacebar on the regular keyboard to start the programme, an identification number was then displayed on screen. The keyboard and mouse were moved to the side, and the modified Adesso keypad remained in front of the participants. Once the identification number was written down, the experimenter began the test for the participants.

At the end of the experiment, the participants were given a debrief which explained the purpose of the experiment in more detail (Appendix D). Participants were also asked to fill out a brief demographic questionnaire (Appendix E).

Training Phase

Participants were presented with an Instruction Screen which consisted of a black screen with the words “PLEASE ENTER YOUR PASSWORD” and a white text box below in the centre of the screen. The first sequence that the participant entered which met the requirements for a valid operant was designated Response Sequence 1. Response Sequence 1 was placed on a continuous schedule of reinforcement. Every entry of Response Sequence 1 was followed by a Programmed Consequence; a reinforcement screen with an animated yellow star and the text “Congrats, You Cracked the Code” in the middle. This screen was presented for 2 seconds before it was replaced by the Instruction Screen for the participant to enter their next response. Untrained Responses—responses that contained four digits that deviated from Response Sequence 1—did not result in a Programmed Consequence and the Instruction Screen remained until the participant entered in Response Sequence 1.

The response rate (in seconds) of Response Sequence 1 was recorded for the duration of each trail block. A trial block consisted of three emissions of Response Sequence 1. All Untrained Responses were recorded during each trial block.

The phase was finished when the participant met criterion. The criterion used was based on Lieving and Lattal’s (2003, as cited in King & Hayes, 2016), this was variant of a relative stability criterion. The overall mean response rate of the final six trial blocks was obtained, as well as the sub-means of the rate of

response for first three trail blocks and final three trial blocks from these final six trail blocks. The stability criterion was assessed by comparing the overall mean to these sub-means. Criterion was met when the two sub-means differed from the overall mean by 10% or less.

Once criterion was met the participant transitioned to the next phase.

Alternative Reinforcement Phase 1

Response Sequence 2 was established in this phase. This was determined by the first entry in this phase which contained four digits with no repeated characters that deviated from Response Sequence 1. In this phase, Response Sequence 2 was placed on a schedule of continuous reinforcement and each entry of Response Sequence 2 resulted in a Programmed Consequence as described in the training phase. Any response sequences that deviated from Response Sequence 2, all Untrained Responses and Response Sequence 1, did not result in a Programmed Consequence. The phase was completed when the participant met criterion, as previously specified, and the participant transitioned to the next phase.

Alternative Reinforcement Phase 2

The first response sequence entered in this phase which deviated from Response Sequence 1 and 2 was designated Response Sequence 3. Response Sequence 3 was placed on a continuous schedule of reinforcement. All other response sequences entered, including Response Sequence 1 and 2, did not result in a programmed consequence. This phase was completed when participants met criterion. Participants in the first condition transitioned to the final phase; the Resurgence Phase. Participants in the second conditioned transitioned to Alternative Reinforcement Phase 3.

Alternative Reinforcement Phase 3

Only participants in the second condition took part in this additional alternative reinforcement phase. Response Sequence 4 was established following the same procedure as the previous Alternative Reinforcement Phases. Once participants met criterion in this condition they then transitioned to the Resurgence Phase.

Resurgence Phase

In this phase, all trained behaviours were placed under extinction. All response sequences—trained and untrained—resulted in no Programmed Consequence and the Instruction Screen remained throughout. This was the final phase which lasted for five minutes and the experiment concluded at the end of this phase. Data was collected onto an external drive for analysis.

Results

Figure 1 shows the group mean proportion of each trained response sequence emitted during extinction for group 1. The group mean proportion for Response 3 was higher than the other responses (M=0.42, SD=0.27), next was Response 1 (M=0.40, SD=0.22) and Response 2 was the least emitted (M=0.19, SD=0.13). The proportion of each response sequence emitted during extinction varied between participants which is shown in Figure 2. The results from two of the participants shows a primacy and recency; emitting a higher proportion both Response 1 and 3 than Response Sequence 2. The other three participants emitted either a higher proportion of Response 1 or Response 3 than Response 2, but not both. Participant 2 did not emit Response 1 during extinction. Figure 3 shows the number of trained response sequences emitted during extinction. The number of trained response sequences emitted during extinction varied between participants.

Participant 1 emitted the fewest trained response sequences, a total of 3 trained response sequences, and Participant 4 emitted the most with a total of 39 trained response sequences emitted.

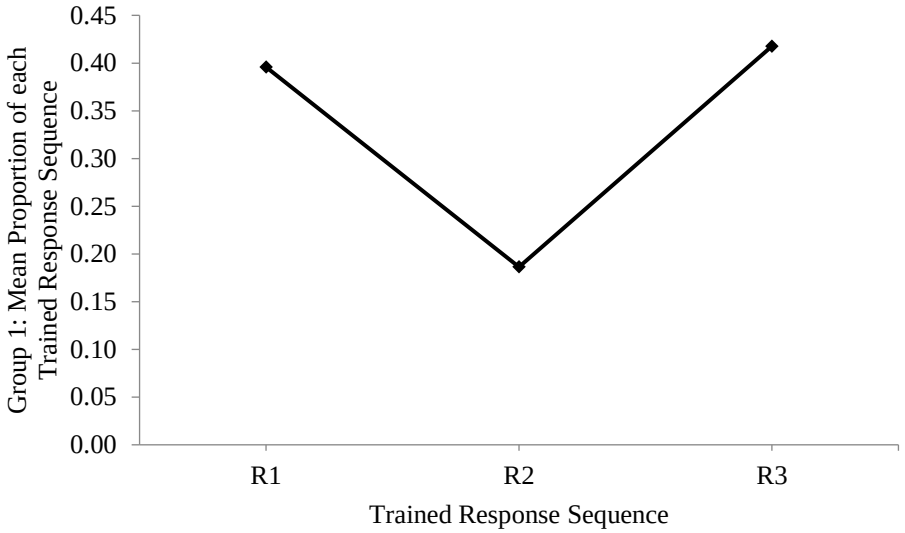

Figure 1. The mean proportion of Trained Response Sequences emitted by Group 1 during extinction.

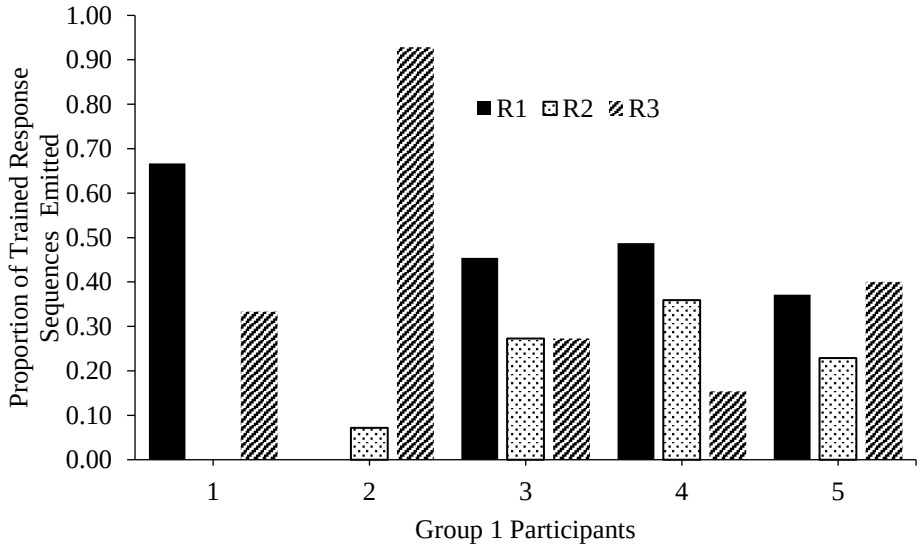

Figure 2. The proportion of Trained Response Sequences emitted by each participant in Group 1 during extinction.

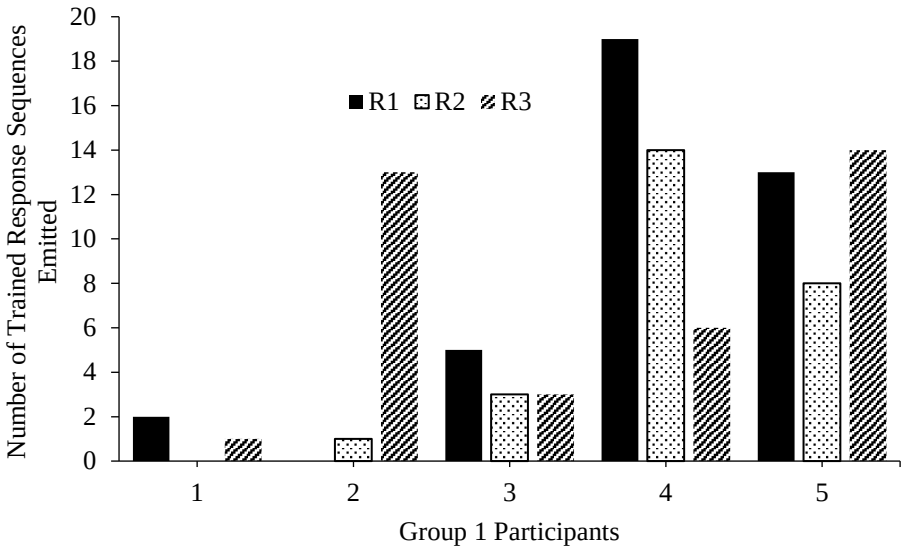

Figure 3. Number of Trained Response Sequences emitted by each participant in Group 1 during extinction

Figure 4 shows the group mean proportion of each trained response sequence emitted during extinction for Group 2. The group mean proportion of Response 1 was higher than all other responses (M=0.27, SD=0.11), next was Response 4 (M=0.26, SD=0.07) then Response 3 (M=0.24, SD=0.12) and lastly Response 2 (M=0.22, SD=0.15). Figure 5 shows that the proportion of each trained response sequences was idiosyncratic across participants. Figure 5 shows that in Group 2, only Participant 4 emitted both Response 1 and Response 4 more than Responses 2 and 3. All participants, except for Participant 2, emitted each trained response at least once during extinction as shown in Figure 6.

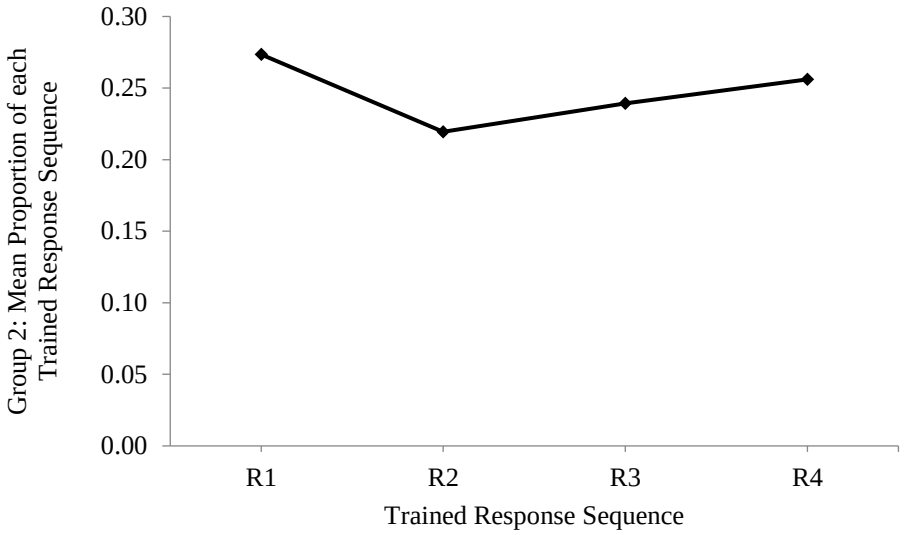

Figure 4. The mean proportion of Trained Response Sequences emitted by Group 2 during extinction.

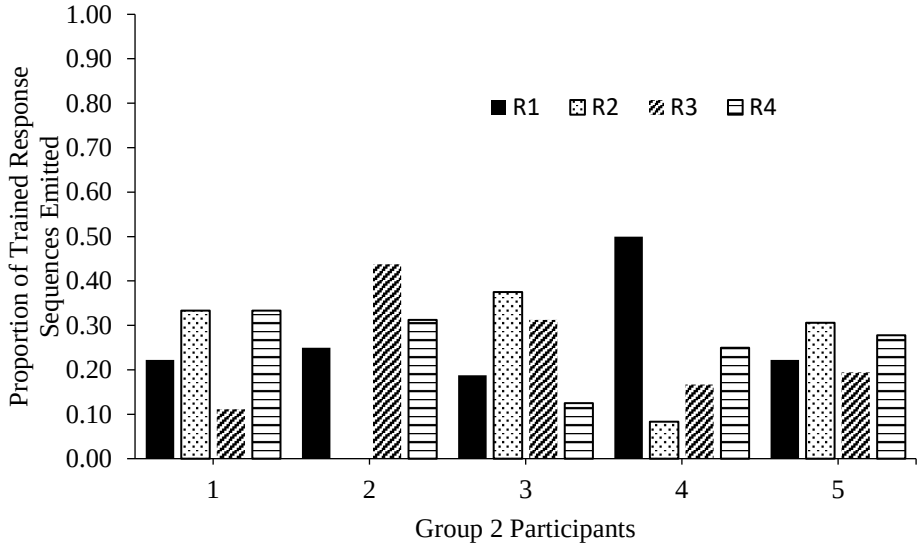

Figure 5. The proportion of Trained Response Sequences emitted by each participant in Group 2 during extinction.

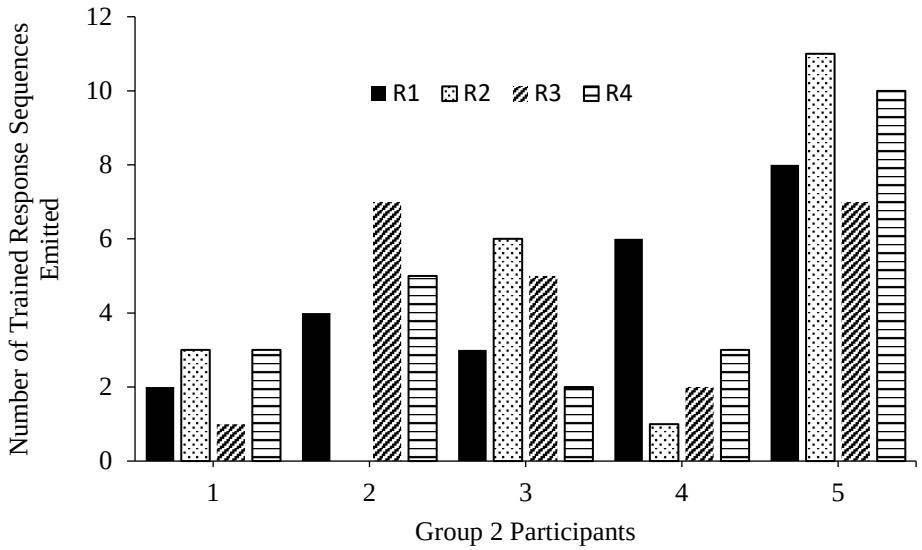

Figure 6. Number of Trained Response Sequences emitted by each participant in Group 2 during extinction

Figure 7 shows the cumulative record of trained response for Group 1. The initial three trained responses emitted during extinction for participants 3 and 5 were in the order of Response 3 then Response 1 and lastly Response 2. Participant 1 emitted Response 3 and then Response 1. Participant 4 emitted the trained responses in the order, Response 3 then Response 2 and lastly Response 1. Participant 2 initially only emitted Response 3.

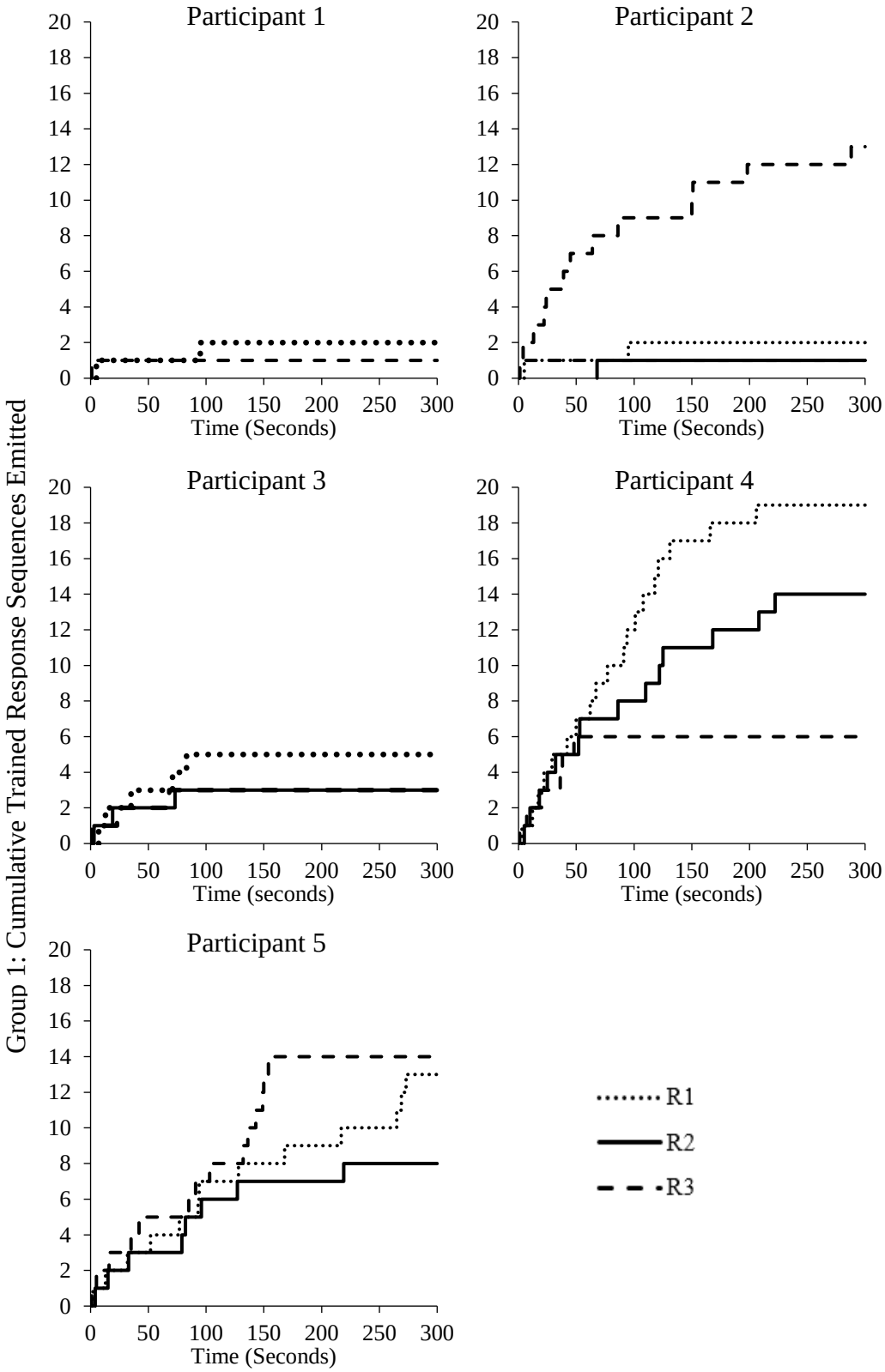

Figure 7. Aggregate cumulative record of each Trained Response Sequence emitted during extinction by Group 1.

Figure 8 shows the cumulative record of trained response for Group 2. The initial four trained responses emitted during extinction for participants 2 and 4 were in the order of Response 4 then Response 1 then Response 4 and lastly Response 1. Participant 1 emitted Response 4 then Response 2 then Response 1 and lastly Response 4 again. Participant 3 emitted the responses in the order Response 4, Response 3, Response 1 and Response 2. Participant 5 emitted the responses in the order Response 4, Response 1, Response 2 and Response 3.

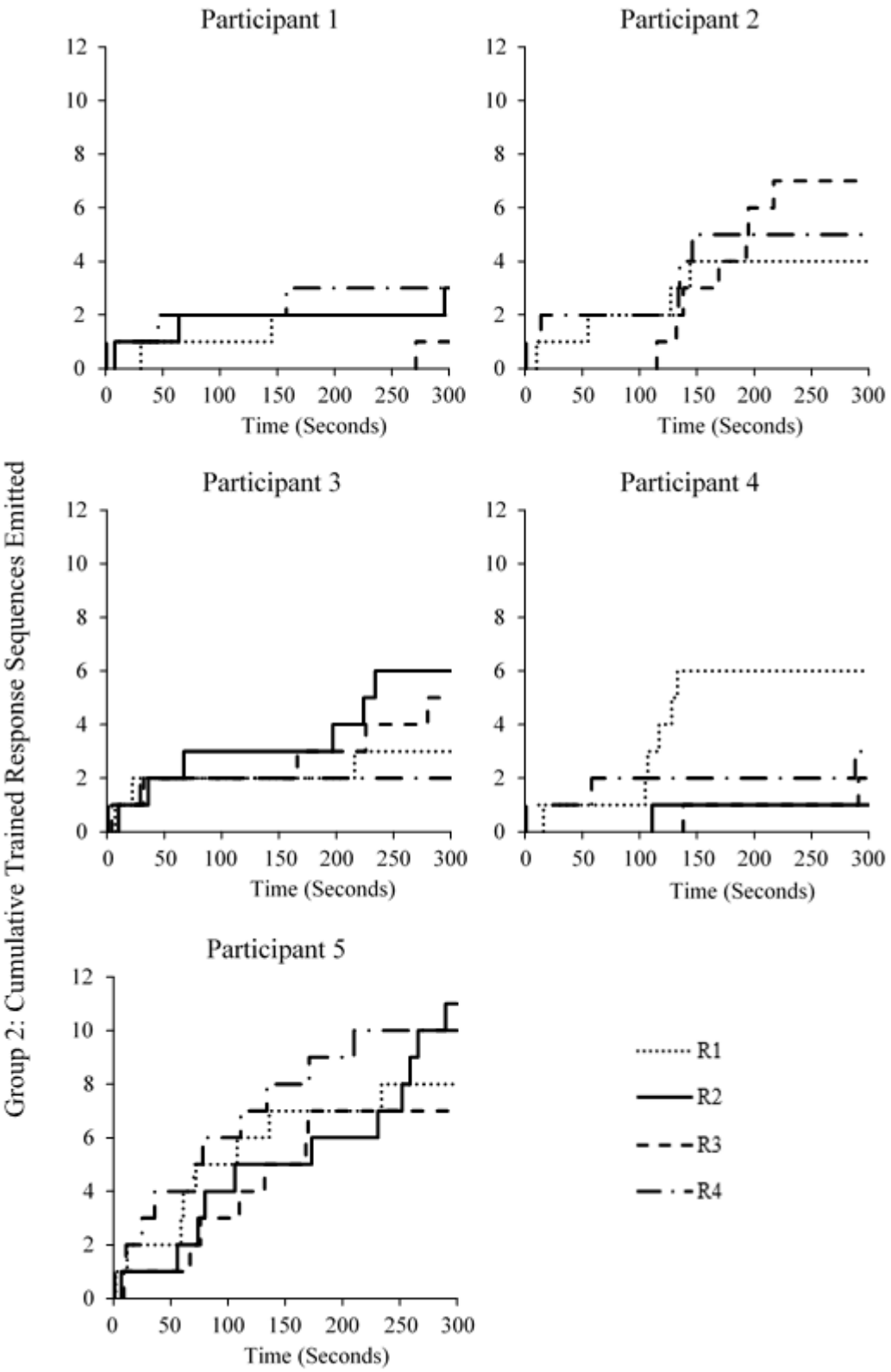

Figure 8. Aggregate cumulative record of each Trained Response Sequence emitted during extinction by Group 2.

Figure 9 shows the proportion of Trained and Untrained response sequences emitted during extinction by participants in Group 1. All participants, except for Participant 3, emitted a higher proportion of Untrained responses than Trained Response Sequences. Figure 10 shows the number of Untrained and Trained Responses sequences by each participant in Group 1. Participant 3 emitted fewer response sequences overall during extinction than the other participants.

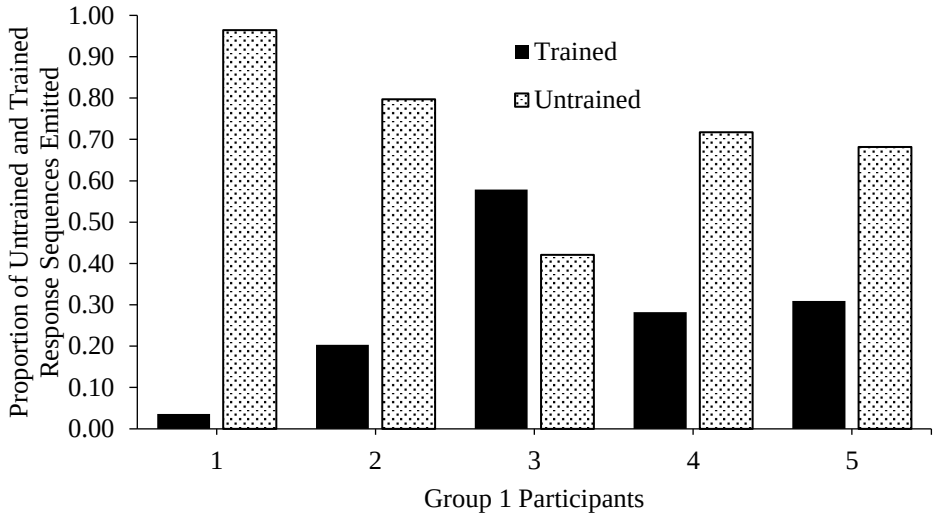

Figure 9. The proportion of Untrained and Trained Response Sequences emitted by each participant in Group 1 during extinction.

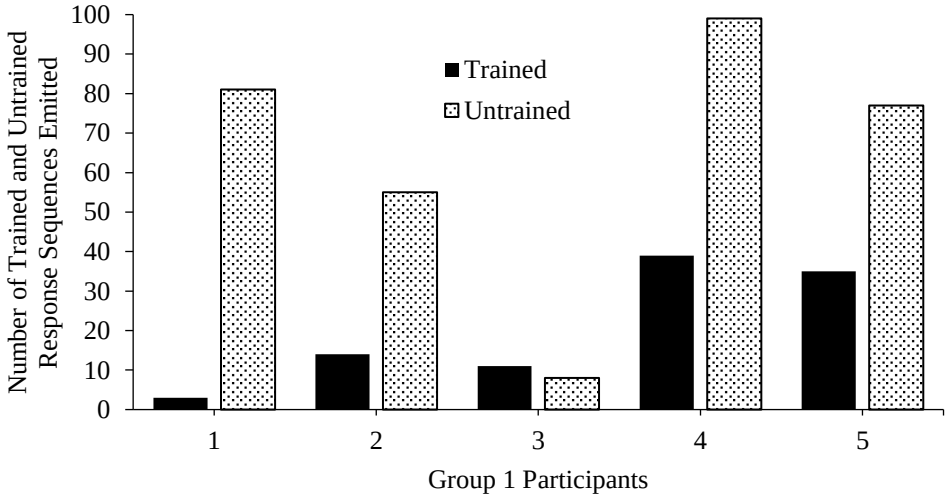

Figure 10. The number of Untrained and Trained Response Sequences emitted by each participant in Group 1 during extinction.

Figure 11 shows the proportion of trained and untrained response sequences emitted during extinction by participants in Group 2 and figure 12 shows the number of Trained and Untrained Responses emitted. All participants emitted more Untrained Responses Sequences.

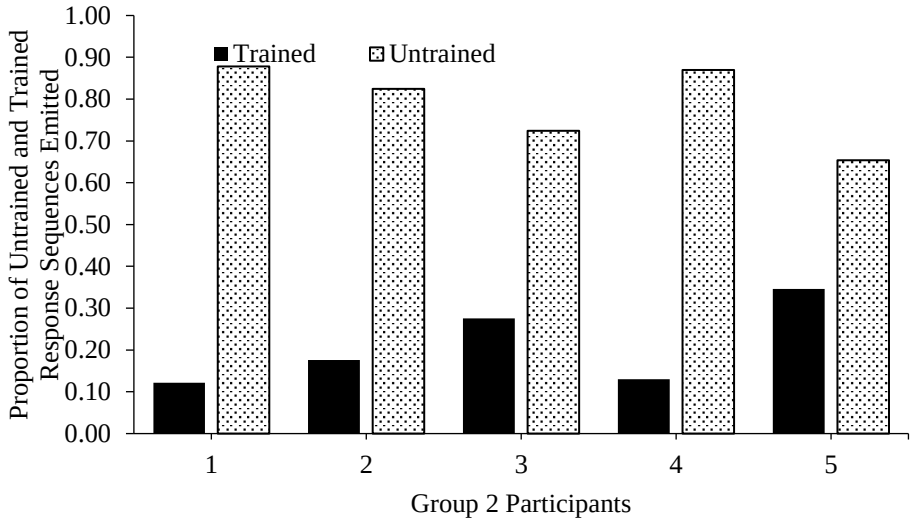

Figure 11. The proportion of untrained and trained response sequences emitted by each participant in Group 2 during extinction.

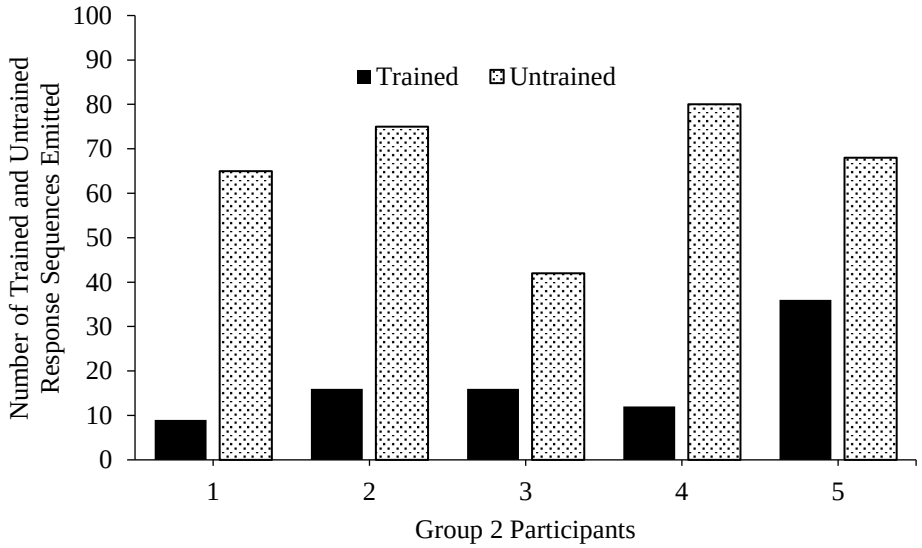

Figure 12. The number of Untrained and Trained Response Sequences emitted by each participant in Group 2 during extinction.

Participants in Group 1 emitted more Unique Untrained response sequences during extinction than Repeated Response Sequences. Figure 13 shows the cumulative record of Repeated and Unique Untrained Response Sequences for Group 1. The difference between the number of Repeated and Unique Response Sequences remained relatively steady across the extinction phase. Figure 14 shows that the proportion of Unique and Repeat Untrained Responses emitted differed between participants, and that both participants 4 and 5 almost had an equal proportion of Unique and Repeated Responses. Figure 15 shows the number of Repeated and Unique Responses emitted and shows that Participant 3 emitted only a few Untrained Responses during extinction overall.

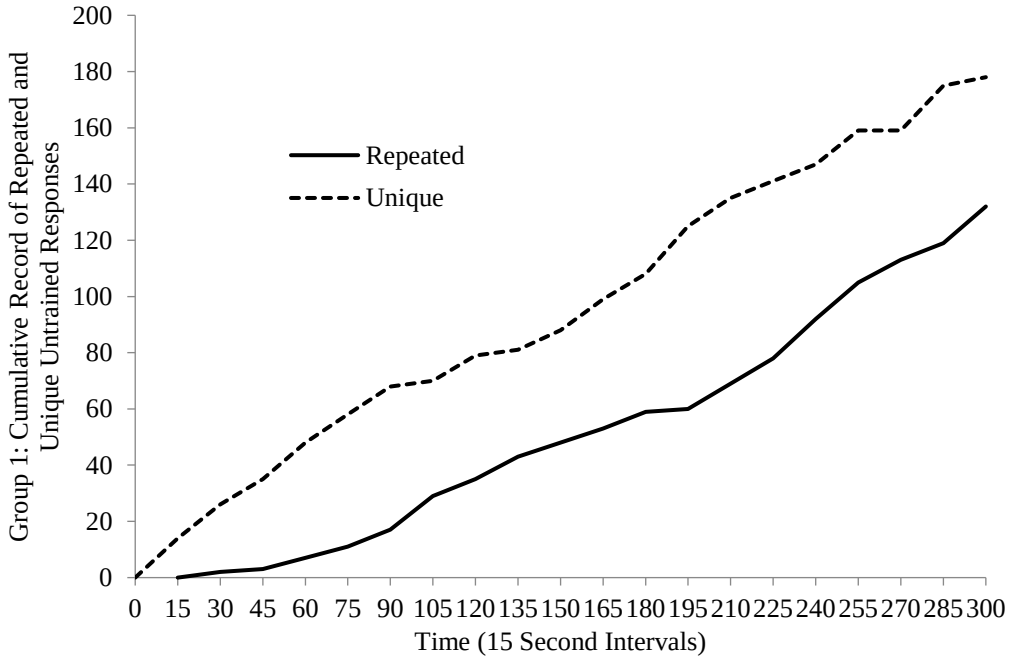

Figure 13. The cumulative record of Repeated and Unique Untrained Response Sequences for Group 1 during extinction in 15 second intervals.

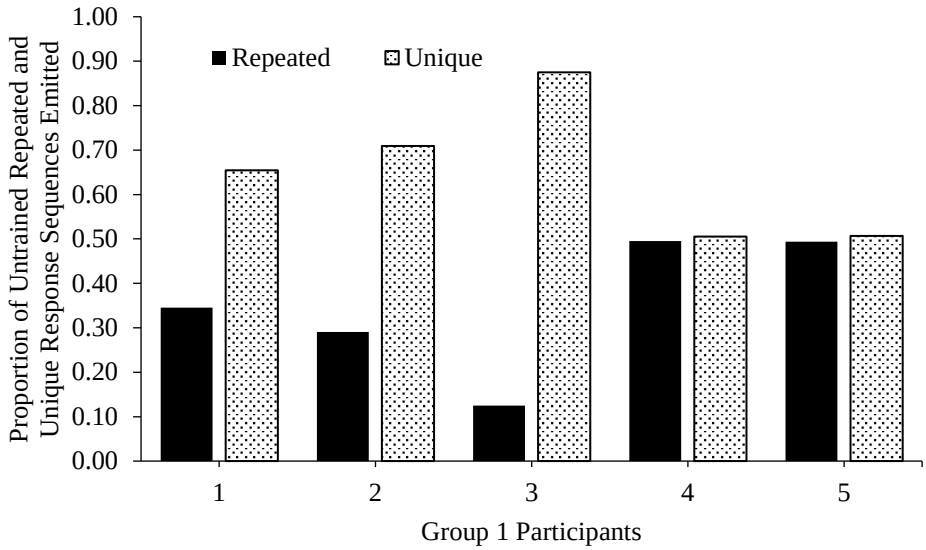

Figure 14. The proportion of Repeated and Unique Untrained Response Sequences emitted by each participant in Group 1 during extinction.

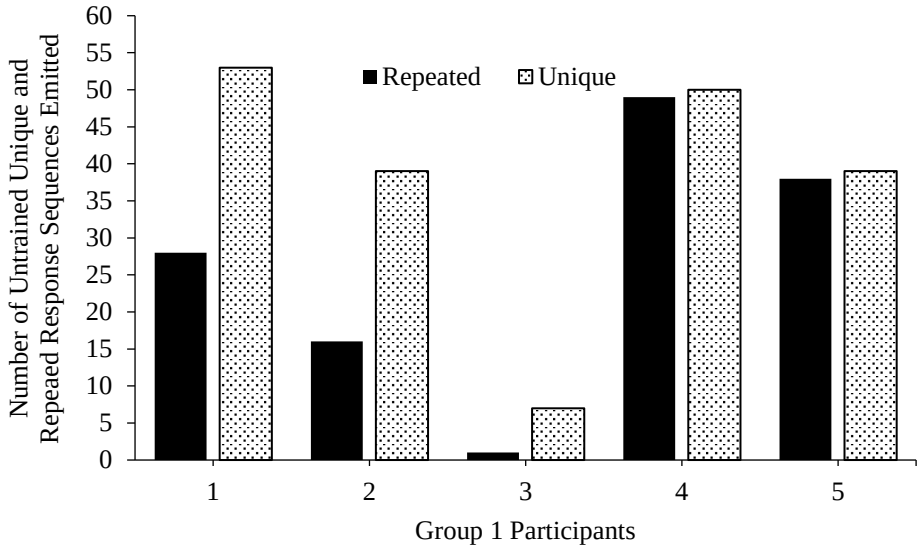

Figure 15. The number of Repeated and Unique Untrained Response Sequences emitted by each participant in Group 1 during extinction.

Participants in Group 2 emitted more Unique Untrained Response Sequences during extinction than Repeated Response Sequences. Figure 16 shows the cumulative record of Repeated and Unique Untrained Response Sequences for Group 2. The difference between the number of Unique and Repeated Untrained Response Sequences emitted increased over the extinction phase. Figure 17 shows the proportion of Unique and Repeated Untrained Response Sequences for each participant in Group 2. Figure 18 shows the number of Unique and Repeated Untrained Response Sequence emitted by each participant. These figures show that all participants, except for Participant 5, emitted more Unique Response Sequences.

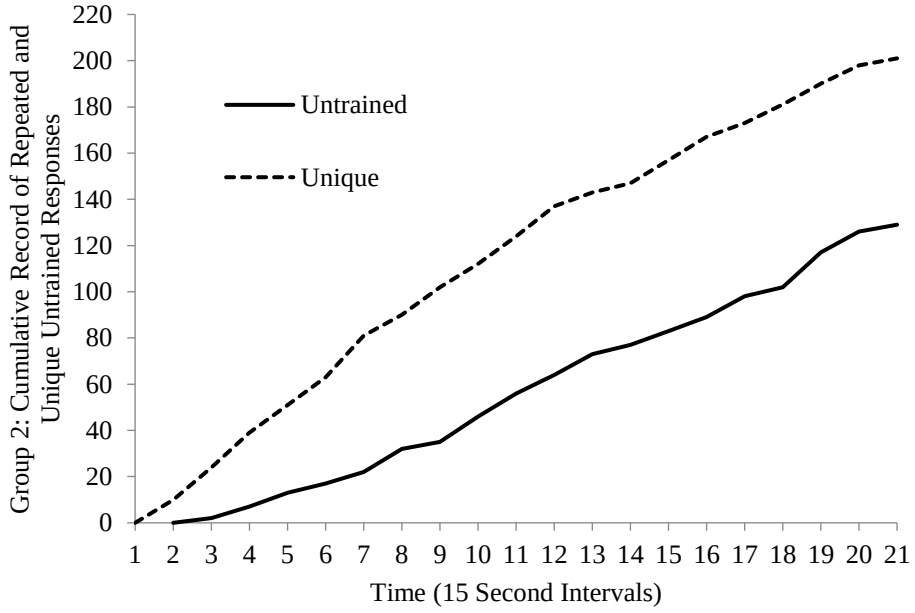

Figure 16. The cumulative record of Repeated and Unique Untrained Response Sequences for Group 2 in 15 second intervals.

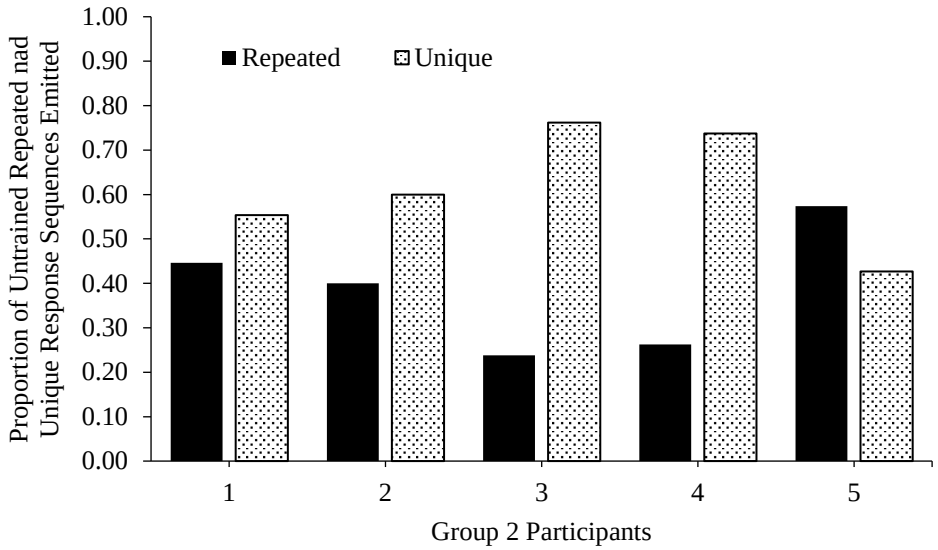

Figure 17. The proportion of Repeated and Unique Untrained Response Sequences emitted by each participant in Group 2 during extinction.

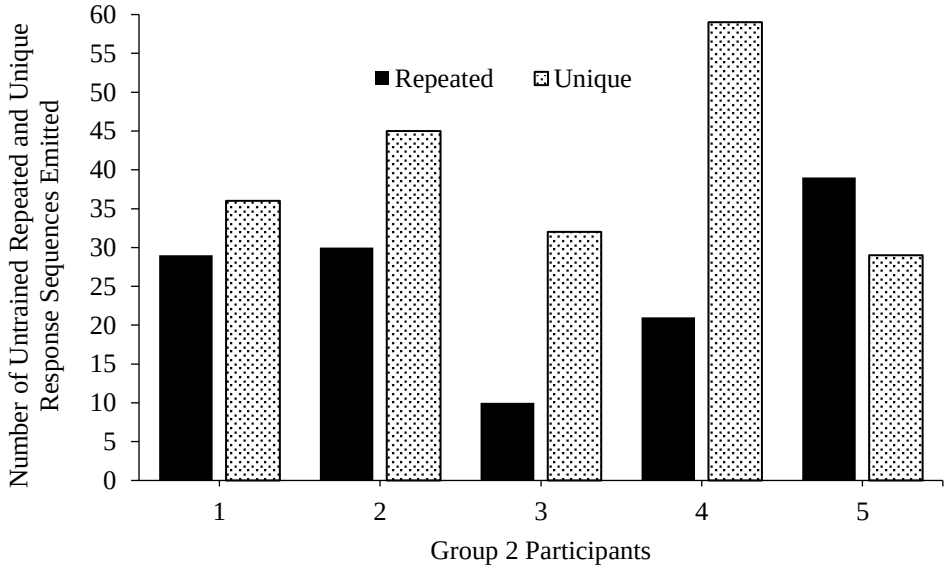

Figure 18. The number of Repeated and Unique Untrained Response Sequences emitted by each participant in Group 2 during extinction.

Discussion

The aim of this study was to research whether the order that behaviours were acquired in affected the prevalence of the behaviour during extinction when three or four topographically similar behaviours were acquired. This study used a modified resurgence procedure adapted from King and Hayes' (2016) study. Participants were randomly assigned to either a three-response condition or a

four-response condition. Participants in the three-response condition took part in a computer-based task with a training phase, two alternative reinforcement phases and then a resurgence phase. Participants in the four-response condition took part in an additional alternative reinforcement phase before transitioning to the resurgence phase. In the training and alternative reinforcement phases the participants learnt a response sequence containing four digits with no repeated digits. The response sequence trained in each phase was established by the first emitted sequence which deviated from any previously acquired response sequence.

The results from the three-response condition supported the hypothesis that there would be a primacy and recency effect observed during resurgence. The proportion of Response Sequence 3 (the last trained response) was larger than the other two trained responses which showed a recency effect. The proportion of Response Sequence 1 (the first trained response) was larger than Response Sequence 2 which showed a primacy effect. The results from the four-response condition did not support the hypothesis that there would also be a primacy and recency effect when participants were sequentially trained to perform four different response sequences. The group mean proportion of each trained response sequence in the four-sequence condition showed a slight primacy and recency effect. However, considering each participants' responses individually, only Participant 4's responding showed primacy and recency. The behaviour of each participant in the four-response condition appeared to be more idiosyncratic.

The results from the three-response condition in this study were consistent with previous research (King & Hayes, 2016; Reed & Morgan, 2006; Mechner & Jones, 2001, 2011). The resurgence of the trained response sequences was

relatively low when compared to the resurgence of behaviours in animal studies such as Reed and Morgan's study in which rats were trained sequentially to emit three right-left response sequences. This relatively low amount of resurgence was also found in King and Hayes' study. Another difference between this study with humans, and Reed and Morgan's, is that during resurgence Response Sequence 3 did not follow the same extinction trend that is normally found in traditional resurgence procedures and in Reed and Morgan's study with rats (Lattal & St Peter Pipkin, 2009; Lieving & Lattal, 2003). In Reed and Morgan's study, they suggested that recency occurred because the last trained response before extinction needed to be extinguished before the other two trained response sequences would re-emerge due to resurgence. However, in this study, participants tended to emit Response Sequence 3 only once without receiving a programmed consequence before emitting a different response sequence. This pattern of responding also occurred with participants in the four-response condition.

The behaviour of the rats in Reed and Morgan's (2006) study was contingency-shaped. The behaviour of the participants in this, and King & Hayes (2016), studies were likely to be under multiple sources of control and behaviours performed by participants during extinction were also likely to be rule-governed. In this study, the initial responses emitted by participants during extinction were not random. Considering only the trained responses sequences, when the last trained response sequence did not result in a programmed consequence, participants in the three-response condition tended to emit another trained response sequence and when that did not result in a programmed consequence they would then emit the trained response sequence that they had not yet emitted.

A similar pattern of behaviour was observed with participants in the four-response condition. A potential explanation for this is that when participants transitioned between each training and alternative reinforcement phase, they learnt that when a response did not result in a programmed consequence, even once, then entering in another four-digit sequence would result in a consequence.

Another reason for the relatively low emission of trained responses is the proportionally high amount of untrained responses emitted by participants in both the three-response and the four-response conditions. The proportionally high amount of untrained responses can be explained by two different variables. First, the transitions between the trained and the alternative reinforcement phases were similar to a differential lag reinforcement schedule (King & Hayes, 2016; Lee, McComas & Jawor, 2002). In a differential lag reinforcement schedule, when a specified number of responses are emitted that response is then placed under extinction and the first response which differs from that previous response is reinforced (Lee, McComas & Jawor). A differential lag reinforcement schedule has been shown to increase behavioural variability and, as such, the procedure used to transition between each phase likely established a history of variability for the participants in this study. The additional exposure to this differential lag reinforcement schedule in the four-response condition may account for a slightly larger number of untrained response sequences emitted by participants in the four-response condition in comparison to participants from the three-response condition.

Second, during extinction there is an increase in behavioural variability, this variability is comprised of behaviours which have previously been reinforced in either that context or similar contexts (Shahan & Chase, 2002). Though the

keypad in this study was modified so that it only contained the keys 1, 3, 5, 7, 9, "Backspace" and "Enter", the keypad is still similar to a keypad on a standard keyboard or even similar to the keypad on devices such as an EFTPOS machine. This means that the behaviours emitted by participants during resurgence were not limited to the behavioural history established in this study, but also by the participants' history of learning prior to this experiment.

The prior learning history of participants in this study did not mean they were limited to emitting response sequences used previously. Participants had the atomic repertoire of button pressing which was under the control of the stimuli of the buttons of the keypad. Behaviour was also controlled by the textual stimuli of the numbers available on the keypad and the rule given at the beginning of the experiment that a valid response sequence contained four-digits with no repeated characters. These multiple sources of control provided the context in which participants emitted a higher proportion of untrained, and valid, novel response sequences during resurgence than trained response sequences, and repeated untrained response sequences.

As written previously, primacy and recency effects were not observed during resurgence for all, but one, of the participants in the four-response condition. This is inconsistent with previous research which typically reported a recency effect (Purcell, 2018; Lambert et al., 2017; Lambert et al., 2015; Leiving et al., 2014). These studies were researching whether Differential Reinforcement of Alternative behaviours (DRA) using serial alternative behaviours would attenuate the resurgence of a target behaviour. The target behaviour was either an already established behaviour or a trained behaviour with a longer history of reinforcement than the alternative behaviours. These studies trained each

behaviour across multiple sessions, using a stability criterion in which responding was consistent over a set number of sessions before participants transitioned to the next phase. In this study, behaviours were acquired sequentially in one session. As suggested earlier, the transition between each phase in this study may have taught participants that when a response no longer resulted in a programmed consequence to emit a different response. With the transition between phases occurring between sessions in the DRA studies, their participants may not have learnt to emit another behaviour immediately after the previous behaviour was placed under extinction.

The results from the four-response condition was not wholly inconsistent with previous research. Purcell's (2018) study also found idiosyncratic difference between participants rather than finding a clear primacy effect. The participants in Purcell's study were typically developing teenagers. In the DRA studies conducted in clinical settings with participants that had intellectual disabilities order effects were found such as a primacy (Lambert et al., 2015; Lambert et al., 2017). Participants in this and Purcell's studies were more likely to be influenced by confounding factors such as their history of learning prior to this study and their ability to follow rules. The behaviour of the participants with intellectual disabilities were more likely to be contingency-shaped.

However, another variable which would have increased the probability of the first trained, or target, response re-emerging more than the other responses in the clinical studies such as Lambert et al.'s (2017) study was the more extensive history of reinforcement of the target behaviour. A more extensive history of reinforcement has been shown to increase the strength of resurgence for that

behaviour when compared to behaviours with a shorter and more recent history of reinforcement (Bruzek, Thompason & Peter, 2009; Mechner & Jones, 2001).

The difference between the results of the four-response condition in this study and Mechner and Jones' (2011) study which found a preference for either primacy or recency when topographically similar response sequences were taught sequentially can likely be attributed predominantly to the tests used. In this study, a resurgence phase was used to determine whether the order that behaviours were acquired in would affect the prevalence of each behaviour during extinction and, due to confounding variables, no effect was found in the four-response condition. Mechner and Jones' study was testing whether participants would have a preference for behaviours based on the order that they were acquired in. This study and Mechner and Jones' were researching whether the order behaviours were acquired in had an effect on two different aspects of behaviour which are not directly comparable. Differences between the procedure used and that variables being measured also means that this study is not directly comparable to traditional serial position—order effect—research.

This study, along with previous studies, contributes to the body of research investigating the way that different history variables impact the resurgence of previously acquired behaviours. Resurgence has been connected to a wide variety of complex human behaviours including problem solving, creativity, drug relapse and the re-emergence of problem behaviours due to poor treatment fidelity when differential reinforcement contingencies are used (Purcell, 2018; Peter, 2015; Podlesnik & Shahan, 2006; Epstein, 1996). Though the results from the three-response group support the body of evidence that a primacy resurgence effect does occur during resurgence, the lack of a clear primacy effect in the four-

response group shows that order that behaviours are acquired in is not a strong predictive factor for the re-emergence of behaviour when confounding factors are also present. It must be acknowledged that there may be other factors that influenced the outcome. However, when considering previous research, other variables such as the length of reinforcement of a behaviour has been shown to be more accurate predictor for the prevalence of a behaviour due to resurgence than primacy or recency; behaviours with a longer history of reinforcement re-emerge more than behaviours with a shorter history of reinforcement (Bruzek, Thompson & Jowek, 2009; Mechner & Jones, 2001). King and Hayes (2016) found that renewal, the spontaneous re-emergence of a behaviour by returning to the context it was reinforced in, interacts with resurgence and may have some effect on primacy and recency effects. Reed and Morgan (2006) showed that when primacy and recency behaviours had more contact than the middle behaviours with extinction, that this longer interaction with extinction mitigated the resurgence of the primacy and recency behaviours when re-tested.

These findings provide a better understanding of the mechanisms which contribute to problem solving. Problem solving is a complex behaviour which involves the interaction of different behavioural mechanisms. The findings from this study suggest that even within a single mechanism, such as resurgence, there are many different factors which effect the behaviour that is produced.

When a problem occurs, and individual comes into contact with a discriminative stimulus but they have no prevailing response that will results in reinforcement (Skinner, 1969; Donahoe & Palmer, 1994; Palmer, 2009; Holth, 2008). There are many different factors with contribute to a problem occurring; a novel context, the need for a novel response, or a change in consequences that

leads to no reinforcement. In this study, the transitions between each phase can be considered a problem since the prevailing response no longer resulted in the programmed consequence and a novel response was required. The resurgence phase also constituted a problem for the participants. None of the participants' responses resulted in reinforcement.

The variables present in this study contributed to different mechanisms of problems solving. The multiple controlling stimuli, such as the stimuli present on the keypad and the rule given at the beginning of the experiment, meant participants could use atomic repertoires established in their prior behavioural history. The stimuli present had also been associated with variable responding and extinction. This history of variable responding meant that the participants were not limited to the trained response sequences. Behavioural variability is an important aspect of problem solving (Birch and Rabinowitz, 1951). The resurgence of trained behaviour was affected by the history of extinction established by the lag schedule of reinforcement may have attenuated the resurgence of the trained behaviours. The order that the behaviours were acquired in was shown to have some effect on resurgence in the three-response condition.

These factors may also be important when considering ways to modify a DRA procedure to attenuate the reinforcement of a maladaptive target behaviour. It shows that variables which cannot be controlled, such as order effects, may be mitigated by variables which can be controlled within a clinical setting.

Future Research and Limitations

Future research should be undertaken to assess how different factors which influence resurgence can be used to mitigate or facilitate the resurgence of a behaviour when multiple behaviours are acquired. In particular, it would be

interesting to research the impact of an explicit extinction phase between training phases, which has been shown to attenuate the resurgence of the target behaviour in a two-response resurgence procedure, when multiple behaviours are acquired (Leiving & Lattal, 2003). Potentially, due to a more extensive contact with extinction, behaviours may re-emerge in reverse order.

Several limitations need to be taken into consideration. First, is the withdrawal of three participants from this study. The withdrawal of one of the participants can be accounted for due to an error occurring with the experiment. The withdrawal of the other two participants was due to the experimenter terminating the experiment because both of those participants failed to transition from the training phase to the first the alternative reinforcement phase. This suggests that the procedure used in this experiment may not be appropriate for everyone. A potential factor may have been that the programmed consequence may not have been an effective reinforcer for all participants.

Second, the four-response condition reveals that there were a number of confounding factors which influenced the findings of this study. This includes the influence of participants behavioural histories prior to the experiment, as well as the likely interaction of rule-governed behaviours. In future research, it may be useful to use a procedure similar to Mechner and Jones (2011) with a resurgence phase rather than a preference test. Establishing one response per session with each session on a separate day may control for the effects that the differential lag reinforcement schedule had on resurgence. Increasing the length of reinforcement of each behaviour may increase the magnitude of the trained responses during resurgence so that the relative amount of resurgence is more comparable to nonhuman studies. Increasing the length of the response sequences used and the

number of response sequences acquired may also mitigate the impact of rule-governed behaviour.

Conclusion

The findings of this study contribute to a better understanding of the factors which influence resurgence. Confounding variables such as rule-governed behaviour or the schedule used to transition between phases can affect the resurgence of behaviour. In regards to problem solving, the influence of these confounding factors highlights just how complex problem solving is. Problem solving involves an interaction of different behavioural mechanisms. These behavioural mechanisms are also influenced by other factors such as latent history effects. Though it is difficult to determine how all of these factors work together to produce problem solving behaviour, the analysis of the different mechanisms of problem solving, such as resurgence, allows for a better understanding problem solving from a behavioural perspective.

The factors which influence resurgence are also important to consider in applied settings when variables are less controlled, but it also means that variables that cannot be controlled such as a problem behaviour being established first may be mitigated by changing variables within the treatment used. Further research needs to be conducted in order to establish what these factors are and how they may be used in a DRA treatment procedure. Doing this may lead to more robust treatments that are less suspectable to relapse.

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Appendix A: Recruitment Poster

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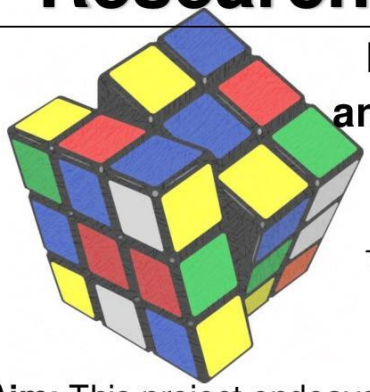
School of Psychology

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Research Participants



Project Title: Order Effects and Resurgence with Humans

Researcher: Lea-Renee Iddles
Supervisor: Tim Edwards
This project is for my Master's Thesis
This study has been approved by the Human Ethics Committee.
Code: HREC2019#17

Aim: This project endeavours to find out whether the order that behaviours are acquired in impacts on their prevalence when they are no longer reinforced for three or four behaviours.
What is involved: You will be required to participate in simulation of password entry in a computer based task. The length of this study will be between 10-60 minutes.
Why Participate: Students enrolled in an eligible Psychology course will be offered either 1% course credit or the choice to enter into a draw for a $50 Countdown Voucher.
Undergraduate students not enrolled in an eligible Psychology course will be able to enter into the draw for a $50 Countdown Voucher.
Interested: To find out more details or to book a time email the researcher at li7@students.waikato.ac.nz

Order Effects and Resurgence
Email: li7@students.waikato.ac.nz

Human Research Ethics Committee

Appendix B: Participation Information Sheet

Participation Information Sheet

Research Project Title: Order Effect and Resurgence in Humans

Researcher: Lea-Renee Iddles

Researcher Contact Details: li7@students.waikato.ac.nz

Supervisor: Tim Edwards

Supervisor Contact Details: tim.edwards@waikato.ac.nz

Invitation

You are invited to participate in this research. Before you agree to participate it is important to understand why this research is being conducted and what is involved. Please read this information sheet. If you have any questions or would like to know more information then you may ask the researcher.

What is the purpose of this research?

The aim of this project is to investigate whether the order in which behaviours are acquired impacts on their prevalence when they are no longer reinforced for three or four behaviours.

Behaviour has been shown to reappear from a person's learning history even when that behaviour has not been seen for a long time. This is known as a history effect and it has been applied to a wide variety of complex human behaviours including drug relapse and problem solving. This connection has been made by extending animal research to human behaviours. The purpose of this study is to research a fundamental aspect of learning with humans.

This study is intended for a Master's Thesis and may also be used in conference presentations and peer-reviewed journal articles.

What is involved in this study?

You will need to attend an experimental session which can last between 10 to 60 minutes.

Before the beginning of each session you will be asked to turn off your cellphone place all of your electronic devices (ie. Cellphones and watches) in your bag.

For this experiment you will undertake a computer based task. This task consists of a computerised simulation of password entry. Instructions for this task will be presented on the computer monitor.

Once you have completed the experiment you will be asked to fill out a simple Demographic Questionnaire and then you will be debriefed on the experiment.

Your rights

Participation in this study is voluntary. If you decide to participate in this study you will be asked to sign a consent form to show that you agreed to take part. You

are free to withdraw from this study up to three weeks after your participation by informing the researcher through email. If you choose, you will receive a copy of the findings when this project has been concluded.

Risks of taking part

There are no anticipated risks involved with taking part in this study.

Benefits of taking part

1% course credit will be offered for participants enrolled in level an eligible Psychology Course. If you are a student enrolled in an eligible Psychology course but do not wish to participate in this study then you can complete a text-based research exercise to earn 1% course credit. Ask the researcher for more information.

Students who do not want course credits, or are not enrolled in an eligible Psychology, will be offered to enter into a draw for a $50 Countdown Voucher.

Confidentiality

All the information collected in this study will be confidential. Only your age and gender will be recorded and reported. I will also report that University students were participants in this study. All data collected will be stored on the researcher's password protected computer and Google Drive.

All data will be anonymised before being shared. A master list identifying participants to the research data will be held on a password protected computer with the password only known to the researcher.

Data Storage

Data will be stored securely on my Supervisor's password protected computer and Google Drive for at least five years after the completion of this project. Exempt from this is the master list which will be deleted three weeks after data collection has been completed.

Concerns or Complaints

If you have any concerns or complaints about this study please contact the researcher, Lea-Renee Iddles. This research project has been approved by the Human Research Ethics Committee at the University of Waikato as HREC2019#17. Any questions or concerns about the ethical conduct of this research may be sent to the Secretary of the Committee, email humanethics@waikato.ac.nz, postal address, Human Research Ethics Committee, University of Waikato, Te Whare Wananga o Waikato, Private Bag 3105, Hamilton 3240.

Ethics Approval

This study has been approved by the Human Ethics Committee, code: HREC2019#17.

Appendix C: Consent Form

School of Psychology

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

CONSENT FORM

A completed copy of this form should be retained by both the researcher and the participant. [Note: you may delete or reword any items that are not relevant to your research and add items that are relevant to your research – **please ensure that the crest and logo above appear on the top of the page**]

Research Project: Order Effects and Resurgence in Human

Please complete the following checklist. Tick (✓) the appropriate box for each point.	**YES**	**NO**
1. I have read the Participant Information Sheet (or it has been read to me) and I understand it.		
2. I have been given sufficient time to consider whether or not to participate in this study		
3. I am satisfied with the answers I have been given regarding the study and I have a copy of this consent form and information sheet		
4. I understand that taking part in this study is voluntary (my choice) and that I may withdraw from the study at any time without penalty		
5. I have the right to decline to participate in any part of the research activity		
6. I know who to contact if I have any questions about the study in general.		
7. I understand that the information supplied by me could be used in future academic publications.		
8. I understand that my participation in this study is confidential and that no material, which could identify me personally, will be used in any reports on this study.		
9. I wish to receive a copy of the findings		

Declaration by participant:
I agree to participate in this research project and I understand that I may withdraw at any time. If I have any concerns about this project, I may contact the convenor of the Psychology Research and Ethics Committee (Professor Nicola Starkey, phone 07 837 9230, email: nicola.starkey@waikato.ac.nz)

Participant's name (Please print):

Signature: Date:

Declaration by member of research team:
I have given a verbal explanation of the research project to the participant, and have answered the participant's questions about it. I believe that the participant understands the study and has given informed consent to participate.

Researcher's name (Please print):

Signature: Date:

Appendix D: Experiment Debrief for Participants

EXPERIMENT DEBRIEF INFORMATION

ORDER EFFECTS AND RESURGENCE IN HUMANS

This experiment was designed to examine whether the order that a person learned a behaviour in impacts on their prevalence during extinction when three or four behaviours have been acquired. Previous experiments on Order Effects and Resurgence have shown that there is typically a Recency effect and a Primacy Effect. A Recency Effect is when the last behaviour acquired occurs more often than the other acquired behaviours. A Primacy effect is when the first behaviour acquired occurs more often than other acquired behaviours. Previous experiments on Order Effects and Resurgence have either been conducted on animals or in an applied setting which can have many confounding variables. The purpose of this project was to see whether an Order Effect occurred with humans in a controlled setting.

What is Resurgence?

A resurgence procedure typically consists of three phases. First, a target response is acquired through reinforcement which increases the likelihood of that response occurring. Second, the target response is placed under extinction, this means it is no longer reinforced, and an alternative response is reinforced instead. Lastly, there is a resurgence phase where both responses are under extinction. In this phase the target behaviour re-emerges, this is resurgence. This study alters this procedure so that a participant acquires either three or four behaviours before the resurgence phase.

The Experiment.

This experiment is a single-subject design which means that the participant acts as their own control. The independent variable order a participant acquired a behaviour, this was made up of a sequence containing mutually four digits. The dependent variable was frequency of the acquired behaviours during extinction. It is expected that the most recently acquired behaviour and the first acquired behaviour will occur at a higher frequency than the other behaviours which would show a Recency and Primacy Effect.

This project is also interested in whether the number of behaviours acquired in the experiment has any effect on the Recency and Primacy Order Effects. One group acquired three behaviours and the other group acquired four. The independent variable was frequency of the acquired behaviours during extinction, and whether Recency and Primacy still occurred. A Recency and Primacy Effect is expected to occur in both groups.

Why is this important to study?

Resurgence has been linked to many complex human behaviours including Problem Solving. An example is when a person loses their keys. A person will tend to do things which have resulted in their finding their keys in the past such as

looking in all of the places they have found their key before and sometimes rechecking the same places. This is resurgence. People often have large learning histories and have acquired many behaviours. This project seeks to increase the understanding of factor which influence how behaviours re-emerge.

Further Reading.

Peter, C. (2015). Six reasons why applied behavior analysts should know about resurgence. *Revista Mexicana de Análisis de la Conducta*, *41*(2), 252-268.

Confidentiality

All the information collected in this study will be confidential. Only your age and gender will be recorded and reported. I will also report that University students were participants in this study. All data collected will be stored on the researcher's password protected computer and Google Drive.

All data will be anonymised before being shared. A master list identifying participants to the research data will be held on a password protected computer with the password only known to the researcher.

Data Storage

Data will be stored securely on my Supervisor's password protected computer and Google Drive for at least five years after the completion of this project. Exempt from this is the master list which will be deleted three weeks after data collection has been completed.

Concerns or Complaints

If you have any concerns or complaints about this study please contact the researcher, Lea-Renee Iddles. If you do not believe that your concerns have been adequately dealt with or you have concerns about the ethical conduct of this research you can send these concerns to the Secretary of the Committee, email humanethics@waikato.ac.nz, postal address, Human Research Ethics Committee, University of Waikato, Te Whare Wananga o Waikato, Private Bag 3105, Hamilton 3240.

Thank you for participating in this study.

Appendix E: Demographic Questionnaire

Demographic Questionnaire

Gender: Male/Female/Other (Circle one)

Age:_____