University of Nevada, Reno

Choice and Negative Reinforcement:

The Effects of Amount, Delay and Probability

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Psychology

by

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Abstract

In behavior analysis, self-control is defined as selecting a large, delayed reinforcer over a small, immediate (or less delayed) reinforcer while selecting the small-immediate reinforcer is termed impulsive (Ainslie, 1974; Rachlin & Green, 1972). This definition highlights the importance of the delay to, and magnitude of, reinforcement in choice making behavior. These two variables have been studied extensively in the self-control paradigm. A distinct but theoretically related area of research, discounting, investigates the interaction between magnitude and probability of reinforcement. Even though results of discounting studies suggest that the probability of reinforcement plays a large role in choice behavior (e.g., Rachlin, Logue Gibbon, & Frankel, 1986; Rachlin, Raineri, & Cross, 1991), there has been little investigation of this factor in the self-control research. The current study aimed to investigate the effect of probabilities of reinforcement of less than 1 on the choice-making behavior of adults. The first experiment examined selections between uncertain immediate and certain delayed reinforcers and the second experiment examined selections between uncertain large and certain small magnitude reinforcers. These experiments were done using negative reinforcement (the removal of a loud white-noise) during a preferred task (watching a DVD movie), as it has been demonstrated that humans are more likely to respond impulsively in studies employing negative, rather than positive, reinforcers (e.g., MacAleese, 2009; Navarick, 1982; Solnick, Kannenberg, Eckerman, &Waller, 1980). The data show that when probability of reinforcement is held constant, adult humans prefer immediate (Experiment 1) and large magnitude (Experiment 2) reinforcers and that reducing the probability of reinforcement can induce preference shifts in humans.

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Choice and Negative Reinforcement: The Effects of Amount, Delay and Probability

The examination of the conditions under which an organism chooses among alternative sources of reinforcement constitutes an active area of research in behavior analysis. Investigating choice in humans is particularly important, as many people regularly behave in ways that put them at risk for harmful and even life-threatening consequences. Smoking and chewing tobacco despite the risk of cancer, having unprotected sex without regard for sexually transmitted diseases, and spending money today without saving for the future are common examples of behaviors that result in immediate satisfaction but in the long run are not very beneficial to the individual and society. We call these people impulsive and the choices they make, short-sighted. In contrast, people may forego immediate gratification in favor of delaying their pleasure. Sticking to a diet by not splurging on dessert, exercising for the sake of a longer life, and studying for an exam instead of sleeping are common examples of behaviors that in the long run are beneficial to the person and society. We might say these people are self-controlled and that the choices they make, self-sacrificing.

In the general vernacular, self-control and impulsivity are terms that refer to one's ability -- or inability -- to control their own behavior. The ability is commonly viewed as a personality trait. People with impulsive personalities, for example, are unable to muster the willpower to overcome the allure of immediate gratification and suffer as a result of this personal weakness. Indeed, helping people overcome this shortcoming is a well-established, world-wide institution. In the case of self-control, evidently people are able to resist the temptation of immediate pleasure for a pleasure that is further removed in time by exercising their willpower. These people are admired for the strength of their will, and empowering people with this strength is the promise of the institutions devoted to alleviating the suffering of people without it.

From a behavior analytic point of view, self-control and impulsivity do not refer to the ability to control one's behavior, to an individual's personality, or to the strength of an individual's willpower. Instead, as Rachlin (1974) pointed out long ago, the conditions under which we observe a person behaving either impulsively or in a self-controlled manner center on circumstances in which they must choose among various reinforcements that are available at different times and in different amounts. From this perspective, a self-controlled choice involves selecting a reinforcer that is relatively large and temporally delayed. By comparison, an impulsive choice is one in which a relatively small and temporally sooner reinforcer is selected (Ainslie, 1974; Rachlin & Green, 1972).

This combination of reinforcer delay and amount defines what is known today as the "self-control paradigm" (Logue, 1995). In this paradigm, the behavior of choosing is analyzed as a function of variations in these two independent variables.

The behavior analytic literature on self-control has grown steadily, and prodigiously, since the seminal studies in the 1970s. Organisms such as rats and pigeons have been the subjects of most of this research, and the general finding from hundreds of studies is that they and other nonhumans routinely select the impulsive alternative. There are several conditions under which selections reverse from the impulsive to the self-control alternative. For example, by gradually decreasing the delay to a small reinforcer (Mazur & Logue, 1978), by increasing the delay to both the smaller and larger reinforcers, keeping the difference in delay constant (Rachlin & Green, 1972), or by forcing the organism to "commit" to the self-control alternative prior to being exposed both to it and to the impulsive alternative (Ainslie, 1974; Rachlin & Green, 1972). But again, the general finding is that nonhumans make impulsive selections.

In contrast to nonhumans, humans ordinarily select the self-control alternative. The number of studies and participants on which this generality is based is small, however, and the supporting findings are derived from laboratory experiments utilizing points which may be exchanged for money, course credits and other nominal reinforcements for responding during the course of the study (e.g., Flora & Pavlik, 1992, Hyten, Madden, & Field, 1994; King & Logue, 1990). Confidence in the generality of self-control in humans is low, then, and is further constrained by studies showing impulsivity when primary reinforcements such as food are used (e.g., Forzano, Chelonis, Casey, Forward, Stachowiak, & Wood, 2010; Forzano & Logue, 1992; Forzano & Logue, 1995; Logue, & King, 1991).

That a person may favor the self-control alternative over the impulsive alternative when conditioned reinforcers are used but may instead favor the impulsive alternative when primary reinforcers are used underscores the potential for motivation to affect the selections made by humans in a self-control paradigm. It also raises a related question regarding how selections are affected under conditions of aversive stimulation. We turn to that question below, as it is central to the present research.

Self-control and Aversive Stimulation

Flora, Schieferecke, and Bremenkamp (1992) conducted a series of experiments involving positive reinforcement in the context of a loud, continuous tone. Participants were given a choice between earning a few points immediately or earning more points after a short delay. Participants exposed to the noise selected the impulsive alternative, while those participants making their selections in the absence of the noise selected the self-control alternative. In a second experiment, participants were exposed to both the tone on and tone off conditions. Those who experienced the tone on condition first responded impulsively in the

presence as well as the subsequent absence of the tone. Those who first experienced the tone off condition tended to select the self-control option when the tone was later present.

In another study utilizing positive reinforcement in the context of aversive stimulation, Flora, Wilkerson, and Flora (2003) gave participants a series of options while their hands were submerged in either warm or cold water. They earned money for keeping their hand in the water and for their selections on a computer while their hands were in the water. Participants in the warm water condition made more self-controlled selections and kept their hand in the water longer than the cold water participants, who took their hands out of the water earlier and repeatedly and made many more impulsive selections. Participants in the cold water condition also rated their pain as much higher compared to the individuals in the warm water condition.

The studies by Flora et al (1992, 2003) suggest that the mere presence of aversive stimuli can affect the selections humans make in a self-control paradigm. Solnick, Kannenberg, Eckerman, and Waller (1980) examined this matter in a more direct way by introducing a negative reinforcement contingency. Participants completed math problems in the presence of periodic bursts of a "white noise" tone set at 90 decibels (db). Two keys were available. Responses on one key turned the tone off immediately, or following a short delay (15 s), and for a short period of time; responses on the second key turned the tone off after a longer delay and for a longer period of time.

Different instructions regarding these two options were given to the four groups of participants. The "immediacy-informed" groups were told that, "the green button turns the noise off immediately (the 0 s group), or sooner (the 15 s group), and that one of them turn the noise off for a longer period of time," (p.68). The "duration and immediacy-informed" groups received similar instructions but were also told that pressing the blue button turns off the tone for

a longer period of time. The selections made by Solnick et al's (1980) participants in the duration and immediacy-informed groups shifted from impulsive to self-control when the delay was 0 versus 15 s respectively. The immediacy-informed groups selected the self-control alternative more frequently at no delay compared to a 15 s delay. A second experiment varied three values of amount and delay and found similar selections and selection reversals. A third experiment showed that when a participant commits to selecting the self-control alternative, their behavior conforms to that commitment.

Navarick (1982) examined the effects of different combinations of magnitude and delay in a negative reinforcement procedure involving white noise. Participants were given (1) unequal delays to reinforcement (white noise termination), (2) unequal amounts of reinforcement (duration of white noise termination), or (3) both unequal delays and amounts of reinforcement. There was no baseline task, participants were simply exposed to the noise and made noise termination selections. When reinforcer amounts were equal, participants selected the immediate alternative, and when delays were equal, they selected larger alternative. When selecting between the small, immediate reinforcer and the large, delayed reinforcer, the duration to the delay to reinforcement was important. In groups with a small delay to the larger reinforcer, preference for the small, immediate reinforcer was minimal. This preference for the small, immediate reinforcer increased systematically, however, across groups experiencing longer delays to the larger reinforcer.

MacAleese (2009) conducted three experiments on choice and negative reinforcement. Utilizing a preparation first introduced by Tarbox (2006), participants were engaged in a baseline task, watching television shows on DVD, while white noise played occasionally in the background. They could terminate the noise temporarily by selecting one of two alternatives,

each nested within one of four conditions. Condition A pitted an immediate large reinforcer against an immediate small reinforcer. Condition B put immediate and delayed reinforcers of the same magnitude against one another, and Condition C placed immediate, small amount reinforcers against delayed, larger amount reinforcers. Participants almost always selected the large reinforcer (Condition A), the immediate reinforcer (Condition B) and the small, no delay reinforcer (Condition C).

The conditions that prevail in the natural environment are quite different from the laboratory. Consider addiction cessation. When an individual experiences withdrawal symptoms they may be immediately relieved, for a short period of time, by ingesting the addictive substance (e.g., a cigarette). Waiting to smoke a cigarette does not extend the following period of withdrawal relief. Instead, individuals may experience short-term relief from the aversive conditions created by the absence of the addictive substance by ingesting it, or endure a longer period of aversive conditions without ingestion in order to more permanently escape them (e.g., endure the withdrawal symptoms in the absence of a cigarette and eventually they will subside).

In order to more closely represent natural conditions such as these, MacAleese (2009) included a fourth condition (D) wherein participants were exposed to unequal amounts of noise, depending upon the alternative they selected. Selection of the small, immediate option would turn off the noise immediately for a short period of time (30 s) and then turn it back on for a short period of time (30 s) before a new trial began. When the large, delayed alternative was selected, the noise would persist temporarily (30 s) then turn off and remain off for a long period of time (60 s) before a new trial began. Selecting the impulsive alternative resulted in more

frequent trials and more exposure to the noise compared to the self-control alternative. Participants selected the impulsive alternative almost exclusively.

In a second experiment, MacAleese (2009) varied the magnitude of the negative reinforcer. Participants were divided into two groups. One group was exposed to a loud, moderate, and then a low tone, while the second group was exposed to a low, moderate, and then a loud tone. In sharp contrast to Navarick (1982) and Solnick et al (1980), MacAleese found that the smaller, sooner alternative was selected regardless of the loudness of the tone or the order it was presented.

The different outcomes are most likely related to the presence and nature of the activity involved in each study. Participants in Solnick et al (1980) solved math problems while making their selections. Navarick's (1982) participants sat still while making selections related to the amount and delay of white noise. In contrast, MacAleese (2009) introduced a highly preferred activity, watching a favorite television show. The importance of this is that the reinforcing properties attendant to eliminating the noise presumably was both established and enhanced under these highly favored circumstances, thereby increasing the likelihood that participants would respond impulsively by turning off the noise immediately. Under comparably less favored circumstances, eliminating the noise is less valuable, which may increase the likelihood of self-controlled responding.

Relevant to this is the third experiment by MacAleese (2009) wherein participants were asked to select their three most preferred and their three least preferred television shows (e.g., Friends, Seinfeld). One group was presented with three episodes in a most-to-least preferred order, and the other group was presented with three episodes in a least-to-most preferred order. Participants in the most-to-least preferred order selected the no delay, small amount option while

watching their most preferred show. Their selections shifted to the delayed, larger option, however, while watching their less preferred shows. The participants in the least-to-most preferred order made similar selections, i.e., the no delay, smaller amount option while watching their most preferred shows and the short delay, larger amount option while watching their less favorite shows. That an impulsive selection was more likely in the presence of highly preferred DVDs and self-controlled selections in the presence of low preferred DVDs provides additional evidence that motivation is an important factor to consider in the self-control paradigm.

The studies of self-control and aversive stimulation demonstrate that humans will behave impulsively in some experimental settings. These studies are consistent with research utilizing positive reinforcement in demonstrating sensitivity to variation in reinforcer amount and delay (e.g., Ainslie & Hernstein, 1981; King & Logue, 1990; MacAleese, 2009; Navarick, 1982; Navarick & Fantino, 1976; Rachlin & Green, 1972). Further, the results of MacAleese (2009) suggest that these variables may not be the only, or even the most important variables influencing human choice. In addition to motivation, it is possible that variables such as the probability of reinforcer delivery play an important role in choice. The investigation of variables such as these is an area that has been largely neglected, however.

Self-control and Uncertainty

Consider an organism in an environment where food is scarce. An impulsive selection – stopping to eat a few crumbs of food now instead of moving on to a larger meal later -- is a desirable behavior, one that must surely contribute to the organism's immediate survival. A bias toward a short delay to reinforcement might also mean that longer delays add an element of risk or uncertainty to the self-control paradigm: a delayed reinforcer might also be uncertain (see

Fawcett, McNamara, & Alasdair, 2012; Flora, et al., 2003; King & Logue, 1992; Navarick, 1987).

The effects of uncertainty in a self-control paradigm are examined conveniently by manipulating the probability of reinforcement. In a study by Navarick (1987), participants, divided into one of six groups, viewed photographs of celebrities. Individuals in one group selected between certain and uncertain reinforcers (presentation of photos) of the same magnitude (duration of presentation) and delay. The certain reinforcer was most often selected. A second group selected between a certain larger reinforcer and a certain smaller reinforcer. They selected the larger reinforcer. A third and fourth group selected between a small-certain reinforcer and a large-uncertain reinforcer, with parametric variations in the probability of reinforcement in the large-uncertain conditions. Participants in these groups showed a preference for the small-certain reinforcer. The fifth group selected between a small-certain-immediate reinforcer and a large-uncertain-delayed reinforcer. A preference for the small-certain-immediate reinforcer was seen. The sixth and final group of individuals selected between a small-certain-delayed reinforcer and a large-uncertain-immediate reinforcer. Participants in this group preferred the large-uncertain-immediate reinforcer. While Navarick (1987) conducted a number of systematic manipulations within this study, missing was a condition examining the effects of probability and delay while holding magnitude constant.

What Navarick's (1987) results show is that humans prefer large, certain, immediate reinforcers over reinforcers that are small, delayed and uncertain. This is not surprising, of course, yet the larger point is that the addition of reinforcement probability to magnitude and delay may yield a more comprehensive analysis of self-control.

A good example of how the three variables might interact is seen in unhealthy behaviors, for example, excessive drinking. The drinker is presumably controlled by the immediacy of the effects of alcohol, which may also be available in large and unlimited quantities. The harmful effects of drinking on liver function, for instance, are not just delayed – they are also uncertain. Not everyone who drinks excessively develops cirrhosis, and by the same token, not every heavy smoker gets cancer, not every frequent gambler develops a gambling pathology, and so on. For humans, it's always the "other guy" and not themselves who will suffer from an "excessive" lifestyle. There is an element of uncertainty to events that are delayed in time, then, and the assumption is that this may either (1) add to the value of an immediate reinforcer or (2) detract from the value of a delayed reinforcer. A third assumption is that uncertainty and delay effect behavior similarly because uncertainty serves as a discriminative stimulus for delay (Rachlin, Castrogiovanni, & Cross, 1987).

Based on this third assumption, Rachlin et al (1987) manipulated magnitude and probability with humans in a concurrent chains procedure. The procedure was an adaptation of Rachlin and Green (1972) in which all delays were replaced with probabilities. Participants were given 10 red and 10 blue poker chips that they used to place a "bet" on a range of numbers from 1 to 17. Each color was associated with a different range of numbers and with a different probability of reinforcement in the first link of the chain. Red chips were associated with a high probability of reinforcement (numbers 1-15) and blue chips were associated with a low probability of reinforcement (numbers 1-3). The first link in both chains was the same, the participant bet either a red or a blue chip and the experimenter spun the spinner. If the spinner landed on a number associated with the chip, the participant "won" the bet then moved on to the second link. If they did not win the bet, they lost the chip and then bet again.

The second link of the first chain involved a bet on a large, less probable reinforcer ($5 for landing on numbers 1-4). Participants had the opportunity to select between (1) a smaller, more probable reinforcer ($1 for landing on numbers 1-17), and (2) a larger, less probable reinforcer ($4 for landing on numbers 1-5) in the second link of the second chain. If participants "won" during the second link they earned a monetary reward in the amount equivalent to their bet ($1, $4, or $5). In the first link, participants generally bet on the second chain, and generally bet their red (high probability) chips first. In the second link, they then selected the small, high probability reinforcer. When blue (low probability) chips were bet, most participants selected the larger, low probability reinforcer in the second link. These results suggest that humans prefer a small, more probable reinforcer, over a larger, less probable one.

With a procedure using punishment in addition to positive reinforcement, King and Logue (1992) examined the effects of uncertain "interruptions" (i.e., time-out) in reinforcement during which no new reinforcers (points that could be traded for money) accumulated. Participants responded on a concurrent chains schedule in which the initial selection (sliding a rod to the left or right) led to an opportunity to earn points by an additional response (turning a knob). The opportunities to earn points consisted of a shorter duration presented immediately or a longer duration presented after a delay. Participants in Experiment 1 experienced a number of conditions in which the probability of 60 second interruptions varied (P = .1, .2, and .4). During this experiment interruptions could occur at any time in the session (but only if at least 60 s had elapsed since the previous interruption). Participants generally selected the opportunity to earn points following a delay, but for a longer duration regardless of the probability of interruptions.

In Experiment 2, the probability of interruptions was held constant at .1, but the durations varied (30 s, 120 s, and 240 s). Participants again selected the delayed opportunity to earn

reinforcers for a longer period of time. In Experiment 3, the interruptions only occurred during the delay period to the larger reinforcer, and the probability of interruptions was .5. In this experiment, preference shifted and participants selected the opportunity to earn reinforcers immediately, but for a shorter duration. Finally, Experiment 4 was similar to Experiment 1 but differed in that no interruptions occurred. Participants selected the larger-later alternative. Given these results, uncertain interruptions in the opportunity to earn reinforcers had no significant effect on participants' behavior compared to their baseline rates of responding unless the interruptions led to a change in the relative rate of reinforcement, as they did in Experiment 3.

Probability Discounting

Because the self-control literature is focused on reinforcement delay and amount, most studies involving reinforcement probability are found in the so-called probability discounting literature (see Critchfield & Kollins, 2001). Most of this literature relates to the effects of delay and amount on an individual's own subjective value of the consequences of their selections (e.g., Rachlin, Raineri, & Cross, 1991).

In non-probability discounting studies, participants are asked to imagine various hypothetical situations pitting one alternative against another, for example, receiving $10 dollars now or $100 in a week. On this adjusting procedure, delay and magnitude are manipulated parametrically until a participant is indifferent, meaning that he or she is equally likely to select one or the other alternative (Green & Myerson, 2010). Deviations from indifference are then plotted as a function of variations in delay and magnitude and may be used, for instance, to predict a shift from a smaller, sooner reinforcer to a larger, later reinforcer.

Consider selecting between a guaranteed $10 or $100 with 50/50 chance of it being delivered. In this case, amount and probability are manipulated until a participant is equally

likely to select one or the other option. Deviations from this indifference point are then plotted as a function of variations in amount and probability to arrive at a prediction regarding how a person's selections change, for instance, from a smaller, certain reinforcer to a comparably larger, uncertain reinforcer (Green & Myerson, 2010).

When the delay and amount of positive reinforcement are manipulated, the usual outcome with humans is self-control, that is, the larger, longer alternative is preferred over the sooner, smaller option. When amount and probability of positive reinforcement are manipulated, humans tend to select the smaller, certain reinforcer (Green & Myerson, 2010). Whether this may be construed as an impulsive selection or as something else, for instance, a "risk-averse" selection is an interesting theoretical question, one that also raises the question of whether or not the assumption that probability functions as a discriminative stimulus for delay is accurate (e.g., Green and Myerson, 2010; Green, Myerson, & Ostaszewski, 1999; Stevenson, 1986).

The way to answer these questions is to analyze behavior under various conditions of reinforcement amount, delay and probability. The self-control paradigm is ideally suited for this analysis. It seems, too, that a negative reinforcement contingency involving the termination of an aversive event such as a loud tone in the context of an ongoing activity such as watching television offers an advantage over, for instance, hypothetical monetary contingencies with questionable motivational attributes. Moreover, the oft-cited claim that humans generally respond in self-controlled ways runs counter to the common observation that people can be notoriously impulsive. Still, the conditions under which impulsive selections are made in the laboratory appear restricted to the presence of aversive events (MacAleese, 2009; Navarick, 1982; Solnick et al., 1980), thus making the study of those events fundamental to the analysis of behavior in the self-control paradigm. Apropos to this point, the present research centers on how

variations in the probability of negative reinforcement interact with variations in reinforcer amount and delay in a modified self-control paradigm.

Purpose

The aim of this research was to examine the effects of reinforcement probability on the choices made by humans in a modified self-control paradigm. Specifically, the study examined the impact of various probabilities of reinforcement in relation to various reinforcement amounts and delays. Throughout, the contingencies involved negative reinforcement.

Two experiments were conducted, each preceded by a condition that replicated the standard self-control procedure whereby participants select between a smaller, sooner alternative and a comparably larger, later alternative, in this case, the cessation of a tone (the aversive stimulus) superimposed on a baseline schedule of positive reinforcement (viewing a favorite movie). In previous studies using a similar procedure, participants selected the impulsive alternative, that is, the one that terminates the tone immediately for a short period of time over the one that delays the offset of the tone for a comparably longer period of time (MacAleese, 2009; Navarick, 1982; Solnick et al., 1980). The procedure of superimposing an aversive event over a positive baseline has been utilized only in one study (MacAleese, 2009), thus creating a need to systematically replicate the procedure for purposes of confirming the impulsive finding, establishing the generality of the methodology and creating a platform for the current research.

Participants in Experiment 1 subsequently selected between alternatives that pit an immediate, uncertain reinforcer against a delayed, certain reinforcer, with reinforcer amount held constant across the two alternatives. Participants in Experiment 2, on the other hand, selected between alternatives that pit a small and certain reinforcer against a larger and uncertain reinforcer, with delay held at a constant, short duration across the two alternatives. The results

of these two experiments supply answers to questions regarding the contribution of reinforcement probability to the selections made by humans in the context of a self-control paradigm involving contingencies of negative reinforcement.

General Method

Participants and Setting

The participants were 49 undergraduate students at the University of Nevada, Reno. Participants were recruited through the university's SONA recruitment system. Participants were at least 18 years of age and had normal, self-reported hearing and sight.

Experimental sessions were conducted in a small room in the basement of the Warren G. Nelson Building, located off the main campus of the University of Nevada, Reno. The room included a desk, chair, computer, mouse, and speakers.

The experiment was conducted using a Sony laptop computer with Windows XP®. A program written in Microsoft Access® presented all stimulus events and recorded all responses made by the participants in relation to those events.

The computer monitor displayed video from a DVD movie selected by the participant. The DVD played throughout the session at an ambient sound level of roughly 30-40dB. At preset times, the computer program presented white-noise at an ambient sound level of approximately 60-70dB. After the noise played for a few seconds, two concurrently available buttons appeared on opposite sides of the screen below the viewing area (see Figure 1). One button was red (the left button), and one was black (the right button). Each button corresponded to a particular alternative depending upon the experiment and condition in effect. Participants responded by clicking on the red or black button, at which point both buttons disappeared while

the consequences of the selection were delivered. The buttons reappeared shortly after the white noise was once again presented, and so on, for the duration of the session.

Participant Instructions

Upon arriving for an experimental session, an information sheet describing the study (Appendix A) was read to, or read by, the participant (determined by random assignment). That a participant read the sheet silently is indicated by a (#) in the participant code (see Appendix B for a description of the participant coding method). Once the instructions were read, the experimenter provided an opportunity for the participant to ask questions. The participant could then choose to continue with the study or withdraw from it at that point.

If the participant elected to continue, he or she was asked to remove their watch or any other time-keeping device and also to leave their belongings, including cell phones, with the experimenter for the duration of the session. The participant was then escorted to the experimental setting to begin the session. The participant was provided with a debriefing sheet (Appendix C) at the conclusion of the session which described the purpose of the experiment. The participant was given another opportunity to ask questions and also to withdraw from the study at this point by asking that their data be excluded from the analysis.

Preference Assessment

Participants were given a menu of movies (e.g., Harry Potter, Office Space) and asked to select the one they would most prefer to watch (see Appendix D). As part of the questionnaire at the end of the experiment, participants were asked to estimate the number of times they have seen the movie in the past and report whether or not they liked the movie (see Appendix E).

Forced-choice Trials

At the start of all conditions and phases, participants were exposed to four forced-choice trials wherein they were instructed to select each button two times. The buttons operated according to the parameters of the specific phase and condition, but only one button operated on each of the trials. Following the forced-choice trials, either button could be pressed on every trial and the participant was free to make their own selection. The consequences associated with each button were counterbalanced across participants. Responses made during the forced-choice trials were not included in the data analysis.

Exit Questionnaire

Upon completion of the experiment, participants were asked to complete a brief questionnaire (Appendix E). The eight questions asked participants to describe how the buttons functioned during each part of the experiment, to describe how they felt in the presence of the noise, and to describe their history with the selected movie. They were also given an opportunity to provide additional comments. Question 4 was included to assist in monitoring the functioning of the computer program.

Experimental Design and Data Management

A within subjects design with a repeated control condition was utilized in this study. All participants were first exposed to a pre-experimental control condition and then assigned at random to one of two experimental groups. Once assigned, the participants were exposed to Phase 1 of their respective experimental group placements. In Phase 2, participants were assigned at random to one of two conditions.

The dependent measures included the selection responses by each participant -- right and left button presses – and the latency of selection following the introduction of the choice

alternatives. Results included within and between participant analyses. These data have been summarized, tabulated, and analyzed visually and descriptively for trends and tendencies for all experiments, phases and conditions.

Replication Condition

All participants were first exposed to a replication condition that was fashioned after the procedures described by MacAleese (2009, Experiment 1 C). Participants were exposed to 15 seconds of white noise (60-70dB) before the two buttons appeared on the monitor. Responses to Alternative A (the impulsive alternative) resulted in turning the noise off immediately for 90 seconds and then turning it back on for 90 seconds. Responses to Alternative B (the self-controlled alternative) resulted in the noise remaining on for 60 seconds before turning off for 120 seconds (see panel A of Figure 2). A new trial began with the presentation of the white noise for 15 seconds followed by the presentation of the two buttons on the monitor, and so on, for the duration of the 30 minute session. The button associated with each alternative (whether right or left) was counterbalanced across participants.

Once the session ended, the experimenter entered the room and asked the participant to move away from the computer while the next condition's session was prepared.

Experiment 1

Participants

Twenty-seven undergraduate students, 13 male and 14 female, participated in Experiment 1.

Procedure

Experiment 1 examined the effects of varying the delay to, and probability of, reinforcement while holding the magnitude of reinforcement constant. During this experiment,

the amount of time that the 60-70dB white noise remained off was the same regardless of which button was selected, but differed in terms of whether responses turned the white noise off immediately or after a delay during which time the noise remained on (see Figure 2, panel B). At the start of each session, the white noise was on for 5 seconds, at which point two buttons appeared on the screen. A response to Alternative A turned the noise off immediately for 20 seconds and then back on for 20 seconds before the next trial began. A response to Alternative B also turned off the white noise for 20 seconds, but only after a 20 second delay. The button associated with each alternative was counterbalanced across participants and remained consistent across both phases of the experiment for each participant. The noise parameters were identical to those utilized in Experiment 1 A in MacAleese (2009). These parameters were selected because they were demonstrated to be effective in evoking differentiated selection responses in the MacAleese study.

Phase 1. During Phase 1 the probability of reinforcement for selecting either alternative was 1.0. This phase lasted approximately 25 minutes. When the phase ended the experimenter entered the room and asked the participant to move away from the computer while the Phase 2 was prepared.

Phase 2. The phase was identical to Phase 1 except that participants were randomly assigned to one of two conditions in which the probability of reinforcement for the immediate alternative was manipulated. As a result of ongoing analysis of the data it was determined that an additional condition (Condition B) may provide further important information regarding the variables of interest. Participants were not randomly assigned to this condition. Each condition represented a different probability of reinforcement for selection of Alternative A. The probability of reinforcement for selecting Alternative A was .75 in Condition A (Phase 2A), .5 in

Condition B (Phase 2B), and .25 in Condition C (Phase 2C). In all cases, if a selection was not reinforced the buttons disappeared and the white-noise remained on until the onset of the next trial and the re-presentation of the buttons. The probability of reinforcement for the selection of Alternative B remained at 1.0.

This phase lasted approximately 25 minutes. Once the phase ended the experimenter entered the room and informed the participant that the experiment had ended.

Experiment 2

Participants

Twenty-two undergraduate students, 12 male and 10 female, participated in Experiment 2.

Procedure

Experiment 2 examined the effects of varying the magnitude and probability of reinforcement while holding the delay to reinforcement constant. During this phase the duration of noise-off varied, but it turned off immediately following a press on either button (see Figure 2, panel C). Trial length remained constant, but total exposure to noise varied. The white-noise was presented for 5 seconds and then the buttons appeared on the screen. Alternative A turned the noise off immediately for 5 seconds and then it turned back on for 35 seconds before the next trial began. Alternative B turned the noise off immediately for 40 seconds and it remained off until the next trial. In both cases, the delay to the noise turning off was equivalent (it turned off immediately), but the magnitude of reinforcement was varied. The button associated with each alternative was counterbalanced across participants and remained consistent across both phases of the experiment for each participant. The noise parameters were a modification of the parameters of Experiment 1 B in MacAleese, (2009). These parameters were selected because

they were demonstrated to be effective in evoking differentiated selection responses in the MacAleese (2009) study.

Phase 1. During Phase 1 the probability of reinforcement for selecting either alternative was 1.0. This phase lasted approximately 25 minutes. Once the phase ended the experimenter entered the room and asked the participant to move away from the computer while Phase 2 was prepared.

Phase 2. This phase was identical to Phase 1 with the exception that participants were randomly assigned to one of two conditions. Each condition represented a different probability of reinforcement for the selection of Alternative B. In Condition A (Phase 2A) the probability of reinforcement for selecting Alternative B was 0.75. In Condition B (Phase 2B) the probability of reinforcement for selecting Alternative B was 0.25. In both cases, if a selection was not reinforced, the buttons disappeared and the white-noise remained on until the onset of the next trial and the re-presentation of the buttons. The probability of Alternative A functioning remained at 1.0.

This phase lasted approximately 25 minutes. Once the phase ended the experimenter entered the room and informed the participant that the experiment has ended.

Results

Replication Condition

Forty-nine individuals participated in the current experiment, 27 in Experiment 1 and 22 in Experiment 2. Table 1 is a summary of the distribution of participants across experiments and conditions. All participants were included in the Replication Condition, though it is important to note that due to an error in setting the program parameters, the data for participant 30F#1 were not recorded and are not included. The data for this condition are found in Figure 3. Data

represent the percentage of trials in which the impulsive alternative (short duration, immediate reinforcement) was selected. A summary of the number of trials per session for each participant can be found in Tables 2 and 3. All sessions included five trials (exclusive of the forced-choice trials). Forty-two participants (82%) selected the impulsive alternative on 50% or more of trials; 25 participants (52%) selected the impulsive alternative on 100% of trials. While most participants selected the impulsive alternative on the majority of trials, 6 participants (13%) responded in a self-controlled manner by selecting the delayed, long duration alternative on a large percentage of trials. Participants 09F, 54M1, and 56M1 selected the immediate alternative on less than 50% of trials and participants 04F2, 36M, and 45M2 did not select the immediate alternative on any trials.

Experiment 1

Experiment 1 included 27 participants (see Table 1). Participants in this experiment selected between immediate and delayed (20 s) negative reinforcement, while magnitude (20 s) was held constant. All individuals experienced Phase 1, in which the probability of reinforcement for either alternative was 1.0.

The mean number of trials per session in Phase 1 was 25 (range: 21-27). The mean percentage of selections of the immediate alternative in Phase 1 was 87% (range: 28.57-100%). The mean latency to a selection response in Phase 1 was 2.82 s (range: 1.24-15.54 s). These data are summarized in Table 4.

Phase 2 included three conditions. The mean number of trials in Condition A ($p = .75$) was 25 (range: 22-27). The mean percentage of selections of the immediate alternative was 73% (range: 0-100%), and the mean latency of selection responses was 2.23 s (range: 1.26-6.53 s). The mean number of trials in Condition B ($p = .5$) was 26 (range: 25-27), the mean percentage of

selections of the immediate alternative was 81% (range: 53.85-96.3%), and the mean latency was 2.6 s (range: 1.72-4.82 s). Finally, the mean number of trials in Condition C (p = .25) was 25 (range: 21-27), the mean percentage of selections of the immediate alternative was 36% (range: 0-85%), and the mean latency to a selection response was 2.1 s (range: 1.19-3.7 s). These data are also summarized in Table 4.

The top panel of Figure 4 depicts the percentage of responses to the immediate alternative for all participants in all phases of Experiment 1. Aggregate percentages were calculated by summing the number of trials in which the immediate alternative was selected across participants and dividing by the sum of the total number of trials across participants in the particular condition. During Phase 1, when the probability of reinforcement was 1.0 for both alternatives participants selected the immediate alternative on 80.87% of trials, compared to 72.76% in Phase 2A (p = .75). Participants in Phase 2B (p = .5) selected the immediate alternative on 96.13% of trials in Phase 1 compared to 80.89% in Phase 2, and those in Phase 2C (p = .25) selected the immediate alternative on 89.2% of trials in Phase 1 compared to 36.9% of trials in Phase 2.

Individual participant data by phase for Experiment 1 are found in Figure 5. The data for Phase 2A (top panel) are the most variable of the three Phase 2 conditions in Experiment 1. Five participants (25M, 32F, 35M#1, 40M, and 44F#2) selected the immediate alternative less in Phase 2 as compared to Phase 1 (a "preference shift"), while the remaining participants selected the immediate button more frequently in Phase 2. The data for participants in Conditions B and C are less variable as participants demonstrated a shift in preference in Phase 2 as compared to Phase 1, with the exceptions of participants 59F#1 and 15M#2. Table 2 provides a summary of the specific session characteristics for each participant.

Table 5 contains information regarding the number of unreinforced trials participants experienced during Phase 2 of Experiment 1. Six participants in Condition A (07F, 25M, 31M, 32F, 36M, and 40M) did not experience unreinforced trials during the forced-choice trials portion of the session. All of these participants experienced unreinforced trials during the remainder of the session and participants 25M, 32M, and 40M demonstrated a preference shift in Phase 2 as compared to Phase 1. All other participants experienced at least 1 unreinforced forced-choice trial and 15 participants demonstrated a preference shift.

Figures 6 through 15 depict individual session data for each participant. The top panel represents the percentage of responses to the immediate alternative in the Replication Condition as well as Phases 1 and 2 of Experiment 1. The bottom panel depicts the proportion of responses made to each alternative during Phases 1 and 2 of Experiment 1, demonstrating the participants' within session pattern of responding. Proportions were calculated by first dividing the session into blocks of four trials. The number of trials in most sessions was not evenly divisible by 4, so remaining trials were added to the last trial block of the session, which include four to seven trials. The number of selections responses to each alternative was divided by the total number of trials in the trial block. Those sessions that included a trial block of more than four trials are denoted in the figure captions (Figures 6-15).

Summary. While most participants in Experiment 1 demonstrated a differentiated pattern of responding during Phase 1 in which they selected the immediate alternative on the greatest proportion of trials, many of the participants who eventually experienced Phase 2A varied from this pattern. For example, differentiated responding developed for Participant 36M's (Figure 8, middle panel) during Phase 1, such that he selected the immediate alternative on a decreasing proportion of trials throughout the session. His selection responses were

undifferentiated in Phase 2A. His data do not demonstrate a preference shift (Figure 8, top-middle panel). A similar pattern is observed in the data for participants 31M (Figure 7, middle panel) and 41M#1 (Figure 9, left panel).

The data for participants who did demonstrate a preference shift during Phase 2 (all conditions) generally followed one of two patterns. The first was differentiated responding during Phase 1 followed by variable responding during Phase 2. For example, following the first trial block in Phase 1, Participant 25M (Figure 7, left panel) selected the immediate alternative on all trials. He then responded variably during Phase 2A by allocating responses to both alternatives throughout the session. The overall percentage of selection responses to the immediate alternative was lower in Phase 2B than in Phase 1, demonstrating a preference shift (Figure 7, top-left panel). The pattern of responding for Participants 35M#1 (Figure 8, left panel), 57M1 (Figure 10, right panel), and 48F1 (Figure 15) was similar.

The second pattern of responding, which was only observed in Phase 2C, included differentiated selections during Phase 1 (with responses allocated to the immediate alternative) and in Phase 2 (with responses allocated to the delayed alternative). For example, Participant 44F#2 (Figure 9, right panel) selected only the immediate alternative during Phase 1. During Phase 2A there was a preference shift and she selected only the delayed alternative. Participants 04F2 (Figure 12, left panel), 08F1 (Figure 12, middle panel), and 28F2 (Figure 13, right panel) responded similarly. It is interesting to note that some participants allocated a greater number of responses to the immediate (and less probable) alternative during the later trial blocks of Phase 2. Within session patterns of responding for Participants 58F#2 (Figure 11, left panel), and 39F2 (Figure 14, middle panel) are examples. While the patterns of responding were similar across phases, the percentage of preference shift was different. In general, those participants in Phase

2B allocated a greater proportion of responses to the immediate alternative than those participants in Phases 2A and 2C, and participants in Phase 2C allocated the greatest proportion of responses to the delayed alternative.

Experiment 2

Experiment 2 included 22 participants (see Table 1). Participants in this experiment selected between short (5 s) and long (40 s) duration (small and large magnitude) negative reinforcement, while delay (0 s) was held constant. All individuals experienced Phase 1, in which the probability of reinforcement for either alternative was 1.0.

Group level data for Experiment 2 are summarized in Table 4. The mean number of trials per session in Phase 1 was 25 (range: 23-37%). The mean percentage of selections of the immediate alternative in Phase 1 was 87% (range: 69.23-100%). The mean latency to a selection response in Phase 1 was 1.63 s (range: .62-2.53 s).

Phase 2 included two conditions. Group level data for both conditions are also summarized in Table 4. The mean number of trials in both Conditions A ($p = .75$) and B ($p = .25$) was 25 (range: 21-27 and 22-27 respectively). The mean percentage of selections of the immediate alternative in Condition A was 53% (range: 0-100%) and 54% (range: 0-84.62%) in Condition B. The mean latency to a selection response was 2.17 s (range: .98-3.08 s) in Condition A and 2.1 s (range: 1.13-3.69 s) in Condition B.

The bottom panel of Figure 4 depicts the aggregate percentage of responses to the long duration alternative for all participants in all phases of Experiment 2. Only data for those individuals who participated in the specific Phase 2 condition were included in the Phase 1 comparison. The aggregate percentages were calculated in the same manner as in Experiment 1. During Phase 1, when the probability of reinforcement was 1.0 for both alternatives, participants

selected the long duration alternative on 90.18% of trials, compared to 52.5% in Phase 2A (p = .75). Participants in Phase 2B (p = .25) selected the long duration alternative on 84.34% of trials in Phase 1 compared to 31.79% in Phase 2.

Individual participant data by phase for Experiment 2 are found in Figure 16. All but two participants (49M1 and 50M) in Phase 2A (top panel) demonstrated a preference shift away from the long duration alternative as compared to Phase 1. The preference shift is greater for those participants in Phase 2B (bottom panel), with the exception of one outlier, Participant 16M#1.

Table 6 contains information regarding the number of unreinforced trials participants experienced during Phase 2. Five participants in Condition A (09F, 21F, 34M#, 50M, and 51F) did not experience unreinforced trials during the forced-choice trials portion of the session, though they experienced unreinforced trials during the remainder of the session. Participant 50M was the only participant who did not experience unreinforced forced-choice trials and also did not demonstrate a preference shift during Phase 2A. Two other participants, 49M1 and 16M#1 did not demonstrate a preference shift, though they experienced unreinforced forced-choice trials and unreinforced trials during the remainder of the session (see Figure 16).

Data for individual participants are found in Figures 17 though 24. Again, the top panel represents the percentage of responses to the immediate alternative in the Replication Condition and to the long duration alternative in Phases 1 and 2 of Experiment 2 for each participant. The bottom panel depicts the proportion of responses to both alternatives during Phases 1 and 2 of Experiment 2, demonstrating the within session pattern of responding. Proportions were calculated by the method described in Experiment 1.

Summary. Patterns of responding by participants in Experiment 2 were similar to those of participants' in Experiment 1. Most participants in Phase 2A (p = .75) demonstrated a

differentiated pattern of responding throughout Phase 1, though there were a few exceptions. Participants 05F1 (Figure 17, left panel), 09F (Figure 17, middle panel), and 50M (Figure 19, right panel) did not demonstrate differentiated responding to the long duration button until late in Phase 1, after the fourth or fifth trial block. Of these participants, 50M was the only one that continued to select the long duration alternative during Phase 2 (Figure 19, top-right panel). His responding during this phase was entirely differentiated as he made all selection responses to the long duration alternative. This participant did not experience unreinforced trials during the forced-choice trials portion of the session, but did experience three unreinforced trials later in the session (see Table 6).

Participant 49M1 (Figure 19, middle panel) also continued to select the long duration alternative during Phase 2A of Experiment 2. Responding was differentiated and all responses (with the exception of second trial block) were allocated to the long duration button during Phase 1. The same pattern of responding was observed during Phase 2A. Participant 49M1 did experience one unreinforced trial during the forced-choice trials portion of the Phase 2A session (see Table 6).

All other participants in Phase 2A of Experiment 2 demonstrated a shift in responding away from the long duration alternative as compared to selection responses in Phase 1. While the overall percentage of selection responses made to the longer duration alternative was lower during Phase 2A, the proportion of responses allocated to either alternative varied throughout the session for most participants. The data for Participants 09F (Figure 17, middle panel) and 38M#1 (Figure 19, left panel), are examples of the variability in responding throughout Phase 2A as they allocated a proportion of responses to both alternatives throughout the session. The data for Participant 38M#1 (Figure 19, left panel) are interesting in that he allocated a greater

proportion of responses to the long duration alternative later in the session than he did earlier. Two participants, 05F1 (Figure 17, left panel) and 27F#2 (Figure 18, middle panel) demonstrated stable, differentiated responding to the short duration alternative during Phase 2A. These participants experienced unreinforced trials (1 and 2 respectively) during the forced-choice trials portion of the sessions (see Table 6).

In general, the individuals who experienced Phase 2B (p =.25; Figures 21-24) demonstrated less variability and greater differentiation in responding during Phase 2 as compared to those participants in Phase 2A (p = .75). Participant 16M#1 (Figure 21, middle panel) was the only participant that did not shift preference in Phase 2B. Responses are differentiated during both phases with most responses allocated to the long duration alternative. All participants in Phase 2B of Experiment 2 experienced at least 1 unreinforced trial during the forced-choice trials portion of the session (see Table 6).

Integrity of the Apparatus

Figure 25 represents the aggregate percentage of unreinforced trials in each condition of Phase 2 of Experiment 1 (top panel) and Experiment 2 (bottom panel). These data were calculated by summing the total unreinforced selections of the preferred alternative, aggregate across participants in the Phase 2 condition of interest, and dividing by the total number of selections of the preferred alternative in that condition. In Experiment 1, 26.1%, 53.5%, and 72% of trials in Phase 2 Conditions A (p = .75), B (p = .5), and C (p =.25), respectively, were unreinforced. In Experiment 2, 25.2% of trials in Phase 2 Condition A (p = .75) were unreinforced and 59.6% of trials in Condition B (p = .25) were unreinforced. These data serve as an integrity check and indicate that the computer program was working as described and applied the probability criterion in each Phase 2 condition accurately.

Exit Questionnaire

An exit questionnaire was given to participants upon completion of Phase 2 (Appendix E). It included eight questions, the first three of which asked participants to describe how the buttons functioned during each part of the experiment. Table 7 provides a summary of participant responses. The magnitude and delay contingencies for each phase (as well as the probability contingency for Phase 2) were recorded separately, as most participants commented on one part of the contingency, but not the other(s). For instance, when describing the replication condition Participant 12M#1 wrote, "One button had a long time in which after clicking it, it took time for the noise to stop. Sometimes it cut off after clicking." This is an accurate description of the delay contingency during the Replication Condition (immediate versus delayed noise removal), but does not include a reference to the magnitude contingency (short or long duration of the noise-free period).

The majority participants attempted to describe the delay contingency during the Replication Condition as well as Phases 1 and 2 of each experiment without also referring to the magnitude contingency. Participant 36M was the only participant who responded in a self-controlled manner and also described both parts of the contingency accurately on Question 1 ("The red button seems to have given instant relief from the noise, but would cause a delay in the buttons appearing to the next occurrence. The black was the reverse.").

Many participants referred to the probability contingency when answering Question 3 about Phase 2, but most were only partially accurate. For instance, Participant 37M2 wrote, "The red button seemed to only shut the noise [off] at certain times, while the black would shut it off instantly, but only for a few seconds." This is a partially accurate description of the probability contingency ($p = .25$) because while it describes the button as turning the noise off

inconsistently, it does not describe the parameters involved (it also partially describes the magnitude and delay contingences). Only Participants 40M, 55F1, and 49M1 accurately described the probability contingency in place during Phase 2 by specifically describing how frequently the selection was reinforced.

While most participant responses were only partially accurate or only described one contingency in a phase, a few participants (e.g., 35M#1, 58F#2, 15M#2, and 08F1) described multiple contingencies accurately across phases (see Table 7). Only one participant, 18M1, described an entire phase accurately by describing the magnitude and delay contingencies in the Replication Condition ("It seemed the red button gave the most relief from the noise, but for a shorter period of time. The red button was instant gratification. The black button seemed to make the noise go longer, but it also kept it off longer."). Despite his understanding of the contingency, he responded impulsively during the Replication Condition (see Figure 3).

Question 4 asked participants to report whether or not the buttons ever appeared in the absence of the noise in order to monitor the functioning of the computer program. Thirty-eight participants reported that the buttons never appeared in the absence of the noise. Eight participants answered, "yes," and 3 participants did not provide an answer.

On Question 5 participants described how they felt while the noise was on. Of the 49 participants, all but two (04F2 and 49M1) described their emotional reaction to the noise as negative, using the words "annoyed," "irritated," "bothered," "angry," or, "distracted" (see Table 7).

Questions 6 and 7 asked participants to report the number of times they had previously viewed the selected movie and whether or not they liked the movie. These data are summarized in Table 8; Figure 26 is a summary of the movies selected by participants in the study. Forty-

three participants reported that they had viewed the selected movie at least one time previously and 47 participants reported that they liked the movie. Participant 12M#1 had not previously viewed the movie Super 8 and reported that he liked it, "somewhat." Participant 40M reported that he had viewed the movie Inception two times previously and that he did not like the movie during the experiment because of the noise playing over it.

Twelve participants wrote additional comments at the end of the survey (Question 8; Table 7). The comments by Participants 25M, 40M, 48F1, 34M#, 17M2, and 20F2 regarded the negative effect of the noise of the movie. The remaining comments were unrelated to the participants' reaction to the specific conditions of the experiment.

Discussion

The data presented here generally confirm what the extant literature on choice would predict. When the probability of reinforcement was 1.0 for both alternatives, participants selected the (1) small-immediate alternative (Replication Condition; Figure 3), (2) the immediate alternative (Experiment 1; Figure 4, top panel), and (3) the large magnitude alternative (Experiment 2; Figure 4, bottom panel). When the probability of reinforcement for the preferred alternative was less than 1.0, however, preference shifted from the uncertain to the certain alternative for most participants (Experiments 1 & 2, Phase 2, Figure 4). We shall now turn to a discussion of these findings in detail.

Replication Condition

The purpose of the Replication Condition was to confirm the reliability of previous findings and the methodological generality of the current experimental preparation and apparatus. Though nonhumans respond impulsively, previous research utilizing positive reinforcement in a self-control paradigm has generally failed to produce impulsive responding in humans (e.g., Flora &

Pavlik, 1992; Hyten, Madden, & Field, 1994; King & Logue, 1990). Investigations utilizing negative instead of positive reinforcers has shown impulsive responding in humans (e.g., MacAleese, 2009; Navarick 1987; Solnick et al, 1980). The condition was a direct replication of Experiment 1 C of MacAleese (2009), and similarly to the participants in that study, 42 of the 48 participants for whom data are included responded impulsively (Figure 3). The data then suggest that the apparatus functioned as desired and was successful in evoking impulsive responding. Further, the results are consistent with other studies utilizing negative reinforcement in the self-control paradigm. Taken in combination with the results of previous studies, these data provide further evidence that participants are likely to respond impulsively in laboratory preparations utilizing negative reinforcement. This is an important methodological point given that analogue investigations of self-control are intended to create an environment that simulates the natural environment.

Experiment 1

Experiment 1 involved a within participants investigation of the variables of probability and delay in a modified self-control paradigm. The purpose of Phase 1 was to establish a baseline of selecting the immediate or delayed alternative more frequently when magnitude and probability of reinforcement were held constant. As expected, participants selected the immediate alternative on a greater percentage of trials than the delayed alternative.

In addition to serving as a baseline for Phase 2, Phase 1 makes a methodological contribution to the self-control literature regarding the generality of the apparatus and preparation. The noise and delay parameters used in this experiment were the same as the ones used in Experiment 1A of MacAleese (2009). In that and the current study, participants normally selected the immediate alternative. Moreover, the present data are consistent with the

results of other self-control studies using negative reinforcement with humans (Navarick, 1982; Solnick, et al., 1980), as well as with results of self-control studies demonstrating impulsivity in nonhuman organisms. Thus, the parameters and preparation produce predictable, reliable, and generalizable features of choosing behavior.

Phase 2 examined the effects of reduced values for the probability of reinforcement for selection of the preferred alternative from Phase 1, in this case the immediate alternative, as compared to responding in Phase 1. The parametric examination included three different probability manipulations (p =.75, .5, and .25). It was anticipated that a preference shift would be observed generally in all conditions. Further, for those participants in Phase 2A and Phase 2C, the percentage of selection responses made to the immediate alternative roughly coincided with the probability of reinforcement in place.

While the group level data confirm predictions regarding the relevant variables, they do not provide a full account. Ongoing visual inspection of the individual within participant data revealed a high level of variability in the responding of participants in Condition A as compared to their baseline performance in Phase 1, and as compared to the responding of participants in Condition C. Six of the eleven participants selected the immediate alternative during Phase 2 at least as frequently as they had in Phase 1 (see Figure 5). It was determined that adding a third condition (Condition B, p = .5) would be useful in providing additional information and clarification regarding the variables of interest (delay and probability). Participants in Condition B responded similarly to those in Condition C (Figure 5).

Possible explanations for the differences in individuals' responding during Phase 2A as compared to Phases 2B and 2C include 1) the noise parameters for each alternative as insufficiently salient to participants to produce differential responding, 2) the participants

assuming that the apparatus had malfunctioned, 3) participants did not attend to the infrequent unreinforced trials, and 4) the probability of reinforcement was sufficiently high for the participants to risk losing a noise free period. We shall discuss each alternative in turn.

Questions one through three of the Exit Questionnaire (Appendix E) provide a way to examine whether the parameters and contingencies of each phase were salient for individual participants. Few participants in Experiment 1 were able to accurately describe any part of the contingency in place during Phase 2 (see Table 7), and still, the participants in Conditions B and C, as well as some participants in Condition A, demonstrated a preference shift. It is likely, therefore, that the variability observed in Condition A is unrelated to the ambiguity of the noise parameters.

For two participants, 31M and 23M1, it is possible that patterns of responding were related to assumptions regarding the general functioning, or malfunctioning, of the apparatus. Participant 31M reported that the buttons had appeared in the absence of the noise at some point in the experiment, but could not report the specific phase, so it is unknown if this may have contributed to his particular response pattern. Additionally, Participant 23M1 seemed concerned that the buttons did not appear concurrently with the onset of the noise (due to the 5 s inter-trial interval or the period in which noise was present during the trial) and came out of the room at the beginning of the Replication Condition to inform the experimenter that the computer was not working (it was functioning correctly). It is, of course, possible that this interaction impacted later responding in some way. As these two participants were the only to report that they thought the computer program was malfunctioning, it is also unlikely that the variability observed in Phase 2A was related to assumptions about the program functioning incorrectly.

Question 3 from the Exit Questionnaire addresses whether or not participants were attending to the unreinforced trials during Phase 2A. Nine participants attempted to describe, mostly inaccurately, the probability contingency in place during this phase (see Table 7). Thus, while they may not have understood the contingency, they must have been attending to it in order to describe, for instance, that the noise did not always turn off after they selected a button. Furthermore, the questionnaire response data are similar to the data for participants from other phases in which preference shifts were more frequently observed, suggesting that the patterns observed in Phase 2A were not related to the unreinforced trials going unnoticed.

Given that the noise parameters, problems with the apparatus, and participant attention were not the likely explanations for the variability observed in Phase 2A, we will turn now to aspects of the probability contingency. Participants who continued to select the immediate alternative during Phase 2A experienced five to seven unreinforced trials during the session (see Table 5). Despite this, within session data for these participants generally showed differentiated responding during Phase 2A, with responses allocated to the immediate alternative. This is similar to Phase 2B, though the overall between participant variability in that phase is much less than in Phase 2A. It is also very different from Phase 2C which included the greatest percentage shift in preference.

The implication is that the probability of reinforcement in Phase 2A was insufficiently low to evoke a preference shift for many participants. Said another way, the possibility of producing an immediate negative reinforcer was more valuable than the potential of forfeiting it. It is possible that a .75 probability of reinforcement is an indifference point of sorts, the point at which more individuals shift preference as the probability of reinforcement decreases. Future research might include further parametric manipulations of probability values to determine

whether preference shifts and indifference points in the type of preparation used here are similar to those observed in the probability discounting research.

Finally, Navarick (1987) is the only published study to systematically manipulate the probability of reinforcement and the traditional self-control variables of delay and magnitude. That study included manipulations of magnitude and probability while keeping delay constant, as well as various manipulations of the three variables combined, but it did not include a manipulation of probability and delay while holding magnitude constant. Thus, Phase 2 makes an important contribution as a first step toward understanding the interaction between the variables of delay and probability independent from magnitude. Future research might investigate these variables further through parametric manipulations of the probability of reinforcement and by manipulating the parameters of noise duration and frequency. Related to this, the small number of participants in Phase 2B may be a limitation and a future replication of those conditions is warranted.

Experiment 2

Experiment 2 involved a within participants investigation of the variables of probability and magnitude in a modified self-control paradigm. The purpose of Phase 1 was to establish a baseline of selecting the long duration or short duration alternative more frequently when delay to, and probability of, reinforcement were held constant. As expected, participants selected the long duration alternative on a greater percentage of trials than the shorter duration alternative.

Phase 1 of Experiment 2 also makes a methodological contribution to the self-control literature regarding the generality of the apparatus and preparation. The noise and delay parameters applied in this experiment were similar to, but not an exact replication of, the parameters of Experiment 1B of MacAleese (2009) and participants responded similarly by

selecting the immediate alternative. The present data are consistent with the results of MacAleese (2009) and other self-control studies using negative reinforcement (Navarick, 1982; Solnick, et al., 1980) and suggest that the preparation successfully produces predictable and reliable responding by humans given a variety of parameters.

The data for Phase 2A in Experiment 2 more closely match the predicted outcome than those in Experiment 1. Most participants showed a preference shift from the long duration alternative to the short duration alternative. Unlike in Experiment 1, the aggregate percentage of responses to the preferred alternative in Phase 2A (52.5%) was much less than the probability of reinforcement ($p = .75$)

The data for Phase 2B ($p = .25$) are similar to those in Experiment 1 Phase 2C ($p = .25$). Participants selected the long duration alternative on about a third of trials (see Figure 4). Additionally, the within-session patterns of responding for participants in Phase 2B show more differentiation with a greater proportion of responses allocated to the short duration alternative than those in Phase 2A.

Just as in Experiment 1, generally participants were inaccurate or only partially accurate in describing the contingencies present in Phase 2 (Table7). This suggests that participants' responding was under the control of the programmed contingencies rather than rules developed by the participants within session. Still, not all participants responded in accordance with the programmed contingencies and an investigation of participant verbal behavior is warranted. Continued parametric manipulation of the probability of reinforcement and its effect on responding, especially at probabilities greater than .75, would be useful in determining the probability at which a participant is unlikely to shift preference to the certain alternative.

General Discussion

If there is a general statement to be made about the current experiments it is that humans prefer immediate negative reinforcers to delayed ones, large magnitude negative reinforcers to small magnitude ones, and certain negative reinforcers to uncertain ones. Phase 1 of both experiments demonstrates that participants are sensitive to both the magnitude of, and delay to, reinforcement when these variables are manipulated in isolation. However, data from Phase 2 of both experiments demonstrates that these preferences may be affected by changes in the probability of negative reinforcement. As the probability to reinforcement decreased across Phases 2A (p = .75), 2B (p = .5/p = .25), and 2C (p = .25) of each experiment, a greater shift to the certain, though previously less preferred alternative, was observed.

Perhaps one of the most interesting aspects of the current data is the variety of within-session patterns of responding observed in Phase 2. While the global differences observed between phases in Experiments 1 and 2 were generally anticipated, these varied patterns of responding were not. It is reasonable to expect that participants would allocate a proportion of responses to each alternative in accordance with the probability contingency in place. For example, given a .75 probability of reinforcement for the highly preferred (immediate or long duration) alternative, three out of every four selections would be allocated to that alternative. That response allocation corresponds to reinforcement rate is, in fact, the underlying assumption of the Matching Law (Herrnstein, 1974).

While there are examples of participants allocating their responses in accordance with the probability of their reinforcement (e.g., 35M#1, Figure 8, left panel; 21F, Figure 18, left panel), most participants responded variably across the session and many allocated a greater proportion

of responses to the uncertain alternative as the session progressed (and presumably, they had a greater history with the contingencies).

Phases 2A and 2B of Experiment 1 are particularly interesting. In these phases participant response allocation was often variable. In Phase 2A some participants actually selected the preferred, immediate and less probable alternative more frequently than they had in Phase 1 (e.g., 23M1, Figure 6, right panel). During Phase 2B, rather than allocating a proportion of responses to both alternatives throughout the session, a number of participants selected the delayed alternative during a few trials early in the session and then allocated more responses to the immediate (uncertain) alternative near the end of the session. Examples include Participants 58F#2, 59F#1, and 60F1 (Figure 11, left, middle, and right panels, respectively). The within-session patterns of responding for participants in Phase 2C of Experiment 1 are more clearly differentiated as participants allocated a greater proportion of responses to the delayed, certain, and initially less preferred alternative.

The within-session patterns of responding in Experiment 2 (Figures 17-24) are interesting in that they are so different from Experiment 1. Participants allocated responses to both alternatives throughout the sessions (indicating variability in trial-by-trial responding), unlike Phases 2A and B of Experiment 1 in which participants allocated a proportion of responses to both alternatives early in the session then shifted to the uncertain alternative late in the session. The differences in patterns of responding during the two experiments indicate that probability of reinforcement interacts differently with magnitude than it does delay.

There are a variety of potential explanations for the within session patterns described here. Session length may have played a role as the pattern of responding for some participants stabilized late in the session. It is possible that the overall outcome regarding a preference shift

may have been different for these participants if session length were longer. For example, Participant 58F#2's (Figure 11) initial responding in Phase 2 was variable, then stabilized in the third trial block with all further responses allocated to the immediate (uncertain) alternative. The observed preference shift would have been unlikely given additional trial blocks.

Additionally, just as motivation seems to have a large role in whether or not a human responds impulsively in the laboratory, it is also likely to have a role in the within session patterns of responding. In the current study participants were contacting a baseline schedule of positive reinforcement while watching the movie and some of the variability could have been related to the events occurring within the movie. For instance, if the noise was playing over a loud action scene with minimal dialogue, the motivation to terminate the noise may have been lessened because it interrupted the movie less.

It is possible, too, that the specific noise parameters influenced within session patterns of responding. For instance, in Experiment 1, participants would have to experience at least 45 s of noise in order to switch from the immediate alternative to the delayed alternative (the 20 s noise period for the immediate alternative, plus the 5 s inter-trial interval, plus the 20 s delay for the delayed alternative). Once the participant switched the session would return to 20 s of noise on and 20 s off noise of plus an intertrial interval, but it may have been less aversive for some participants to risk forgoing a noise-free period in order to avoid the longer period of noise associated with switching.

These are just a few of the factors that may have influenced within session patterns of responding, and they should be systematically evaluated because the potential broader implications of this type of responding are significant. It is not difficult to imagine situations in which a person may forgo a certain reinforcer for a more highly preferred uncertain one, for

instance, while gambling. If individuals engaged in predictable, identifiable patterns of responding within these situations, it may be possible to develop better individualized and more effective cessation programs, for example.

Another unexpected, but interesting outcome related to participants' initial experience with the Phase 2 contingencies. The forced-choice experience differed for participants depending upon the outcome of the forced-choice trials within each session. For some participants in the current study, their experience with the forced-choice trials seemed to predict their later responding (e.g., those participants that experienced two unreinforced forced-choice trials in Phase 2 were more likely to demonstrate an immediate preference shift) indicating that characteristics of the forced-choice trials may be important independent variables. It is considered standard to expose participants to forced-choice trials in self-control studies (Madden & Johnson, 2010), however, it is possible that the number of forced-choice trials, as well as the specific events during the trials, may affect later responding.

In general, a greater shift in preference was observed for those participants who experienced at least one unreinforced forced-choice trial as compared to those who did not, and this effect was even more apparent for those who experienced two unreinforced trials. Given that forced-choice trials are a standard and efficient way to expose participants to the contingencies in place, it is important to understand their potential influence over responding within session (Madden & Johnson, 2010; Moore, 2010). Continued investigation of patterns of responding in relation to events during the forced-choice trials may have important methodological implications, not only for self-control research, but for any preparation in which they are utilized.

In addition to the previously discussed contributions, the current research also expands the self-control literature with novel methodological contributions. The most important contribution may be the within subjects manipulation utilized in Experiments 1 and 2. An investigation of changes in the behavior of the individual is at the center of behavior science, and yet studies of self-control in humans rarely include a within participant analysis. Of the previous studies utilizing negative reinforcement in a self-control paradigm, only one (MacAleese, 2009) includes a within participants manipulation. None of the previous research involving probability manipulations includes a within participants examination. The current study not only utilizes a within subjects manipulation, but it also demonstrates within subject behavior change. This is unique as well to studies utilizing negative reinforcement as the only other related study which included a within subjects manipulation (Flora et al, 1992) utilized positive reinforcement and did not produce changes in responding across phases. The choices a person makes are often considered to be a personality trait or aspects of one's character, though the current study demonstrates, yet again, that behavior is a product of the interaction of one's environment and history.

The apparatus and preparation constitute another contribution. The body of research utilizing negative reinforcement with humans in a self-control paradigm is very small. Yet, negative reinforcement seems to be much more reliable in evoking impulsive behavior in humans. The Replication Condition offers further evidence that humans are more likely to respond impulsively in negative reinforcement contingencies. Experiments 1 and 2 also provide contributions in the individual manipulation of delay and magnitude (the relevant variables in a self-control paradigm) in relation to probability. Past research has analyzed these variables

concurrently (King & Logue, 1992; Navarick, 1987; Rachlin et al 1987), potentially obscuring the role of each factor individually.

When considering impulsive behavior in the natural environment, the role of motivational variables seems obvious. The mere presence of sugary food can enhance the effectiveness of eating as a reinforcer while at the same time diminishing the reinforcing value of exercising (Forzano et al, 2010). It makes sense, then, to consider motivation when arranging a self-control paradigm, yet many studies fail to produce the impulsive responding that is so prevalent outside of the laboratory. It is possible that the preparations in previous research utilizing conditioned positive reinforcers fail to arrange effective motivating operations (MOs) (Laraway, Snycerski, Michael, & Poling, 2003) while the mere presence of an aversive stimulus establishes its removal as a reinforcer. Thus, those studies utilizing negative reinforcement may more effectively manipulate motivation in a way that is similar to events and contingencies in the natural environment.

In the current study the use of a preferred baseline schedule of positive reinforcement (viewing a movie) may have further enhanced motivation to terminate the noise. It also provides an additional contribution and suggests that when participants are faced with an engaging and preferred baseline task they may respond impulsively in the presence of aversive events. This begs the question of whether the converse is true, which is to ask, do humans respond in a self-controlled manner when engaged in an aversive or non-preferred baseline task and presented with aversive events? The results of Solnick's (1980) study and Experiment 3 of MacAleese (2009) suggest this is the case, though in Solnick's research, participants were given specific instructions and MacAleese's participants were watching less preferred videos (not necessarily an aversive baseline task). Future research might investigate this question more thoroughly

using an aversive baseline task and avoiding the confounds presented by providing specific instructions.

A further contribution regards the consistency of the data both with studies of self-control and probability using positive reinforcement as well as with the predictions drawn from the probability discounting literature. Specifically, past research suggests that when probability and positive reinforcement are manipulated, preference for a larger reinforcer that decreases in certainty will shift to a smaller, more certain reinforcer (e.g., Green & Myerson, 2010; King & Logue, 1992; Rachlin et al., 1987). As predicted, the current data demonstrate a similar shift in preference while manipulating probability and negative reinforcement.

For example, in Experiment 1 the magnitude of both alternatives was consistent; therefore, the participant could shift from the immediate to the delayed alternative and still contact the same magnitude of reinforcement. If, in this case, the delayed alternative is analogous to the "smaller" alternative (as the "smaller" alternative is typically also the "less preferred" alternative) and the immediate alternative is analogous to the "larger" alternative (as the "larger" alternative is typically also the "more preferred" alternative), then participant responding shifted from the larger alternative to the smaller alternative as the probability of reinforcement for the larger alternative decreased. Experiment 2 offers an even more salient example as both alternatives varied in magnitude. In both conditions of Phase 2 participants shifted their responding to the certain, but smaller alternative as the probability of reinforcement for the larger alternative decreased.

While the current study provides a number of contributions, it also includes some limitations as well as directions for future research. For instance, the study did not include a formal preference assessment, but only asked participants to select the movie they would most

like to watch. While it is likely that participants selected their most preferred movie of the options available, it is possible that none of the options would rank as highly preferred for some individuals. Also, six participants selected movies they had not viewed previously (see Table 8) and it is unlikely that these movies were highly preferred for these individuals. Given the implied role of motivational variables in choices regarding the delay, magnitude, and probability of reinforcement, future research should more thoroughly assess and manipulate motivational variables in order to better understand how they interact with probability of reinforcement in a self-control paradigm.

The experimental apparatus represents an important part of any study and the collection of reliable data is dependent upon a reliable apparatus. A variety of steps were taken to ensure continued proper functioning of the computer program throughout the course of the current experiments. The experimenter piloted sessions in each experimental condition at least five, and up to eight, times prior to the initiation of the study and continued to sample the conditions repeatedly throughout the duration of data collection. The experimenter also timed and tracked the presentation of the noise for a period of at least five minutes during each of the three sessions for all participants from outside the door of the session room. During this time the program functioned as expected except in instances of user error, for example in preparing the Replication Condition session for Participant 30F1 in which the data were not recorded. Still, that eight participants reported on question 4 of the Questionnaire (Appendix E) that the buttons had appeared in the absence of the noise at least one time, while the data recorded by the program indicated proper functioning, is a limitation. Future investigations might more closely monitor the functioning of the apparatus in order to determine conclusively that the apparatus functions as described.

While the experimental manipulations are meant to be a controlled influence over participant responding, uncontrolled factors can also influence participants. One such factor in the current study was how well oriented an individual was to the Information Sheet. This sheet included important information regarding where the buttons appeared on the screens as well as general information about the forced-choice trials (see Appendix A). In general, the experimenter read the information sheet (Appendix A) to participants. However, in order to assess any effect that this may have had on participants' subsequent responding, some participants read the instructions independently and are denoted by a (#) in the participant code (see Appendix B). Results for those participants who read the information sheet independently are similar to those participants who heard it read aloud. Still, future research might investigate the effects of participants reading instructions independently versus hearing them read aloud as it may impact whether or not the individual is oriented to the important aspects of the study which are described within those instructions.

The results of the current studies imply that choice responses, at least as they relate to the delay to and magnitude of reinforcement, may be a function of the probability of reinforcement for the more highly preferred alternative. Future research might include continued parametric investigations of probability values in relation to the variables of delay and magnitude, and also investigations of various delay and magnitude manipulations. For instance, it is possible that if the duration of noise in Experiment 1 had been longer, the data for Phase 2A may have included a preference shift for more participants. And while the investigation of probability of reinforcement in relation to magnitude and delay individually is important, it is only a step in understanding the broader question, which is, how does the probability of reinforcement affect

choices in an actual self-control paradigm (e.g., one that involves a choice between smaller-sooner and larger-later alternatives)?

Previous research has suggested that the probability of reinforcement can influence responding of individuals in a self-control paradigm under some conditions (King & Logue, 1987; Navarick, 1992; Rachlin et al 1987), though it has not been investigated in a paradigm utilizing negative reinforcement in the presence of a preferred baseline activity (which has been demonstrated to evoke impulsive, hence more natural, responding). The applied implications of investigations of these three variables are far-reaching when it comes to altering how individuals make choices. Future investigation might examine the probability values at which individuals are most likely to differentiate responding entirely within a self-control paradigm. Participants in the .25 probability conditions for both Experiments 1 and 2 (Conditions C and B respectively) of the current study generally demonstrated greater differentiation in responding than those participants in the conditions that included a higher probability of reinforcement for the preferred (immediate or larger) reinforcer indicating that this may be an appropriate point at which to begin the investigation.

Understanding the conditions under which a person will stop selecting a preferred alternative and shift responding to a less preferred alternative due to the probability of reinforcement for the former could be useful in addressing problematic behaviors such as smoking and drinking. For example, perhaps individuals attempting smoking cessation could purchase packages of cigarettes that contained only a few, randomly placed, cigarettes with nicotine. If the probability of reinforcement by means of withdrawal symptom reduction were quite low, perhaps individuals would forgo smoking altogether.

The current study has implications for the roles of delay and magnitude as they relate to reinforcement in choice behavior. Delay is often considered to have a greater influence on behavior than magnitude. This is essentially the root of the self-control paradigm – the selection of an immediate (or sooner), but small reinforcer over a large, delayed one. The current data indicate that probability may be a more important factor. In each of the current experiments responding shifted such that participants were likely to contact some amount of reinforcement, rather than none at all. That is to say, they were more likely to select a certain reinforcer, although delayed (Experiment 1) or small in magnitude (Experiment 2), rather than an uncertain immediate or larger reinforcer.

It has been suggested that the propensity for impulsivity was selected because an available reinforcer, even a small one, was better than a large reinforcer that fails to become available (Fawcett et al 2012). Further, it has been suggested that probability functions as a discriminative stimulus for delay (i.e., they are functionally equivalent) (Rachlin et al, 1987). The current data support the first assumption, which is to say that any reinforcement is better than no reinforcement. This is especially apparent in Experiment 2 where participants selected the certain, small magnitude reinforcer over the previously preferred, but uncertain, large magnitude reinforcer. It is unclear as to whether the data support the second assumption. The data from Experiment 1 suggest that delay and probability interact. When the probability of reinforcement was 1.0 then delay to reinforcement influenced behavior (participants selected the immediate alternative). When the probability of reinforcement was less than 1.0, delay seemed to have less influence over responding as participants allocated a portion of their responses to the delayed alternative. However, if we consider probability and delay to be functionally equivalent then reducing the probability of reinforcement was equivalent to increasing the delay. Future

investigation of these variables should include manipulations such as reducing the probability of reinforcement for one alternative while increasing the delay for the other alternative by an equivalent amount (determined for instance, by adding the average number of seconds to the delayed alternative that would be experienced if only the probabilistic alternative were selected).

There are very few investigations of the impact of probability in the self-control literature. The data from the current study indicate that the probability of reinforcement is an important factor in human choice. As a result, this study offers important contributions to the investigation of these factors. The results of the current study also extend the already extensive probability discounting literature. While the probability discounting literature examines the effects of probability in relation to magnitude, it focuses on answers to hypothetical questions rather than actual responses to the hypothetical contingencies described. This study addresses these issues by manipulating probability, delay, and magnitude in a basic experimental preparation. The utilization of a baseline schedule of positive reinforcement as well as negative reinforcement offers a further methodological contribution.

The results of the current study have implications for future research in self-control as well as for applications in the natural environment. Probability as it relates to reinforcement in choice situations for humans remains relatively unexamined, yet appears to be an important variable. All organisms live in an environment that is more certain in the short-term than in the long-term. Short-term survival, remaining alive until an opportunity to procreate becomes available, is particularly valuable to these organisms. While short-term survival is also highly important for humans, the characteristics of the environment which select "impulsive" behavior are often detrimental in the long-term. A smoker is not guaranteed to develop lung cancer by quitting (avoidance of which would be a large, delayed, uncertain reinforcer), but is guaranteed

to avoid momentary aversive physical and psychological conditions by smoking (a smaller, immediate, certain reinforcer). Similarly, an overeater is not guaranteed to develop diabetes, but is guaranteed to avoid momentary aversive conditions by eating. Individuals who compulsively gamble, abuse drugs, spend beyond their means, and procrastinate offer even more examples.

Humans live well into the uncertain future, generally without immediate threats to survival, and responding solely for reinforcers in the moment can bring more harm than good. In addition to the individual costs described above, the impulsive behavior of individuals (e.g., overeating, smoking, poor fiscal planning, etc.) can have a harmful impact on society (e.g., higher healthcare costs, higher social welfare costs, etc.). Understanding the variables that impact human choice behavior has important applied implications for the well-being of individuals and the societies in which they live.

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Appendix A

Information sheet given to and discussed with participants upon arrival to the experimental setting.

UNIVERSITY OF NEVADA, RENO SOCIAL BEHAVIORAL INSTITUTIONAL REVIEW BOARD

RESEARCH STUDY INFORMATION SHEET

TITLE OF STUDY: Factors Influencing Choice

INVESTIGATOR(S): Patrick M. Ghezzi, Ph.D., BCBA-D, LBA (775) 682-8687
Jennifer Bonow, M.A., BCBA, LBA (775) 530-1154

PROTOCOL #:

SPONSOR:

PURPOSE

You are being asked to participate in a research study. The purpose of this study is to examine how people will choose to turn off noise. More specifically, how people will choose to turn off noise given two different choices. This will occur while watching a preferred DVD. This study is seeking to understand how people behave when they are presented with something that is not preferred.

PARTICIPANTS

You are being asked to participate because you are a UNR undergraduate student, over the age of 18, can use a mouse, have hearing within the normal range, and are registered for a psychology course and are eligible to receive extra credit for research participation. The total enrollment in this study is expected to be 25-40 participants.

PROCEDURES

If you choose to participate in this study, you should plan on a time commitment of approximately 100 minutes to complete a session. During this experiment you will watch a DVD of your choosing, from a provided list. While you are watching the DVD noise will periodically occur which you can turn off by clicking on either of two available buttons that will appear on the screen (the buttons will not block any of the DVD screen). During the first several presentations of noise you will be told which button to press and then later no instructions will appear and you can choose which button to click on to turn off the noise. You will get two brief breaks, one after approximately 30 minutes, and a second approximately 25 minutes later. You will stay in the experimental room during these breaks. After the third period (approximately 25 minutes after the second break) the experimenter will stop the DVD and you will be asked to complete a brief survey before leaving. Please leave any devices that can tell time, including watches, cell phones, palm pilots and so on, as well as your personal belongings with the experimenter. In addition, once the session starts please remain seated, unless you decide you

do not want to finish the experiment, in which case you can leave at any time. Once the session is complete, you will be debriefed regarding the procedures and findings.

DISCOMFORTS, INCONVENIENCES, AND/OR RISKS

During your participation in this study you may be annoyed upon the presentation of noise while you are watching the DVD. However, we do not anticipate that these feelings will have a lasting effect. It is possible that there are unknown or unforeseen risks with participation in this study.

Your privacy will be protected at all times. In addition, you will not be identified in any way for your participation in this study.

BENEFITS

There may be no direct benefits to you as a participant in this study.

CONFIDENTIALITY

Your identity will be protected to the extent allowed by law. You will not be personally identified in any reports or publications that may result from this study.

The Department of Health and Human Service (HHS), other federal agencies as necessary, and the University of Nevada, Reno Social Behavioral Institutional Review Board may inspect your study records.

You will only meet with the co-investigator or a research assistant when participating in a session. No personal information, including your name, will be collected. Data from your session will be stored using an alpha-numeric code that does not include any identifying information. Data will be stored in an encrypted file on a password protected flash drive. These data will be stored indefinitely.

COSTS/COMPENSATION

There will be no cost to you for participating in this research study. You will receive Psychology Experience Credits (PECs) as follows: 0-60 minutes equals 2 credit, 61-120 minutes equals 4 credits and so on.

DISCLOSURE OF FINANCIAL INTERESTS

The researchers have no financial interests regarding this study.

RIGHT TO REFUSE OR WITHDRAW

You may refuse to participate or withdraw from the study at any time. However, if you withdraw before completing the study you will be awarded PECs in full-credit increments according to the time you have spent participating in the study according to the subject pool policies.

QUESTIONS

If you have questions about this study, please ask now. Or, if you have questions in the future or wish to report a research-related injury, please contact Patrick M. Ghezzi, Ph.D. at (775) 682-8687 or Jennifer Bonow at (775) 530-1154 at any time.

You may ask about your rights as a research subject or you may report (anonymously if you so choose) any comments, concern, or complaints to the University of Nevada, Reno Social Behavioral Institutional Review Board, telephone number (775) 327-2368, or by addressing a letter to the Chair of the Board, c/o UNR Office of Human Research Protection, 205 Ross Hall / 331, University of Nevada, Reno, Reno, Nevada, 89557.

Appendix B

Method for determining participant codes.

Participant codes include a variety of information about the participant and the experimental conditions the participant experienced. Participants were assigned numbers in chronological order as indicated by the first number in the participant code. The number is followed by an "M," or "F," indicating whether the participant was male or female. A number sign indicates that the participant read the information sheet independently, while the absence of this symbol indicates that the experimenter read the information sheet aloud. The final number indicates how many unreinforced trials occurred during the forced-choice trials portion of the Phase 2 condition the participant experienced. The absence of a number indicates that all forced-choice trials were reinforced during Phase 2.

Examples

21F: 21st participant, female, experimenter read the information sheet aloud, all forced-choice trials in Phase 2 were reinforced.
35M#1: 35th participant, male, read the information sheet independently, 1 unreinforced trial during the forced-choice trials portion of Phase 2.

Appendix C

Debriefing sheet given to and discussed with participants after experimental sessions.

UNIVERSITY OF NEVDA, RENO
RESEARCH STUDY DEBRIEFING SHEET

TITLE OF STUDY: Factors Influencing Choice
INVESTIGATORS: Patrick M. Ghezzi, Ph.D., BCBA (775) 682-8687
Jennifer Bonow (775) 530-1154
PROTOCOL NUMBER:

PURPOSE
The purpose of this study was to examine how people respond, either in a self-controlled or impulsive manner, when presented with noise while engaging in a preferred activity. This study also examined the differences in responding when particular options were available at a probability of less than 1. This study is attempting to identify and understand another variable that is often present for individuals who are faced with conditions that are unpleasant and replicate this in an analog setting. Examining variables, such as probability, when dealing with self-control may help to improve what is known about the conditions present for individuals who have difficulty in behaving in a self-controlled manner.

You were exposed to 3 conditions. In one condition one button corresponded with an impulsive choice because while the noise would turn off sooner, it also would come back on sooner. The other button was the self-controlled option because it would not come on as frequently if you could withstand the presence of the noise for a longer period of time. In a second condition one button either turned the noise off immediately or for longer period of time and the other button either turned the noise of after a delay or for a shorter period of time. Finally, during one condition the button associated with either immediate or larger removal of the noise worked with a probability of less than 1 (either .25 or .75).

BENEFITS
There may be no direct benefits from participating in this study other than research credits.

CONFIDENTIALITY
Your identity will be protected to the extent allowed by law. No personal or identifying information has been collected and you will not be personally identified in any reports or publications that may result from this study. Data from your session will be stored using an alpha-numeric code that does not include any identifying information. Data will be stored in an encrypted file on a password protected flash drive. These data will be stored indefinitely.

The Department of Health and Human Service (HHS), other federal agencies as necessary, the University of Nevada, Reno Social Behavioral Institutional Review Board may inspect your study records.

COSTS / COMPENSATION
There will be no cost to you for participation in this study. You will receive Psychology Experience Credits (PECs) as follows: 0-60 minutes equals 2 credit, 61-120 minutes equals 4 credits and so on.

QUESTIONS

If you have any additional questions please ask now. If you have additional questions later, contact Patrick M. Ghezzi, Ph.D. at (775) 682-8687 or Jennifer Bonow at (775) 530-1154.

You may ask about your rights as a human subject or you may report (anonymously if you so choose) any comments, concerns, or complaints to the University of Nevada, Reno Social Behavioral Institutional Review Board, telephone number 775-327-2368, or by addressing a letter to the Chair of the Board, c/o Office of Human Research Protection, 205 Ross Hall/331, University of Nevada, Reno; Reno, Nevada 89557.

Appendix D

Menu from which participants selected a DVD to view during the experimental session.

Love Actually
Wedding Crashers
Pirates of the Caribbean
Zoolander
Spiderman
Shrek
Shrek 2
Shrek the Third
Alice in Wonderland
Finding Nemo
Charlie and the Chocolate Factory
The Pursuit of Happyness
Garden State
Across the Universe
American Beauty
The Fantastic Mr. Fox
Dirty Dancing
Inception
Super 8
Superbad
Meet the Parents
Meet the Fockers
The Princess Bride
Young Frankenstein
Mary Poppins
Up
Toy Story
Toy Story 2
Toy Story 3
Casino Royale
Beauty and the Beast
Office Space
Pulp Fiction
Harry Potter and the Sorcerer's Stone
Harry Potter and the Chamber of Secrets
Harry Potter and the Prisoner of Azkaban
Harry Potter and the Goblet of Fire
Harry Potter and the Order of the Phoenix
Harry Potter and the Deathly Hallows Part 1
The Bourne Identity
The Prestige
The Wedding Singer
Pan's Labyrinth

Appendix E

Exit Questionnaire completed by participants following the final condition of the experiment.

Questionnaire

1. Explain what happened in the first part of the study (i.e., how did the buttons control the noise?).

2. Explain what happened in the second part of the study (i.e., how did the buttons control the noise?).

3. Explain what happened in the third part of the study (i.e., how did the buttons control the noise?).

4. Did the buttons ever appear while the noise was off?

5. How did you feel when the noise was on?

6. How many times have you seen this movie in the past?

7. Did you like this movie?

8. Is there anything else you'd like to add?

Table 1

Participant distribution across experiments.

	Experiment 1				Experiment 2		
	Phase 1 (p = 1.0)	Phase 2 A (p = .75)	Phase 2 B (p = .5)	Phase 2 C (p = .25)	Phase 1 (p = 1.0)	Phase 2 A (p = .75)	Phase 2 B (p = .25)
Male	13	8	3	2	12	6	6
Female	14	3	4	7	10	5	5
Total	27	11	6	10	22	11	11

Table 2

Session characteristics per participant for Experiment 1.

		Replication Condition				Experiment 1							
							Phase 1			Phase 2			
			No. trials				No. trials				No. trials		
Participant	Info. Sheet read aloud	Impulsive button	Impulsive	Total	Mean latency	Immediate button	Immediate	Total	Mean latency	Condition	Immediate	Total	Mean latency
04F2	Y	Right	5	5	2.72	Left	22	22	3.01	C	0	22	2.99
07F	Y	Left	4	5	2.78	Right	22	22	1.72	A	22	22	1.89
08F1	Y	Right	5	5	1.72	Left	22	22	1.7	C	1	21	1.73
12M#1	N	Left	4	5	2.96	Right	22	26	1.94	A	26	27	1.29
14F#2	N	Left	4	5	2.92	Left	26	26	2.43	C	14	25	3.7
15M#2	N	Right	4	5	1.08	Left	14	23	8.52	C	22	26	1.51
23M1	Y	Left	3	5	3.56	Right	6	21	15.54	A	18	23	6.53
25M	Y	Right	3	5	2.88	Right	26	27	1.13	A	18	25	1.26
26F2	Y	Left	5	5	1.9	Left	19	26	1.79	C	3	27	1.19
28F2	Y	Left	5	5	9.8	Right	26	26	1.85	C	0	26	1.76
29F#2	N	Right	5	5	3.42	Left	16	26	2.62	C	8	26	2.6
31M	Y	Right	5	5	3.22	Left	18	25	4.03	A	20	26	2.39
32F	Y	Left	5	5	1.76	Left	26	26	1.32	A	23	26	1.46
35M#1	N	Right	5	5	2.08	Right	26	26	1.9	A	19	27	1.68
36M	Y	Left	0	5	2.82	Left	10	26	1.74	A	11	25	3.11
39F2	Y	Left	5	5	1.94	Right	27	27	1.39	C	23	27	1.81
40M	Y	Right	3	3	3.27	Right	26	26	1.78	A	22	25	1.63
41M#1	N	Right	3	5	2.28	Left	16	26	2.42	A	24	27	1.77
44F#2	N	Right	5	5	2.24	Right	26	26	1.71	A	0	26	1.73
46M1	Y	Right	5	5	2.8	Left	26	26	1.48	C	9	26	1.89
48F1	Y	Left	5	5	4.42	Right	25	26	1.94	C	13	26	2.31
55F1	Y	Right	5	5	3.06	Left	26	26	2.78	B	22	25	4.82
56M1	Y	Left	2	5	3.58	Left	26	26	2.07	B	23	27	1.89
57M1	Y	Right	4	5	2.24	Left	21	25	2.78	B	14	26	3.02
58F#2	N	Right	5	5	1.32	Left	26	26	1.43	B	21	26	2.04
59F#1	N	Left	4	5	2.38	Left	24	26	1.24	B	26	27	1.72
60F1	Y	Right	5	5	3.12	Left	26	26	1.75	B	21	26	1.95

Table 3

Session characteristics per participant for Experiment 2.

		Replication Condition				Experiment 2							
							Phase 1				Phase 2		
			No. trials				No. trials				No. trials		
Participant	Info. Sheet read aloud	Impulsive button	Impulsive	Total	Mean latency	Long duration button	Long duration	Total	Mean latency	Condition	Long duration	Total	Mean latency
05F	Yes	Right	4	5	2.7	Left	19	26	1.52	A	19	26	1.65
09F	Yes	Right	1	5	4.16	Left	19	23	2.53	A	19	21	1.91
10F2	Yes	Right	3	5	1.42	Left	23	23	1.65	B	23	22	2.24
16M#1	No	Right	5	5	3.54	Left	18	24	1.97	B	18	26	2.34
17M2	Yes	Right	4	5	3.26	Left	25	26	1.52	B	25	26	1.74
18M1	Yes	Left	4	5	2.38	Left	25	26	1.6	A	25	26	2.75
20F2	Yes	Right	5	5	2.04	Right	19	26	1.99	B	19	27	1.88
21F	Yes	Left	4	5	2.58	Left	27	27	0.82	A	27	26	1.9
24F1	Yes	Right	5	5	2.06	Right	24	26	2.16	B	24	26	1.6
27F#2	No	Left	5	5	2.4	Left	25	26	1.73	A	25	25	4.01
30F#1	No					Left	26	26	2.33	B	26	26	1.26
33F#1	No	Left	4	5	2.34	Right	18	26	1.23	B	18	27	1.13
34M#	No	Right	4	5	3.56	Left	27	27	0.62	A	27	26	0.98
37M2	Yes	Right	5	5	1.68	Right	20	26	1.39	B	20	25	3.69
38M#1	No	Left	5	5	3.86	Right	23	26	2.12	A	23	26	2.33
43M2	Yes	Left	5	5	2.8	Left	21	26	1.57	B	21	25	2.28
45M2	Yes	Left	0	5	5.2	Right	24	26	2.24	B	24	25	3.38
49M1	Yes	Left	5	5	1	Right	25	26	1.2	A	25	27	1.35
50M	Yes	Right	5	5	2.68	Left	21	26	1.66	A	21	26	1.7
51F	Yes	Right	4	5	2.86	Right	26	26	1.13	A	26	25	1.44
52M1	Yes	Left	5	5	2.3	Left	20	26	1.5	A	20	26	3.08
54M1	Yes	Left	1	5	2.76	Left	19	26	2.13	B	19	25	1.72

Table 4

Mean selection characteristics for Experiments 1 and 2.

	Experiment 1				Experiment 2		
	Phase 1 (p = 1.0)	Phase 2 A (p = .75)	Phase 2 B (p = .5)	Phase 2 C (p = .25)	Phase 1 (p = 1.0)	Phase 2 A (p = .75)	Phase 2 B (p = .25)
No. trials	25 (21-27)	25 (22-27)	26 (25-27)	25 (21-27)	25 (23-27)	25 (21-27)	25 (22-27)
% Probabilistic Alternative	87 (28.57-100)	73 (0-100)	81 (53.85-96.3)	36 (0-85)	87 (69.23-100)	53 (0-100)	54 (0-84.62)
Latency (s)	2.82 (1.24-15.54)	2.23 (1.26-6.53)	2.6 (1.72-4.82)	2.1 (1.19-3.7)	1.63 (.62-2.53)	2.17 (.98-3.08)	2.1 (1.13-3.69)

Table 5

Phase 2 details per participant for Experiment 1.

Participant	Condition	No. Unreinforced Trials		Immediate Alternative	Preference Shift
		Forced Choice	Free Choice		
07F	A	0	7	22	No
12M#1	A	1	6	22	No
23M1	A	1	5	6	Yes
25M	A	0	6	26	Yes
31M	A	0	6	18	Yes
32F	A	0	5	26	No
35M#1	A	1	5	26	No
36M	A	0	6	10	Yes
40M	A	0	3	26	No
41M#1	A	1	4	16	Yes
44F#2	A	2	NA	26	Yes
55F1	B	1	11	26	Yes
56M1	B	1	14	26	Yes
57M1	B	1	6	21	Yes
58F#2	B	2	12	26	Yes
59F#1	B	1	17	24	No
60F1	B	1	8	26	Yes
04F2	C	2	NA	22	No
08F1	C	1	1	22	Yes
14F#2	C	2	10	26	Yes
15M#2	C	2	14	14	No
26F2	C	2	3	19	Yes
28F2	C	2	NA	26	Yes
29F#2	C	2	6	16	Yes
39F2	C	2	15	27	Yes
46M1	C	1	7	26	N o
48F1	C	1	11	25	Yes

Note. NA = the participant did not select the immediate alternative during the session.

Table 6

Phase 2 details per participant for Experiment 2.

Participant	Condition	No. Unreinforced Trials		Long Duration Alternative	Preference Shift
		Forced Choice	Free Choice		
05F1	A	1	NA	19	Yes
09F	A	0	3	19	Yes
18M1	A	1	3	25	Yes
21F	A	0	6	27	Yes
27F#2	A	2	1	25	Yes
34M#	A	0	3	27	Yes
38M#1	A	1	2	23	Yes
49M1	A	1	7	25	No
50M	A	0	3	21	No
51F	A	0	4	26	Yes
52M1	A	1	5	20	Yes
10F2	B	2	NA	23	Yes
16M#1	B	1	15	18	No
17M2	B	2	1	25	Yes
20F2	B	2	7	19	Yes
24F1	B	1	2	24	Yes
30F#1	B	1	6	26	Yes
33F#1	B	1	2	18	Yes
37M2	B	2	11	20	Yes
43M2	B	2	1	21	Yes
45M2	B	2	2	24	Yes
54M1	B	1	6	19	Yes

Note. NA = the participant did not select the immediate alternative during the session.

Table 7

Participant responses to Questionnaire questions 1-3, 5, and 8. Continues onto the next page.

		Contingency Description								
		RC[a]		Phase 1[b]		Phase 2[c]				
Participant.	Experiment	Mag.	Delay	Mag.	Delay	Mag.	Delay	Prob.	Emotional Reaction[d]	Comments[e]
07F	1A (p = .75)	NA	P	NA	P	P	P	NA	Annoyed	I might have #1 &2 backwards. I wanted to see what the other button would do, but it wasn't worth having the noise come back on.
12M#1	1A (p = .75)	NA	A	NA	I	NA	P	I	Annoyed	None
23M1	1A (p = .75)	NA	I	NA	I	NA	I	P	Angry	No
25M	1A (p = .75)	NA	A	NA	A	NA	A	P	Annoyed	Noise wouldn't have been as bad if it was easier to hear the movie.
31M	1A (p = .75)	NA	I	NA	I	NA	NA	P	Distracted	N/A
32F	1A (p = .75)	NA	A	NA	A	NA	P	I	Annoyed	No thank you.
35M#1	1A (p = .75)	NA	A	NA	A	NA	A	P	Annoyed	This experiment was interesting and I enjoyed participating.
36M	1A (p = .75)	NA	A	NA	P	NA	I	NA	Annoyed, aggravated	No comment.
40M	1A (p = .75)	NA	P	NA	P	NA	P	A	Annoyed	It was kind of annoying when the black button didn't turn off the noise like usual.
41M#1	1A (p = .75)	NA	A	NA	P	NA	P	P	Annoyed	N/A
44F#2	1A (p = .75)	NA	A	NA	A	NA	P	I	Annoyed	No
55F1	1B (p = .5)	NA	I	NA	I	NA	I	A	Annoyed	No
56M1	1B (p = .5)	NA	I	NA	I	NA	I	P	Distracted	No
57M1	1B (p = .5)	NA	I	NA	P	NA	P	I	Distracted	NA
58F#2	1B (p = .5)	NA	A	NA	A	NA	A	P	Annoyed	NA
59f#1	1B (p = .5)	P	NA	NA	I	NA	I	NA	Irritated	No
60F1	1B (p = .5)	NA	P	NA	P	NA	I	I	Annoyed, distracted	No
04F2	1C (p = .25)	P	P	P	P	NA	P	NA	Didn't notice it	I learned that I tune out noises after a period of time.
08F1	1C (p = .25)	NA	A	NA	A	NA	I	NA	Annoyed	NA
14F#2	1C (p = .25)	NA	I	NA	I	NA	I	NA	Irritated	No

Table 7, continued. Continues onto the next page.

		Contingency Description								
		RC[a]		Phase 1[b]		Phase 2[c]				
Participant.	Experiment	Mag.	Delay	Mag.	Delay	Mag.	Delay	Prob.	Emotional Reaction[d]	Comments[e]
15M#2	1C (p = .25)	NA	A	NA	A	NA	I	I	Angry	No
26F2	1C (p = .25)	NA	P	NA	P	NA	P	NA	Ignored the sound	No
28F2	1C (p = .25)	NA	A	NA	P	NA	I	NA	Annoyed	No
29F#	1C (p = .25)	NA	P	NA	I	NA	I	NA	Irritated, distracted	Nope
39F	1C (p = .25)	NA	A	NA	P	NA	P	P	Annoyed	No
46M1	1C (p = .25)	NA	A	NA	A	NA	P	P	Distracted	No
48F1	1C (p = .25)	NA	I	NA	I	NA	I	NA	Annoyed	The noise ruined the movie.
05F	2A (p = .75)	NA	P	NA	A	NA	I	NA	Annoyed	NA
18M1	2A (p = .75)	A	A	P	P	NA	NA	P	Irritated	It was a fun experiment. Confusing, but fun.
21F	2A (p = .75)	NA	P	NA	P	NA	NA	P	Annoyed	NA
27F#2	2A (p = .75)	NA	P	NA	P	NA	P	NA	Annoyed	NA
34M#	2A (p = .75)	NA	P	A	P	A	P	I	It sucked	My ears hurt.
38M#1	2A (p = .75)	NA	P	A	P	NA	P	NA	Annoyed	Nope
49M1	2A (p = .75)	NA	P	P	P	P	P	A	Minor nuisance	I would like to know the attentional implications of the study…choice? Or immediate reinforcement vs. delayed?
50M	2A (p = .75)	P	P	P	NA	P	NA	I	Discomforted, annoyed	NA
51F	2A (p = .75)	NA	P	I	I	NA	I	NA	Annoyed, frustrated	No
52M1	2A (p = .75)	NA	A	A	P	NA	NA	I	Very bothered	Great experiment demonstrating the capacity to which the human mind will tolerate sounds.
09F	2B (p = .25)	P	P	I	I	P	P	NA	Irritated	No
10F2	2B (p = .25)	NA	P	NA	I	NA	I	NA	Annoyed	NA
16M#1	2B (p = .25)	P	P	A	P	A	P	P	Annoyed	No
17M2	2B (p = .25)	NA	P	NA	NA	I	I	P	annoyed	Definitely the most distracted I've ever been watching a move.
20F2	2B (p = .25)	P	NA	P	NA	P	NA	NA	Irritated, annoyed	I noticed a definite change in my mood (negatively) when the noise was present.

Table 7, continued.

		Contingency Description								
		RC[a]		Phase 1[b]		Phase 2[c]				
Participant.	Experiment	Mag.	Delay	Mag.	Delay	Mag.	Delay	Prob.	Emotional Reaction[d]	Comments[e]
24F1	2B (p = .25)	NA	NA	I	NA	I	NA	I	Annoyed	No
30F#1	2B (p = .25)			NA	NA	NA	NA	I	Annoyed	No
33F#1	2B (p = .25)	I	NA	I	NA	NA	I	NA	Annoyed	No
37M2	2B (p = .25)	P	NA	A	P	P	P	P	Distracted	NA
43M2	2B (p = .25)	NA	P	P	NA	NA	P	I	Annoyed	No
45M2	2B (p = .25)	P	NA	P	I	P	NA	I	Distracted	NA
54M1	2B (p = .25)	NA	I	NA	I	I	I	NA	Annoyed	No

Note. RC = Replication Condition; A = accurate; P = partially accurate; I = inaccurate; NA = no answer given.
[a]Responses to question 1. [b]Responses to question 2. [c]Responses to question 3. [d]Responses to question 5. [e]Responses to question 8.

Table 8

Participant responses to Questionnaire questions 6 and 7.

Participant	Movie Title	No. Times Viewed[a]	Enjoyed Movie[b]
04F2	Disney`s Up	0	Yes
05F	Love Actually	2	yes
07F	Superbad	2	Yes
08F1	Big Bang Theory	0	Yes
09F	Wedding Singer	Many	yes
10F2	Disney`s Up	4-5	yes
12M#1	Super 8	0	Somewhat
14F#2	Love Actually	1	Yes
15M#2	Super 8	1	Yes
16M#1	Casino Royale	2	yes
17M2	Super 8	1	yes
18M1	The Pursuit of Happiness	Countless	yes
20F2	Up	4-5	Yes
21F	The Prestige	>12	yes
23M1	Casino Royale	1	Yes
24F1	Super Bad	3	yes
25M	Pirates of the Caribbean	Many	Yes
26F2	Finding Nemo	~ 6	Yes
27F#2	Young Frankenstein	~ 5	Yes
28F2	Casino Royale	10	Yes
29F#	The Princess Bride	~ 10	Yes
30F#1	Across the Universe	10	Yes
31M	Wedding Crashers	3	Yes
32F	The Wedding Singer	~ 3	Yes
33F#1	Garden State	6	Yes
34M#	The Bourne Identity	Many	Yes
35M#1	Inception	2	Yes
36M	Office Space	~ 3	Yes
37M2	Zoolander	3-4	Yes
38M#1	Inception	4-5	Yes
39F	Super Bad	1	Yes
40M	Inception	2	No, because of noise
41M#1	Meet the Parents	0	Yes
43M2	Office Space	0	Yes
44F#2	Disney`s Up	~ 5	Yes
45M2	Pulp Fiction	1	Yes
46M1	Inception	1-2	Yes
48F1	Disney`s Up	<3	Yes
49M1	Pulp Fiction	2-3	Yes
50M	Office Space	3	Yes
51F	SuperBad	2-3	Yes
52M1	Young Frankenstein	0	Yes
54M1	Zoolander	1-2	Yes
55F1	Wedding Crashers	2	Yes
56M1	Wedding Crashers	10-15	Yes
57M1	Inception	4	Yes
58F#2	Across the Universe	3-4	Yes
59f#1	Wedding Crashers	1	Yes
60F1	The Wedding Singer	3-4	Yes

Note. [a]Responses to question 6. [b]Responses to question 7.

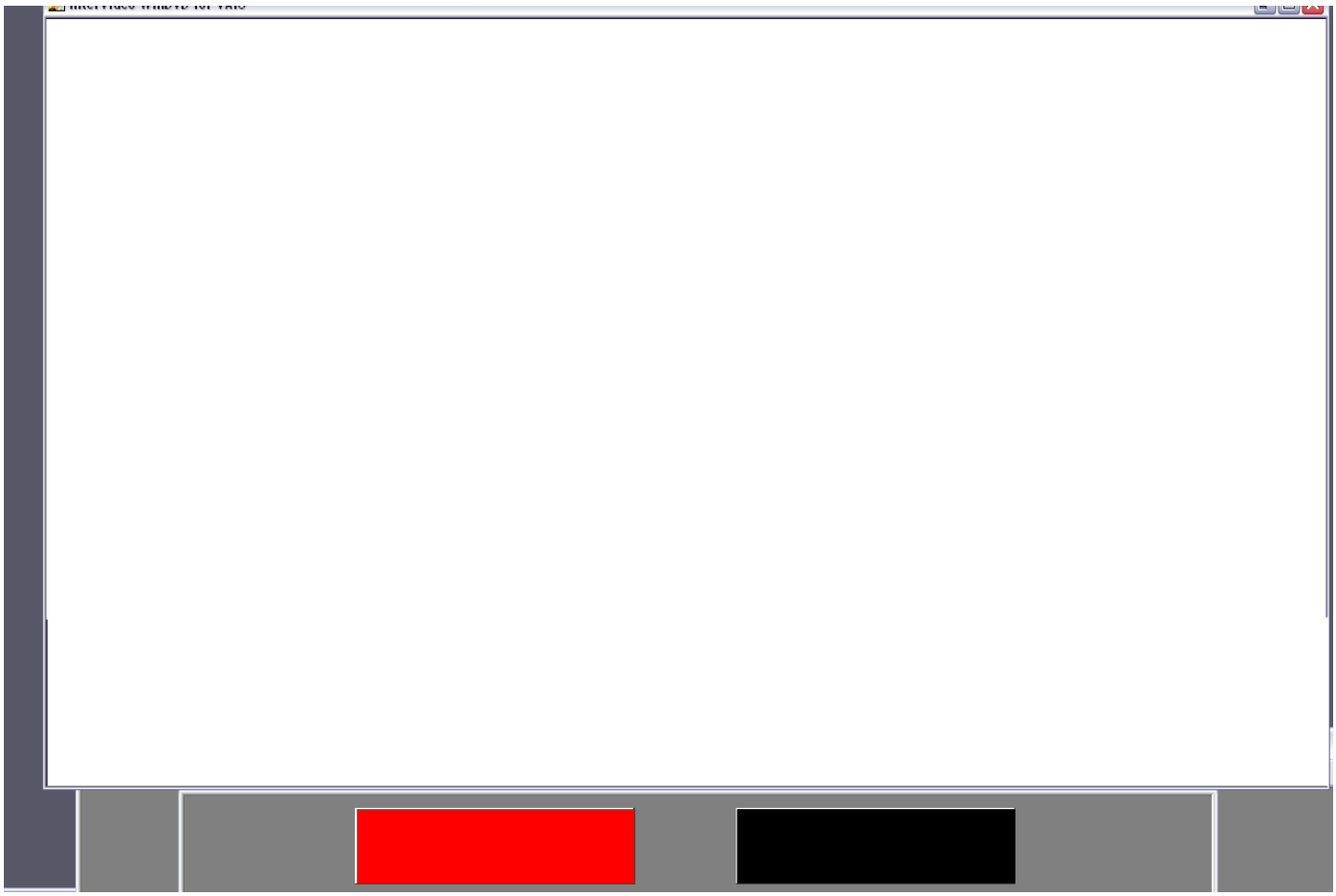


Figure 1. Screenshot of the apparatus. The top window (white area) is where the DVD movie was shown. The red and black buttons are below.

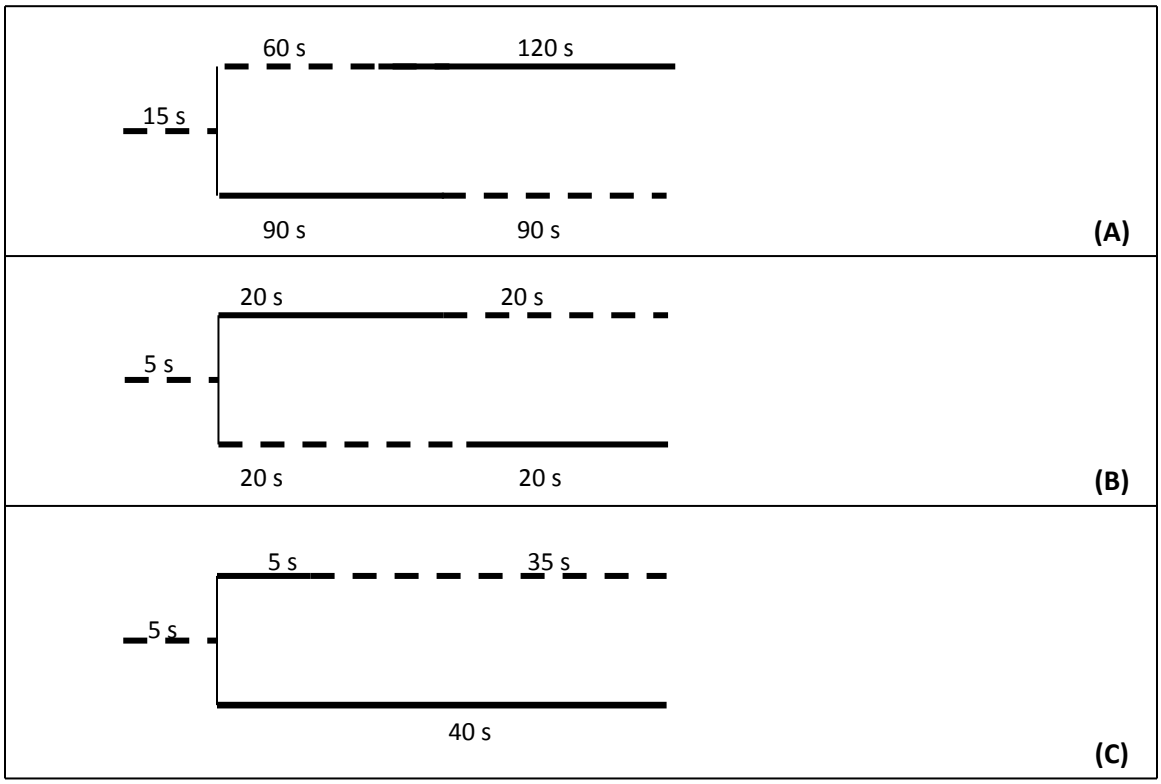


Figure 2. This diagram represents the trials for the Replication Condition (panel A), Experiment 1 (panel B), and Experiment 2 (panel C). Time proceeds from left to right and the broken and solid lines represent noise on and off respectively. In the top panel (A) noise is presented for 15 s before two buttons appear on the screen. A click on the left button (in this diagram the top choice) results in the noise staying on for 60 s and turning off for 120 s. The right button (the bottom choice) results in the noise immediately turning off for 90 s and then turning back on for 90 s. In panel B noise is presented for 5 s before the buttons appear. Selecting the left button turns the noise off immediately for 20 s and back on for 20 s. When the right button is selected the noise stays on for 20 s and then turns off for 20 s. In panel C, selecting the left button turns the noise off for 5 s and then back on for 35 s. Selecting the right button turns the noise off for 40 s. From "Negative reinforcement and self-control in adult humans," by A. N. MacAleese, 2009, Dissertation Abstracts International: Section B: The Sciences and Engineering, 70, 683. Copyright 2009 by A. N. MacAleese. Adapted with permission.

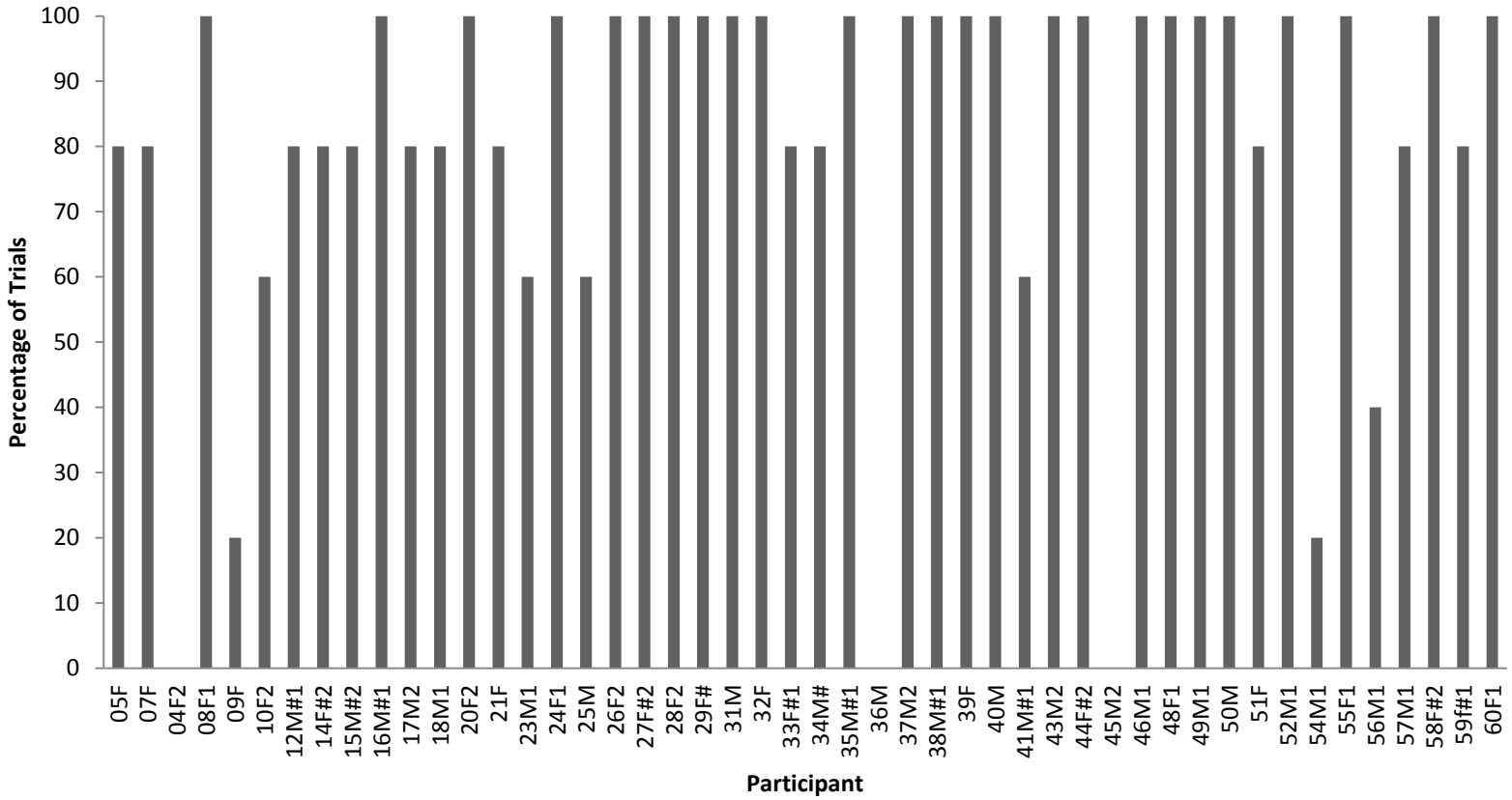


Figure 3. Percentage of trials in which the impulsive alternative (right button) was selected by each participant in the Replication Condition. Due to an error in preparing the session parameters, the data for Participant 30F#1 were not recorded and are not reported here.

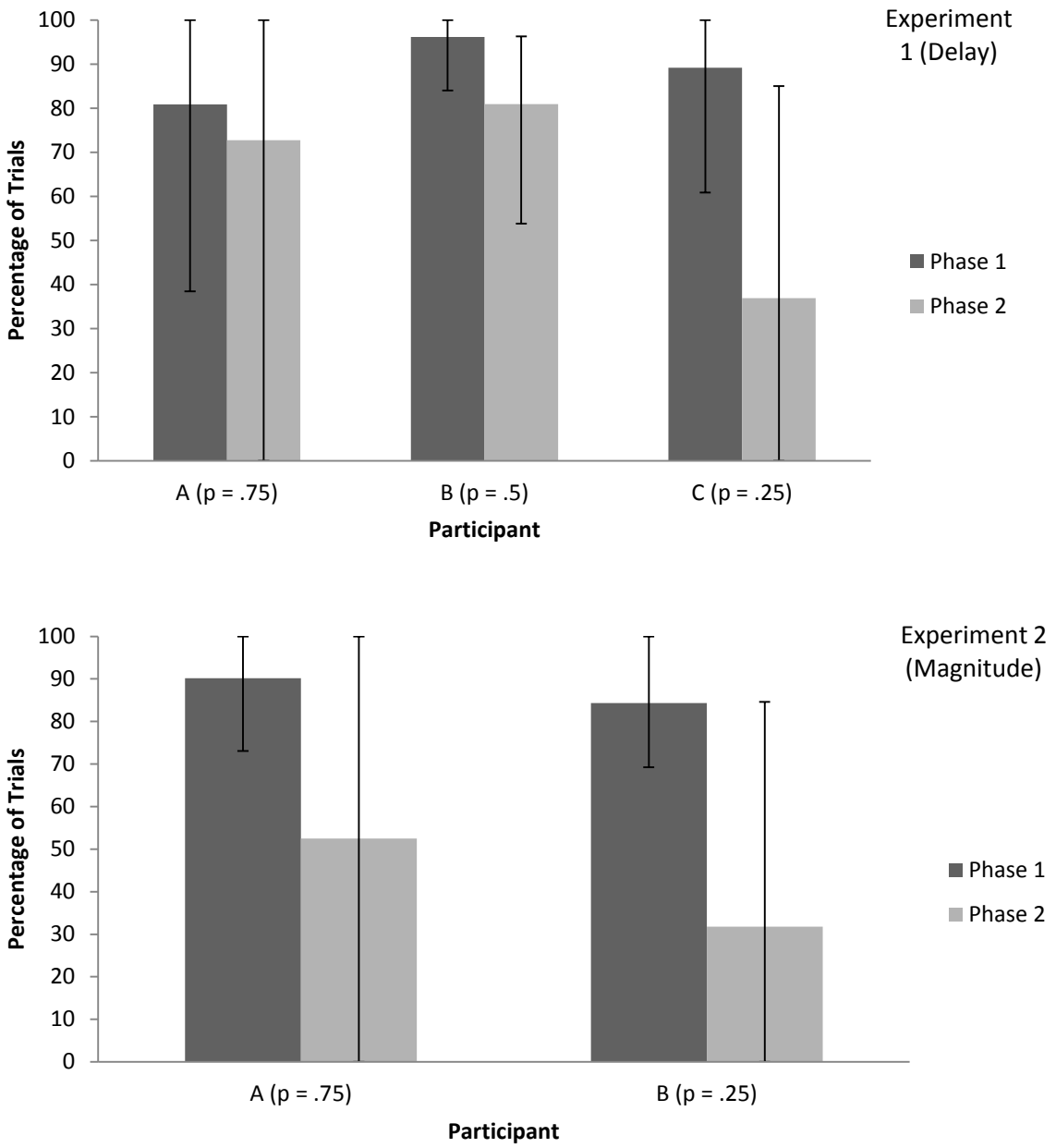


Figure 4. The top panel represents the aggregate percentage of trials in which the immediate alternative was selected in Experiment 1. The bottom panel represents the aggregate percentage of trials in which the large magnitude alternative was selected in Experiment 2. Dark bars represent the percentage of selections during Phase 1 and light bars represent the percentage of selections during Phase 2. The range bars represent the range of mean percentage of trials included in each aggregate percentage.

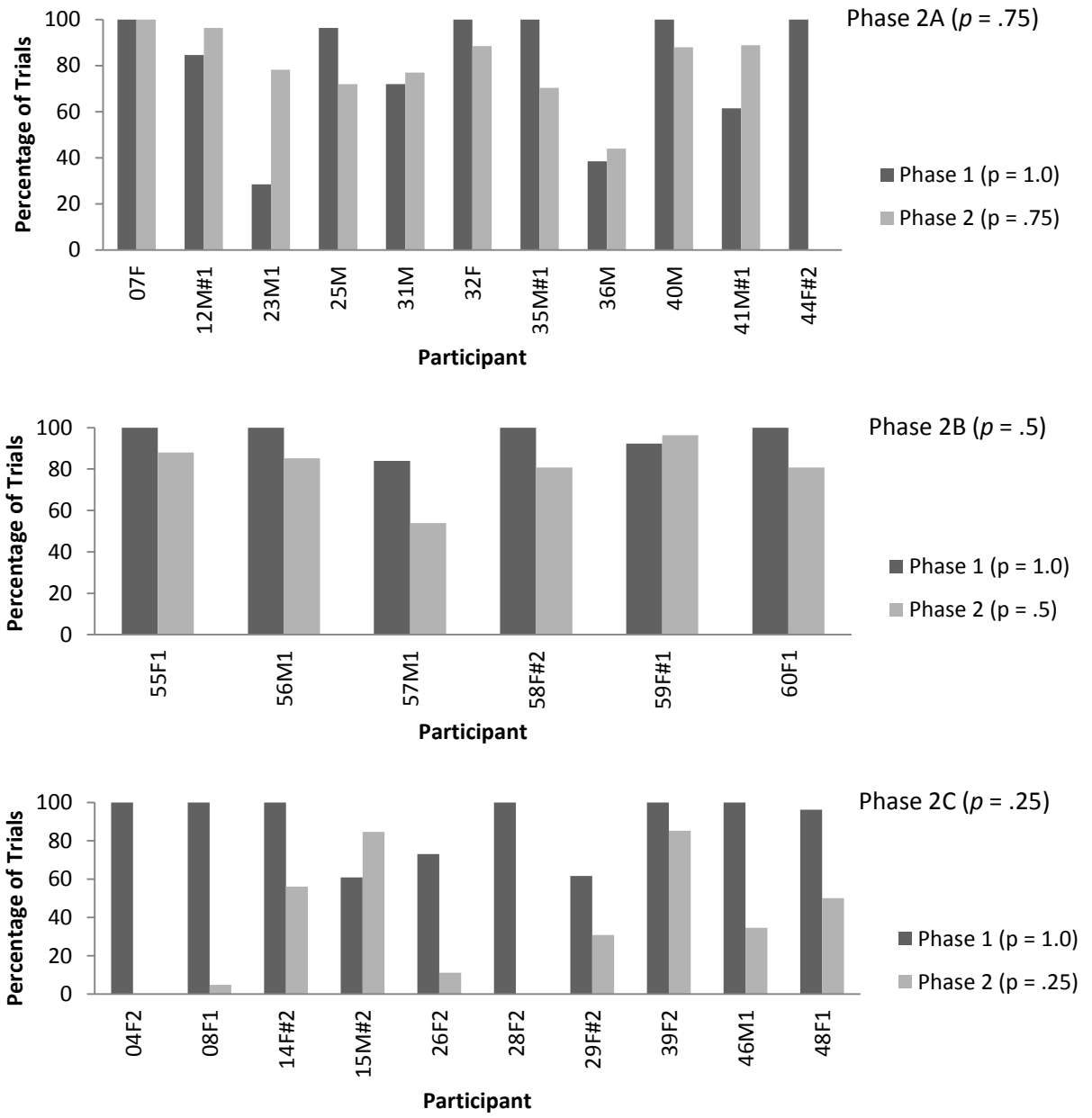


Figure 5. The top, middle, and bottom panels represent the data for participants in Phases 2A, 2B, and 2C, respectively, of Experiment 1. The dark bars represent the percentage of trials in which the immediate alternative was selected in Phase 1. The light bars represent the percentage of trials in which the immediate alternative was selected in Phase 2.

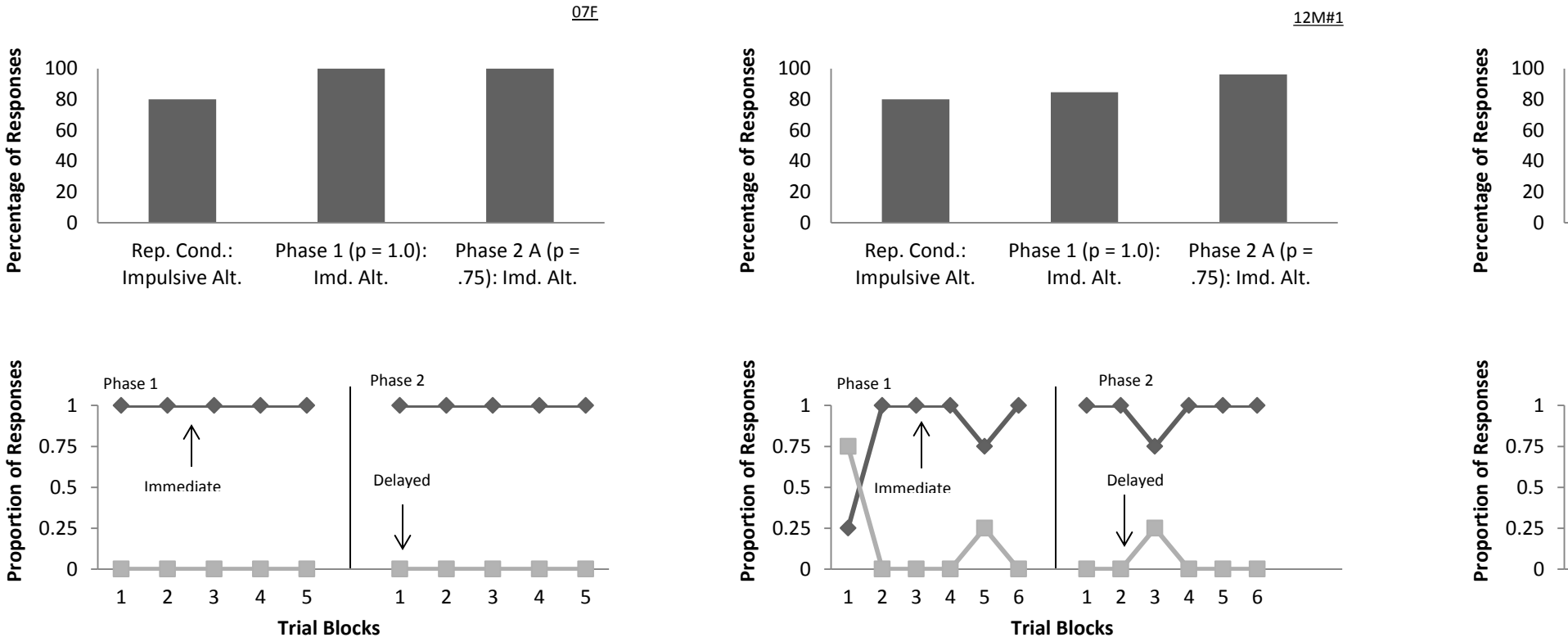


Figure 6. Individual participant data for Experiment 1. The top panel represents the percentage of responses allocated to the smaller-sooner alternative (Replication Condition) or immediate alternative (Phases 1 and 2). The bottom panel represents within session patterns of responding. The dark and light lines represent the proportion of responses made to the immediate and delayed alternatives respectively, during Phases 1 and 2 of Experiment 1. Sessions were divided into blocks of 4 trials in order to calculate proportions. The last trial black in each session includes 4 trials and any remainder. There are 6 trials included in the last trial block of both phases for the left panel, 6 in Phase 1 and 7 in Phase 2 for the middle panel, and 5 in Phase 1 and 7 in Phase 2 for the right panel.

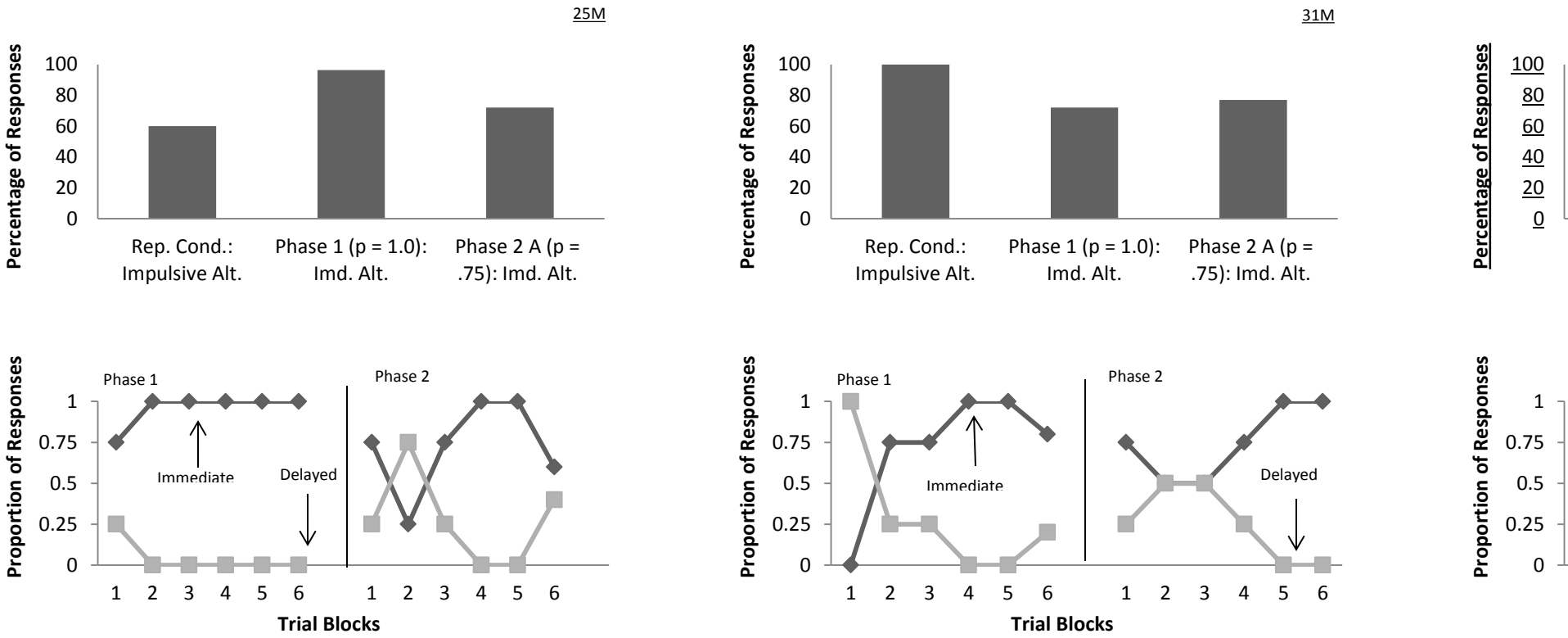


Figure 7. Individual participant data for Experiment 1. The top panel represents the percentage of responses allocated to the smaller-sooner alternative (Replication Condition) or immediate alternative (Phases 1 and 2). The bottom panel represents within session patterns of responding. The dark and light lines represent the proportion of responses made to the immediate and delayed alternatives respectively, during Phases 1 and 2 of Experiment 1. Sessions were divided into blocks of 4 trials in order to calculate proportions. The last trial black in each session includes 4 trials and any remainder. There are 7 trials included in the last trial block of Phase 1 and 5 in Phase 2 for the left panel, 5 in Phase 1 and 6 in Phase 2 for the middle panel, and 6 in both phases for the right panel.

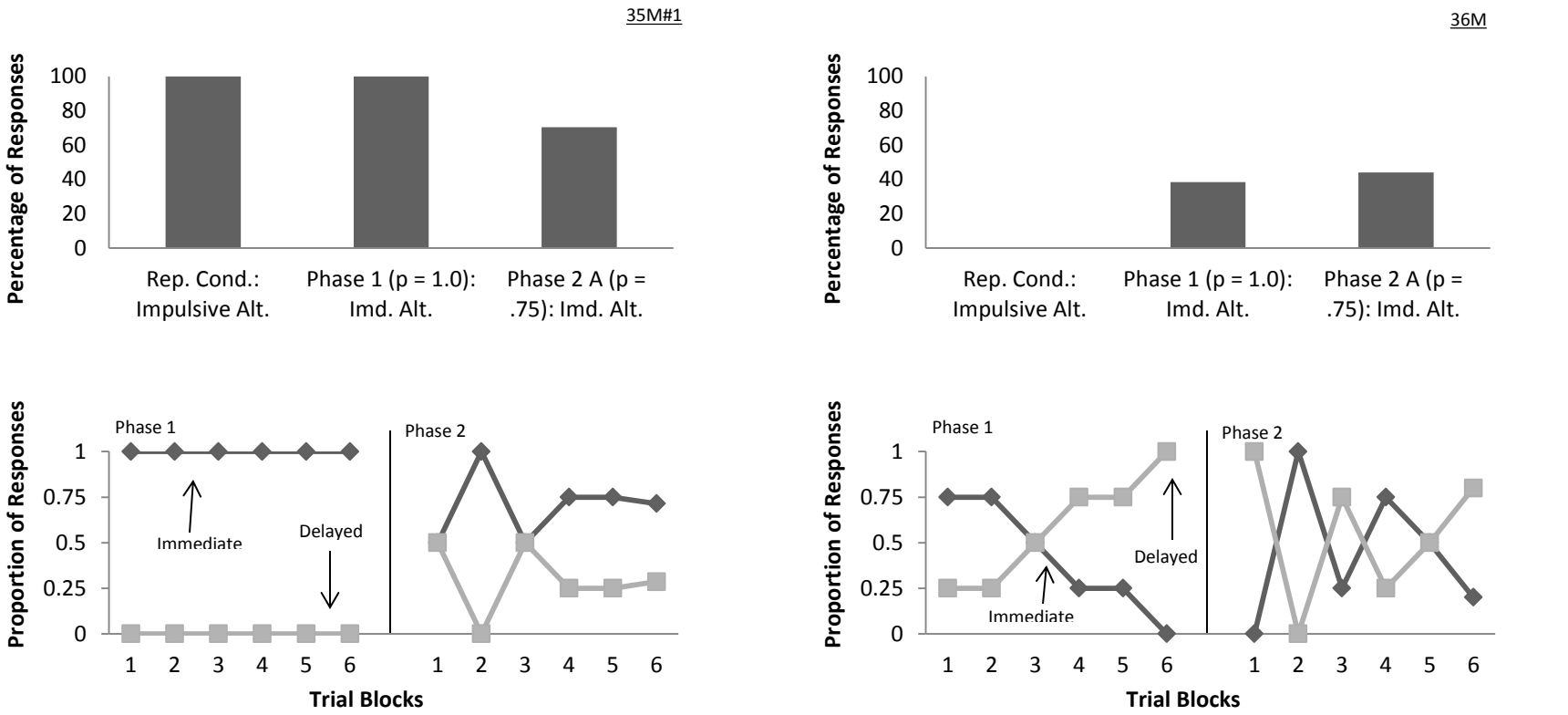


Figure 8. Individual participant data for Experiment 1. The top panel represents the percentage of responses allocated to the smaller-sooner alternative (Replication Condition) or immediate alternative (Phases 1 and 2). The bottom panel represents within session patterns of responding. The dark and light lines represent the proportion of responses made to the immediate and delayed alternatives respectively, during Phases 1 and 2 of Experiment 1. Sessions were divided into blocks of 4 trials in order to calculate proportions. The last trial black in each session includes 4 trials and any remainder. There are 6 trials included in the last trial block of Phase 1 and 7 in Phase 2 for the left panel and 6 in Phase 1 and 5 in Phase 2 for both the middle and left panels.

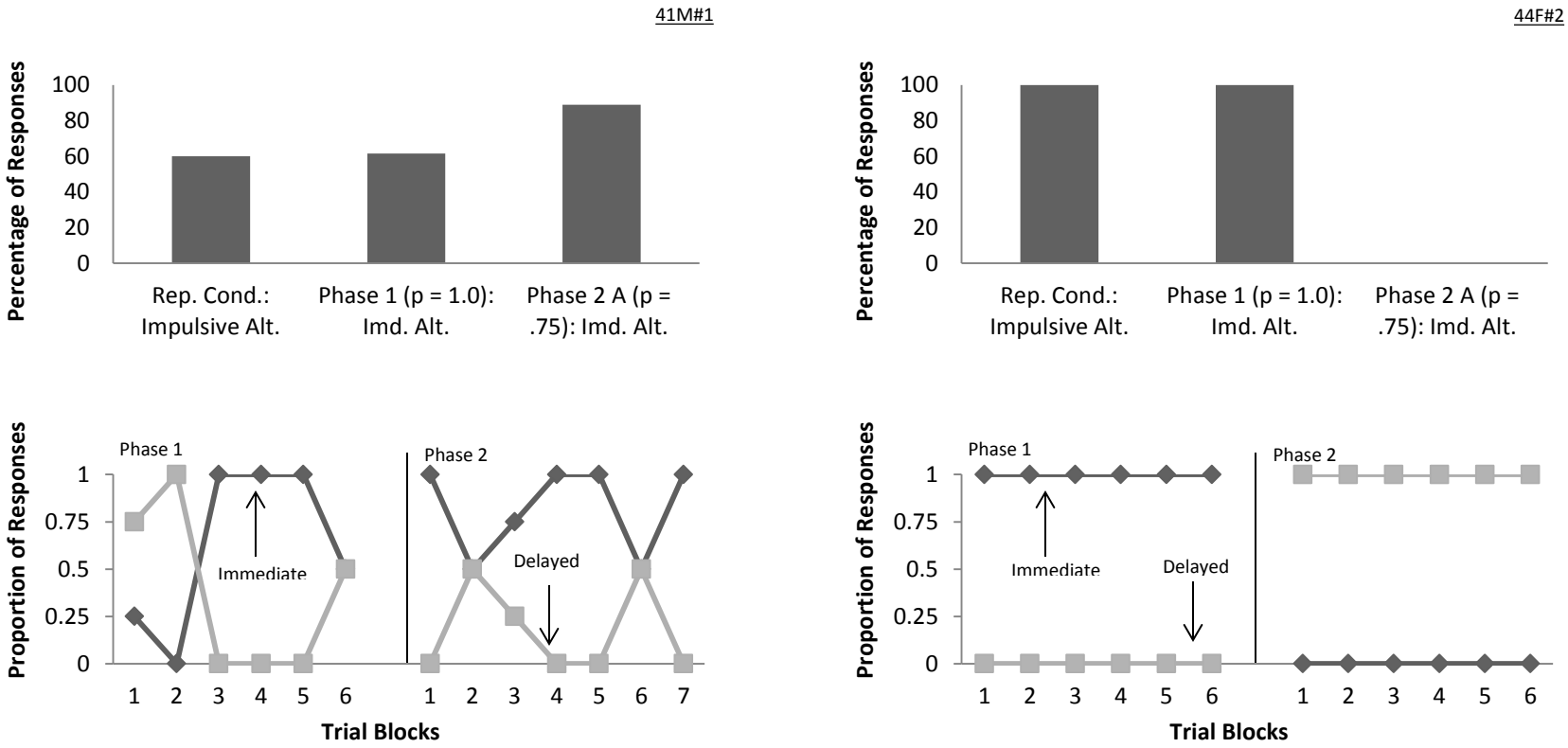


Figure 9. Individual participant data for Experiment 1. The top panel represents the percentage of responses allocated to the smaller-sooner alternative (Replication Condition) or immediate alternative (Phases 1 and 2). The bottom panel represents within session patterns of responding. The dark and light lines represent the proportion of responses made to the immediate and delayed alternatives respectively, during Phases 1 and 2 of Experiment 1. Sessions were divided into blocks of 4 trials in order to calculate proportions. The last trial black in each session includes 4 trials and any remainder. There are 6 trials included in the last trial block of Phase 1 and 7 in Phase 2 for the left panel and 6 in both phases of the right panel.

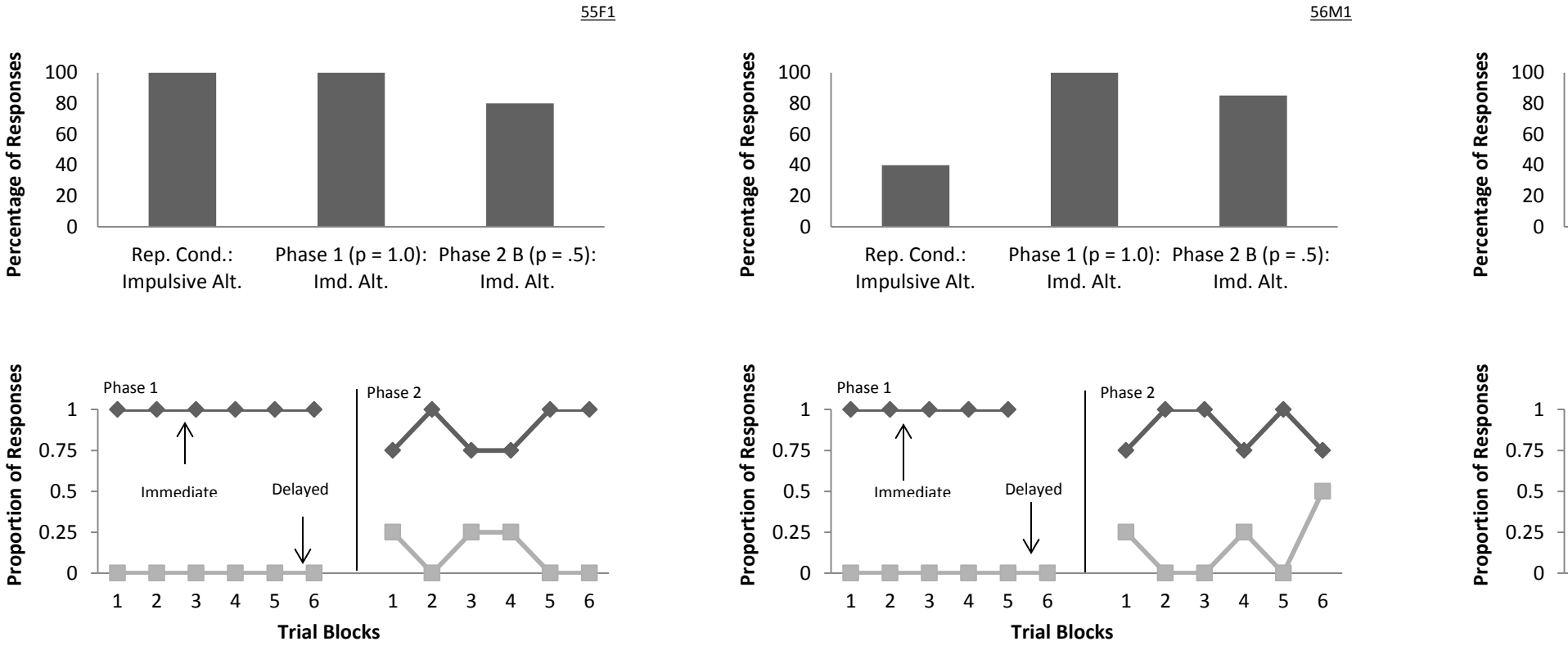


Figure 10. Individual participant data for Experiment 1. The top panel represents the percentage of responses allocated to the smaller-sooner alternative (Replication Condition) or immediate alternative (Phases 1 and 2). The bottom panel represents within session patterns of responding. The dark and light lines represent the proportion of responses made to the immediate and delayed alternatives respectively, during Phases 1 and 2 of Experiment 1. Sessions were divided into blocks of 4 trials in order to calculate proportions. The last trial black in each session includes 4 trials and any remainder. There are 6 trials included in the last trial block of Phase 1 and 5 in Phase 2 for the left panel and middle panels, and 5 in Phase 1 and 6 in Phase 2 for the right panel.

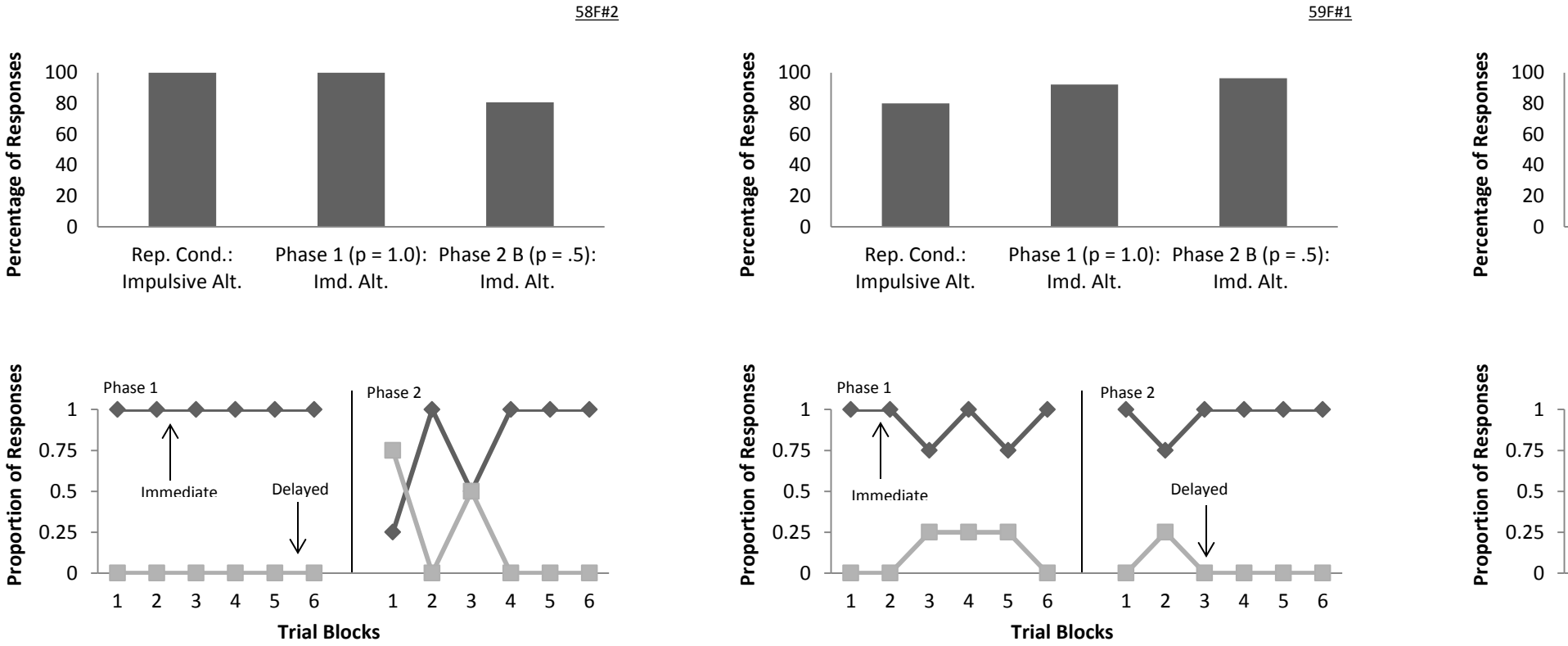


Figure 11. Individual participant data for Experiment 1. The top panel represents the percentage of responses allocated to the smaller-sooner alternative (Replication Condition) or immediate alternative (Phases 1 and 2). The bottom panel represents within session patterns of responding. The dark and light lines represent the proportion of responses made to the immediate and delayed alternatives respectively, during Phases 1 and 2 of Experiment 1. Sessions were divided into blocks of 4 trials in order to calculate proportions. The last trial black in each session includes 4 trials and any remainder. There are 6 trials included in the last trial block of both phases for the left and right panels, and 6 in Phase 1 and 7 in Phase 2 for the middle panel.

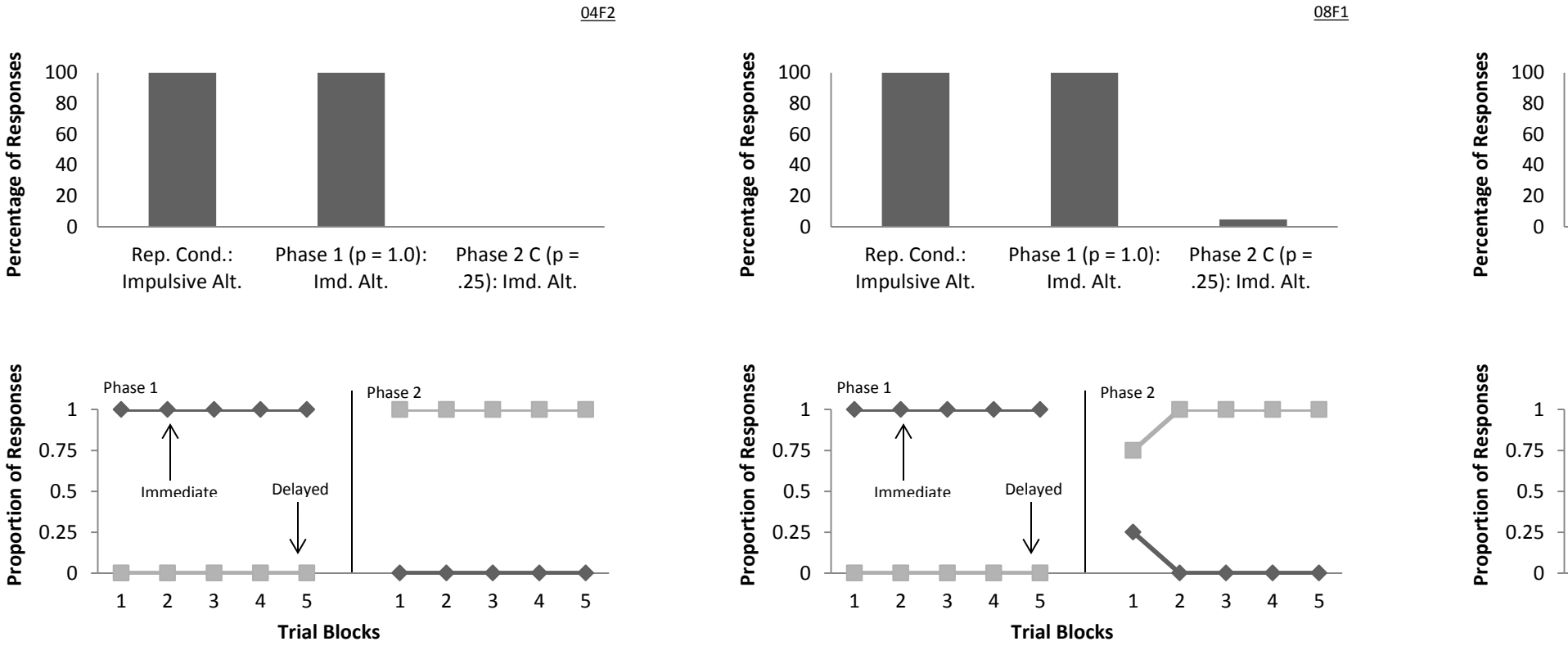


Figure 12. Individual participant data for Experiment 1. The top panel represents the percentage of responses allocated to the smaller-sooner alternative (Replication Condition) or immediate alternative (Phases 1 and 2). The bottom panel represents within session patterns of responding. The dark and light lines represent the proportion of responses made to the immediate and delayed alternatives respectively, during Phases 1 and 2 of Experiment 1. Sessions were divided into blocks of 4 trials in order to calculate proportions. The last trial black in each session includes 4 trials and any remainder. There are 6 trials included in the last trial block of both phases for the left panel, and 6 in Phase 1 and 5 in Phase 2 for the middle and right panels.

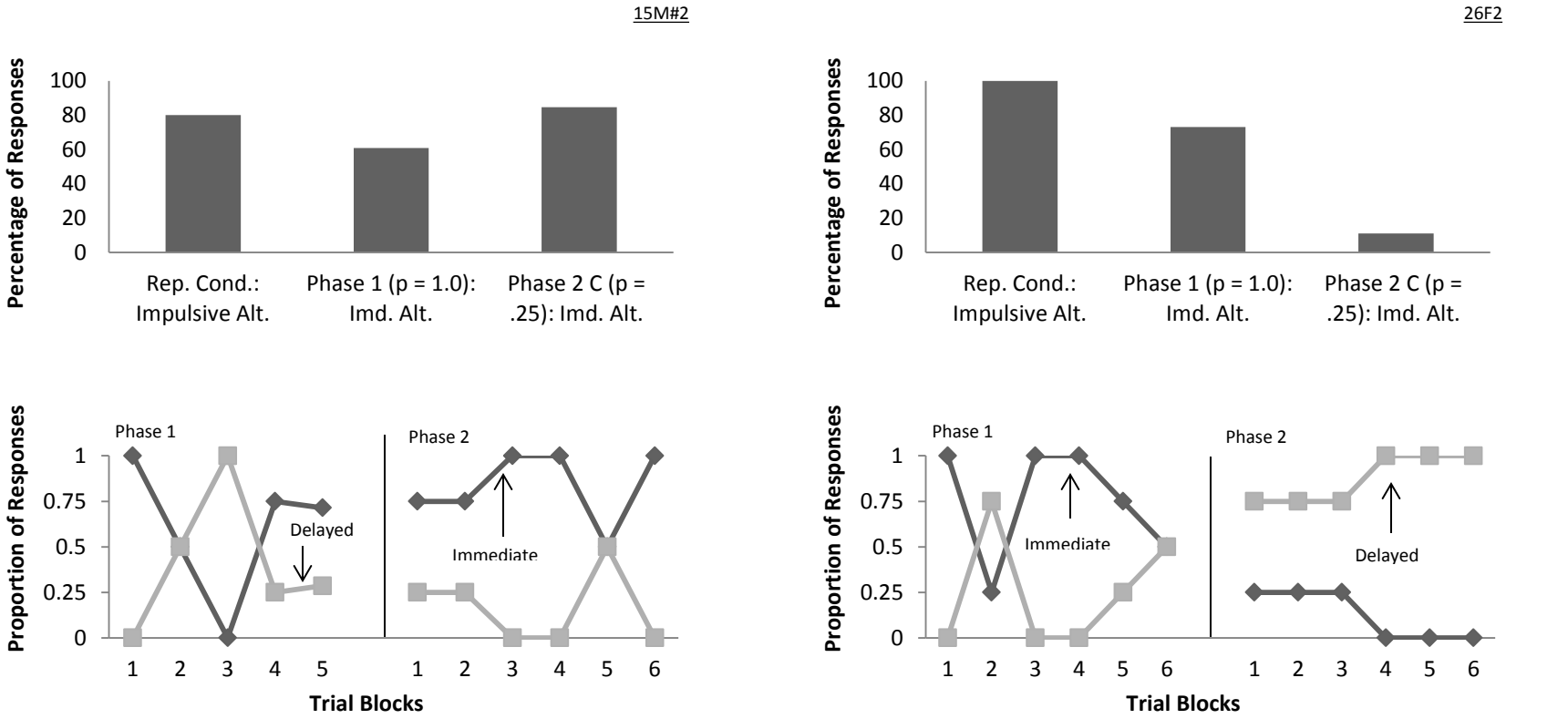


Figure 13. Individual participant data for Experiment 1. The top panel represents the percentage of responses allocated to the smaller-sooner alternative (Replication Condition) or immediate alternative (Phases 1 and 2). The bottom panel represents within session patterns of responding. The dark and light lines represent the proportion of responses made to the immediate and delayed alternatives respectively, during Phases 1 and 2 of Experiment 1. Sessions were divided into blocks of 4 trials in order to calculate proportions. The last trial black in each session includes 4 trials and any remainder. There are 7 trials included in the last trial block of Phase 1 and 6 in Phase 2 for the left panel, 6 in Phase 1 and 7 in Phase 2 for the middle panel, and 6 in both phases right panel.

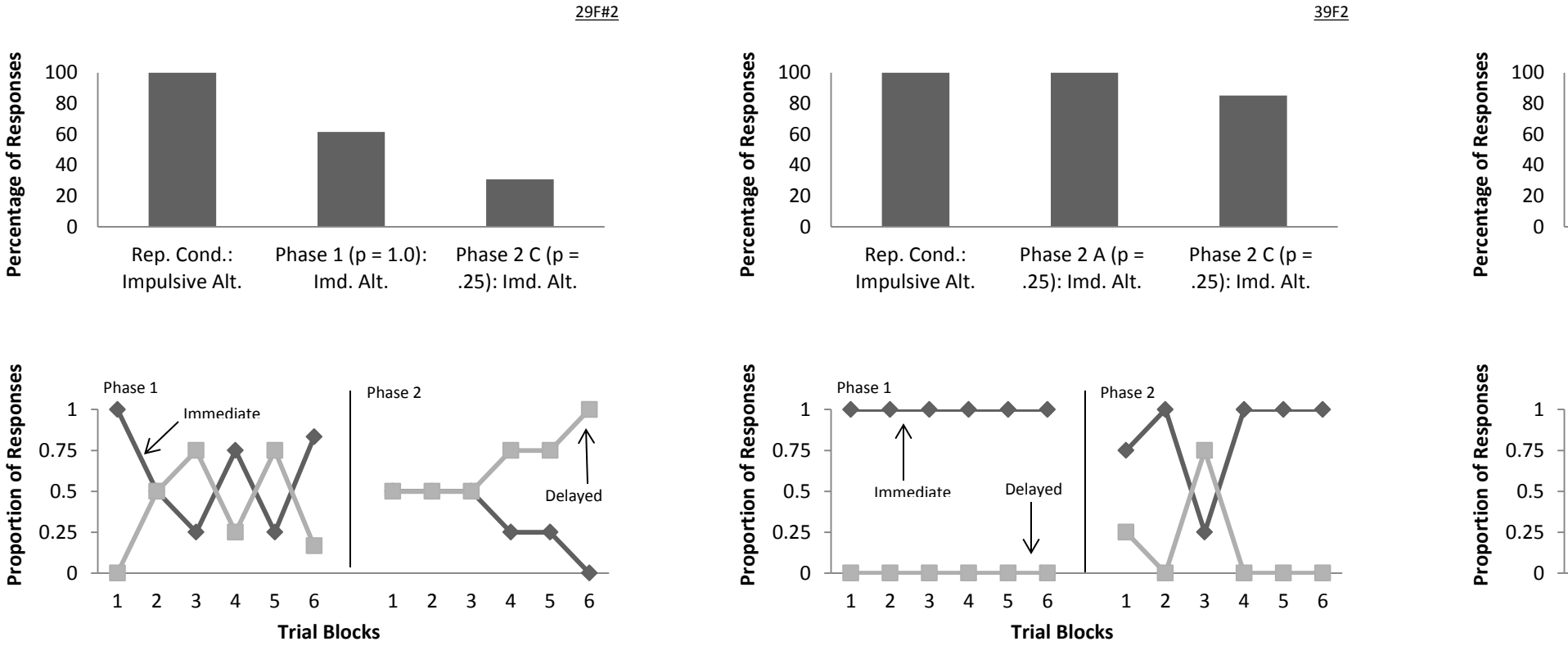


Figure 14. Individual participant data for Experiment 1. The top panel represents the percentage of responses allocated to the smaller-sooner alternative (Replication Condition) or immediate alternative (Phases 1 and 2). The bottom panel represents within session patterns of responding. The dark and light lines represent the proportion of responses made to the immediate and delayed alternatives respectively, during Phases 1 and 2 of Experiment 1. Sessions were divided into blocks of 4 trials in order to calculate proportions. The last trial black in each session includes 4 trials and any remainder. There are 6 trials included in the last trial block of both phases for the left and right panels, and 7 in both phases for the middle panel.

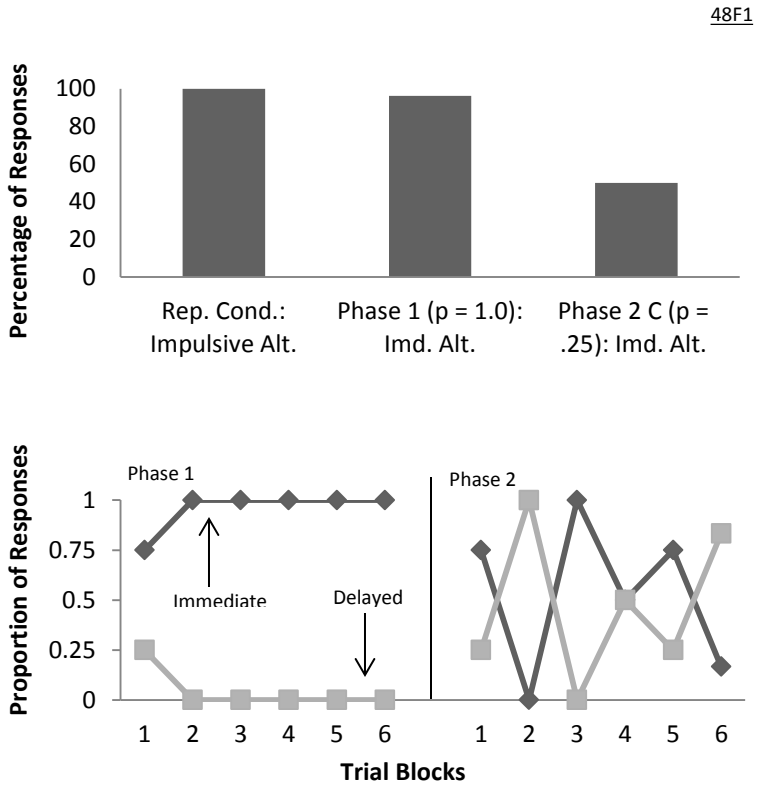


Figure 15. Individual participant data for Experiment 1. The top panel represents the percentage of responses allocated to the smaller-sooner alternative (Replication Condition) or immediate alternative (Phases 1 and 2). The bottom panel represents within session patterns of responding. The dark and light lines represent the proportion of responses made to the immediate and delayed alternatives respectively, during Phases 1 and 2 of Experiment 1. Sessions were divided into blocks of 4 trials in order to calculate proportions. The last trial black in each session includes 4 trials and any remainder. There are 6 trials included in the last trial block of both phases.

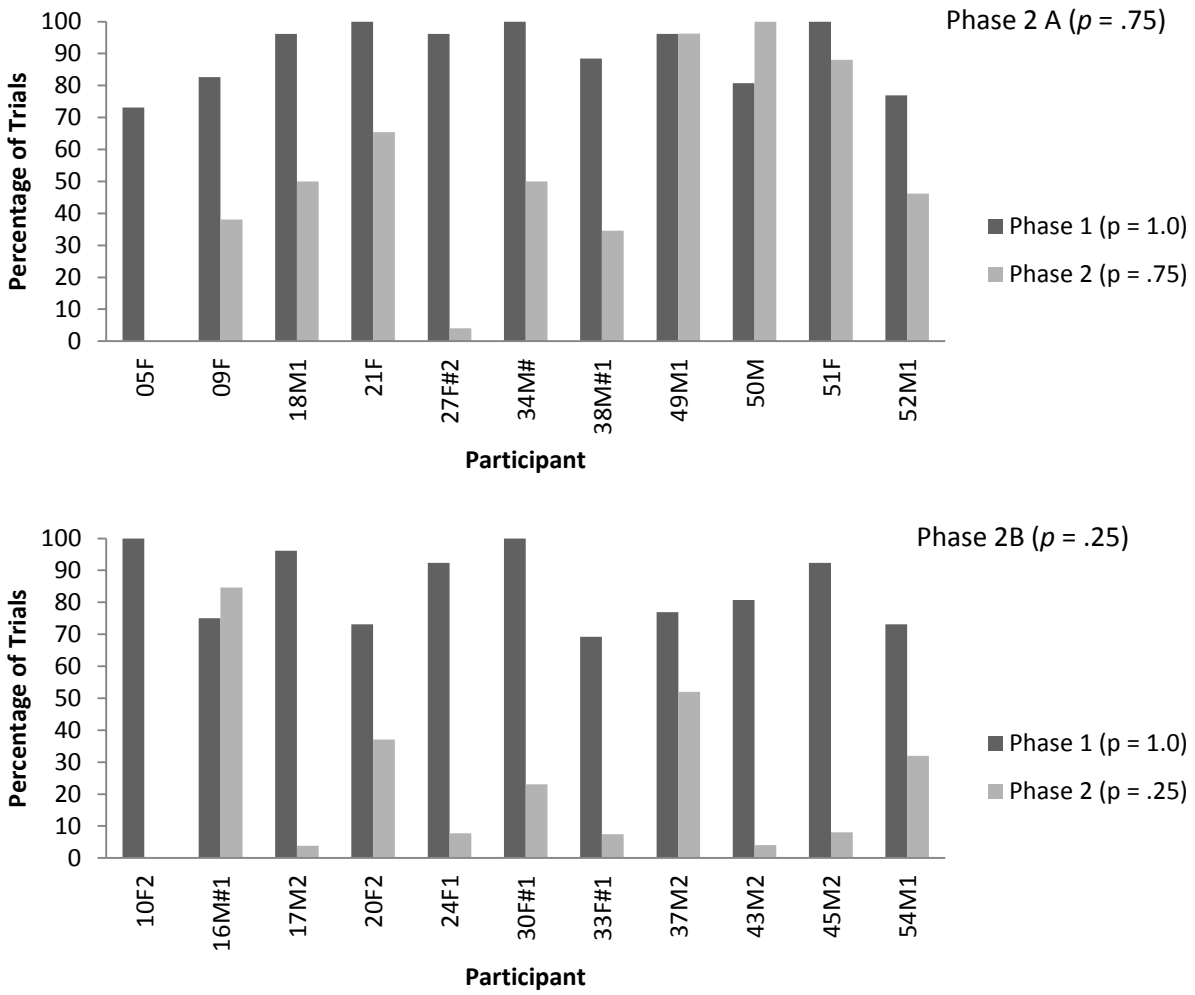


Figure 16. The top panel represents the data for participants in Phase 2A of Experiment 2, the bottom panel represents data for participants in Phase 2B of Experiment 2. In both panels the dark bars represent the percentage of trials in which the large magnitude alternative was selected in Phase 1. The light bars represent the percentage of trials in which the large magnitude alternative was selected in Phase 2.

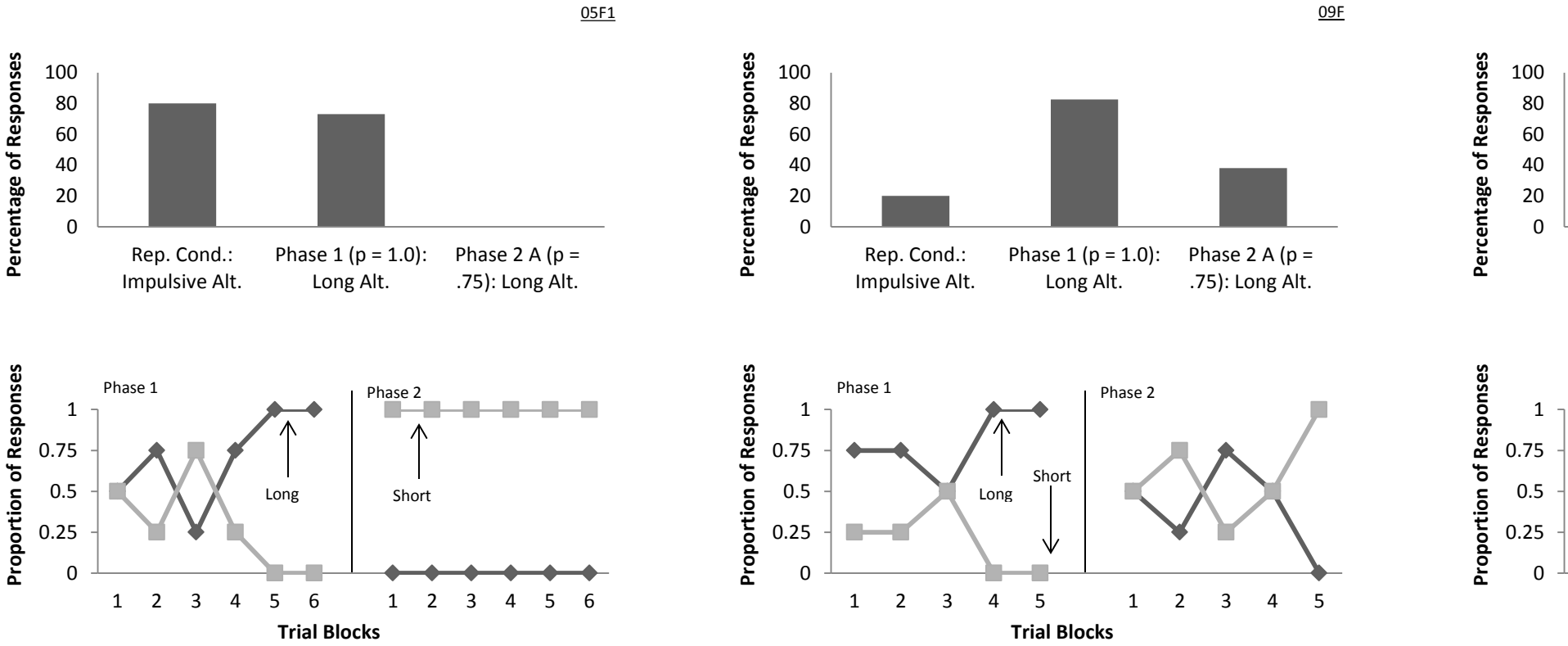


Figure 17. Individual participant data for Experiment 2. The top panel represents the percentage of responses allocated to the smaller-sooner alternative (Replication Condition) or immediate alternative (Phases 1 and 2). The bottom panel represents within session patterns of responding. The dark and light lines represent the proportion of responses made to the immediate and delayed alternatives respectively, during Phases 1 and 2 of Experiment 1. Sessions were divided into blocks of 4 trials in order to calculate proportions. The last trial black in each session includes 4 trials and any remainder. There are 6 trials included in the last trial block of both phases for the left and right panels, and 7 in Phase 1 and 5 in Phase 2 for the middle panel.

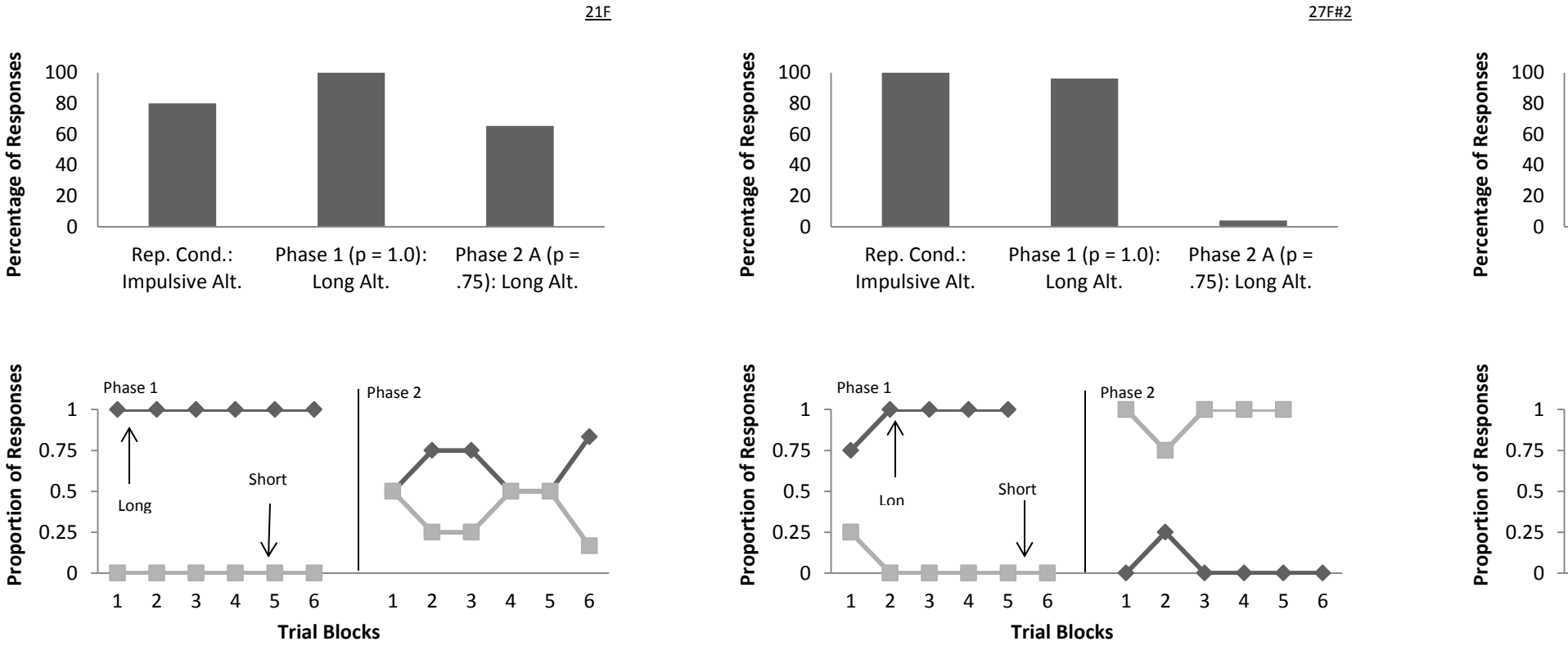


Figure 18. Individual participant data for Experiment 2. The top panel represents the percentage of responses allocated to the smaller-sooner alternative (Replication Condition) or immediate alternative (Phases 1 and 2). The bottom panel represents within session patterns of responding. The dark and light lines represent the proportion of responses made to the immediate and delayed alternatives respectively, during Phases 1 and 2 of Experiment 1. Sessions were divided into blocks of 4 trials in order to calculate proportions. The last trial black in each session includes 4 trials and any remainder. There are 7 trials included in the last trial block of Phase 1 and 6 in Phase 2 for the left and right panels, and 6 in Phase 1 and 5 in Phase 2 for the middle panel.

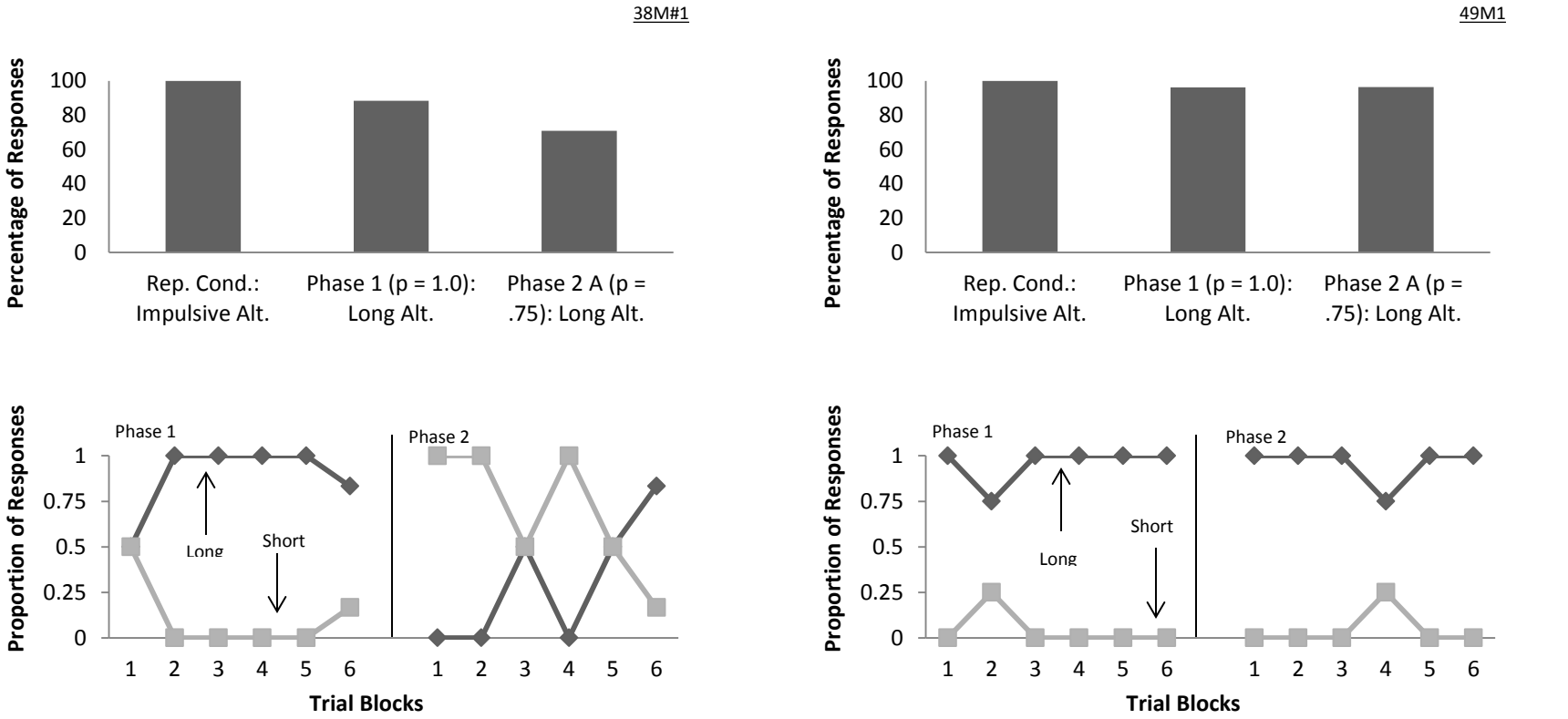


Figure 19. Individual participant data for Experiment 2. The top panel represents the percentage of responses allocated to the smaller-sooner alternative (Replication Condition) or immediate alternative (Phases 1 and 2). The bottom panel represents within session patterns of responding. The dark and light lines represent the proportion of responses made to the immediate and delayed alternatives respectively, during Phases 1 and 2 of Experiment 1. Sessions were divided into blocks of 4 trials in order to calculate proportions. The last trial black in each session includes 4 trials and any remainder. There are 6 trials included in the last trial block of both phases for the left and right panels, and 6 in Phase 1 and 7 in Phase 2 for the middle panel.

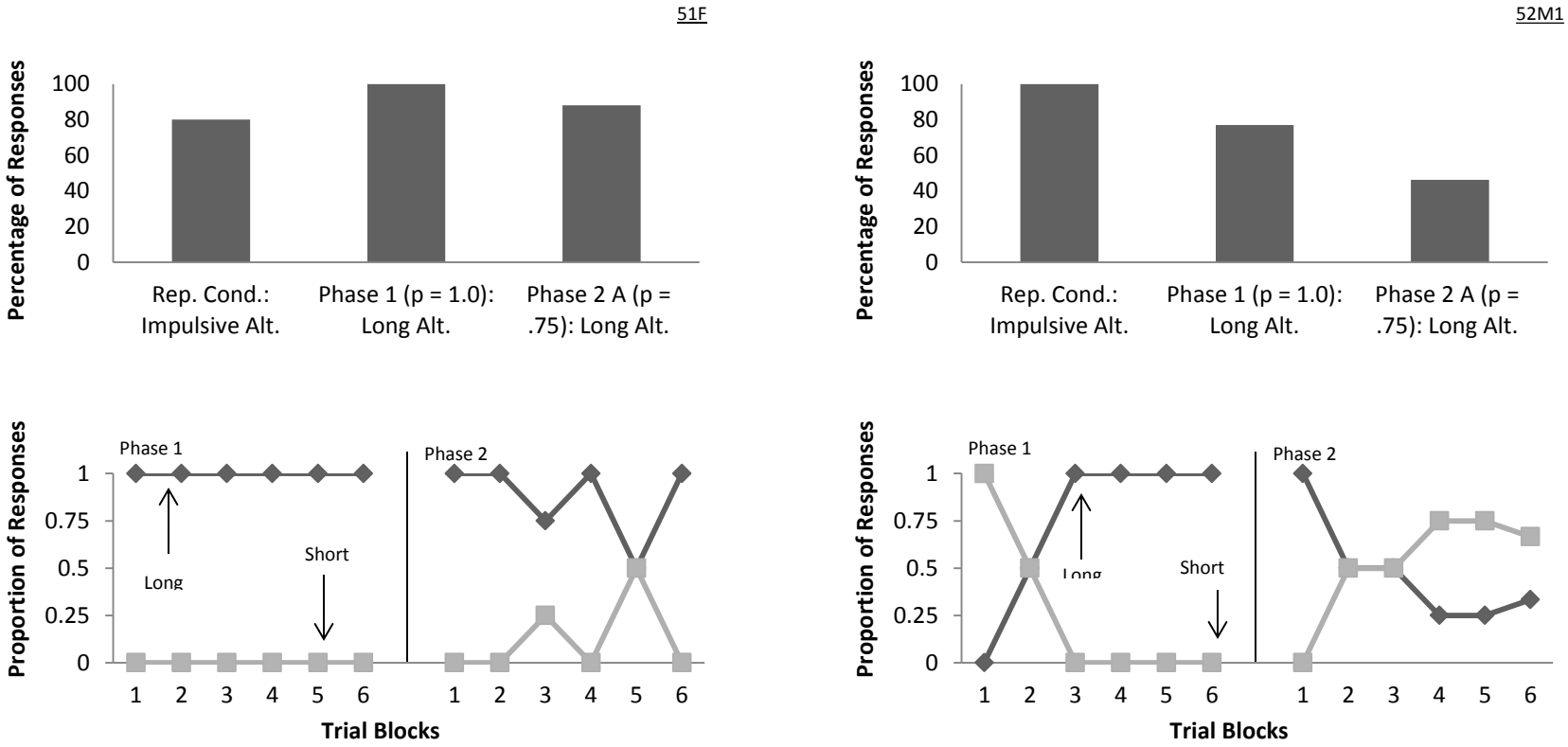


Figure 20. Individual participant data for Experiment 2. The top panel represents the percentage of responses allocated to the smaller-sooner alternative (Replication Condition) or immediate alternative (Phases 1 and 2). The bottom panel represents within session patterns of responding. The dark and light lines represent the proportion of responses made to the immediate and delayed alternatives respectively, during Phases 1 and 2 of Experiment 1. Sessions were divided into blocks of 4 trials in order to calculate proportions. The last trial black in each session includes 4 trials and any remainder. There are 6 trials included in the last trial block of Phase 1 and 5 in Phase 2 for the left panel, and 6 in both phases for the right panel.

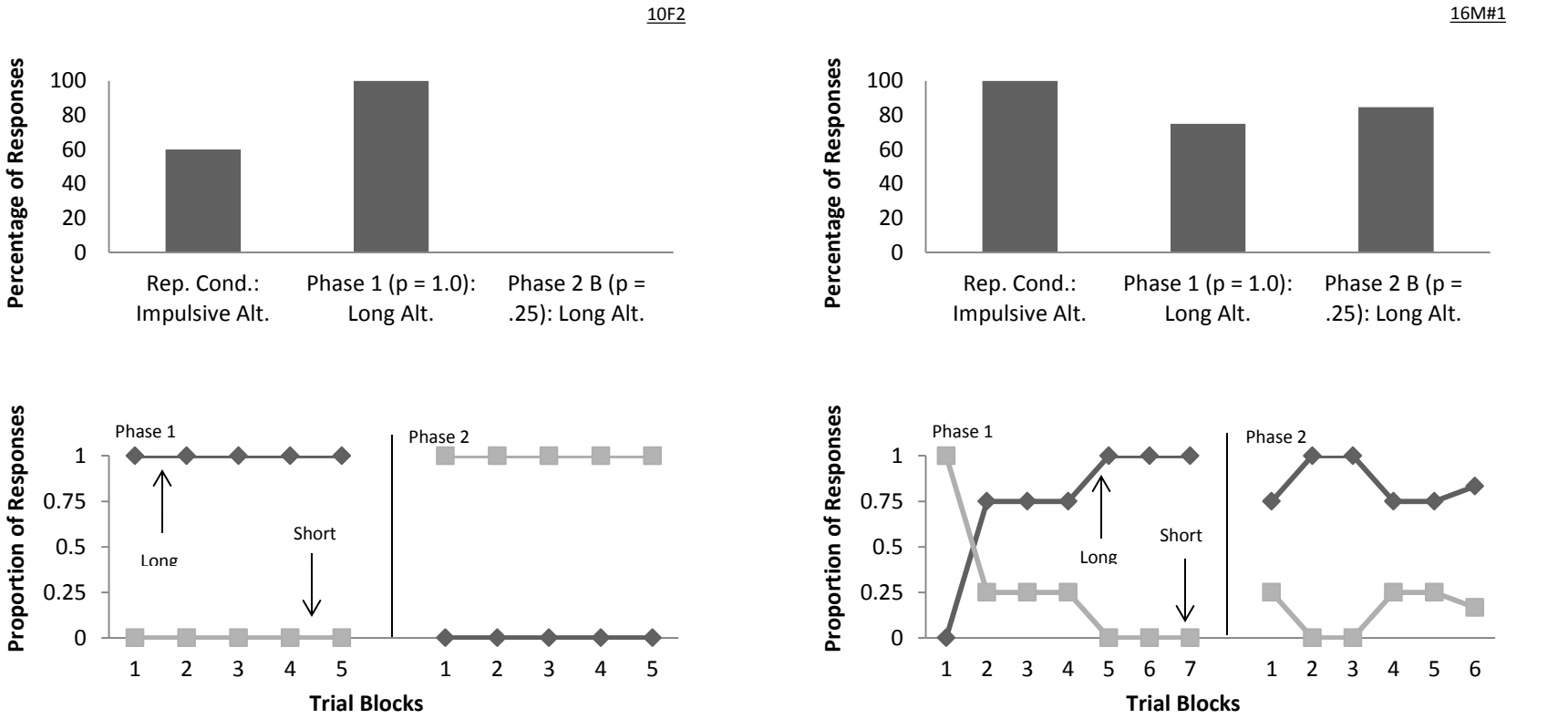
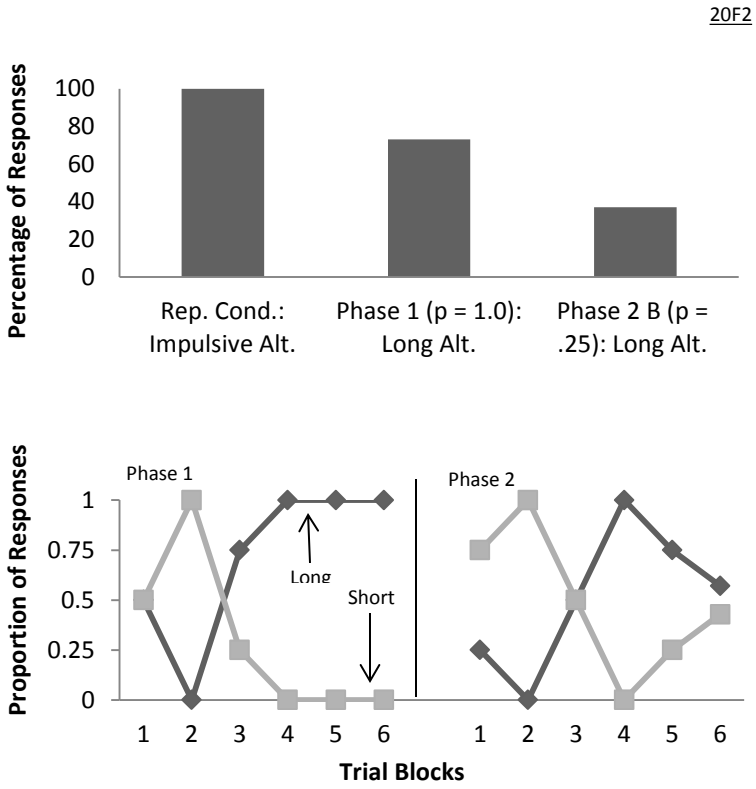
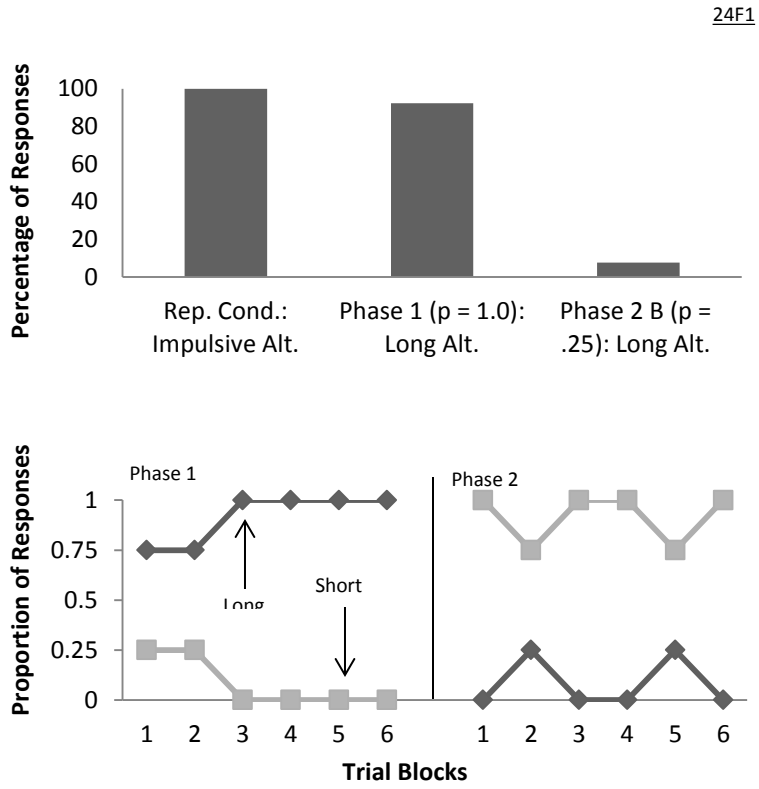


Figure 21. Individual participant data for Experiment 2. The top panel represents the percentage of responses allocated to the smaller-sooner alternative (Replication Condition) or immediate alternative (Phases 1 and 2). The bottom panel represents within session patterns of responding. The dark and light lines represent the proportion of responses made to the immediate and delayed alternatives respectively, during Phases 1 and 2 of Experiment 1. Sessions were divided into blocks of 4 trials in order to calculate proportions. The last trial black in each session includes 4 trials and any remainder. There are 7 trials included in the last trial block of Phase 1 and 6 for Phase 2 in the left panel, 4 in Phase 1 and 6 in Phase 2 in the middle panel, and 6 in both phases for the right panel.





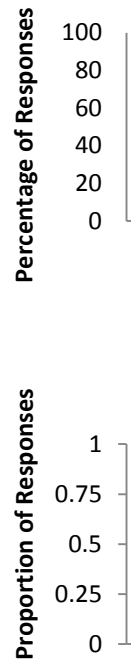


Figure 22. Individual participant data for Experiment 2. The top panel represents the percentage of responses allocated to the smaller-sooner alternative (Replication Condition) or immediate alternative (Phases 1 and 2). The bottom panel represents within session patterns of responding. The dark and light lines represent the proportion of responses made to the immediate and delayed alternatives respectively, during Phases 1 and 2 of Experiment 1. Sessions were divided into blocks of 4 trials in order to calculate proportions. The last trial black in each session includes 4 trials and any remainder. There are 6 trials included in the last trial block of Phase 1 and 7 for Phase 2 in the left panel, and 6 in both phases for the middle and right panels. Replication Condition data are not reported for Participant 30F#1.

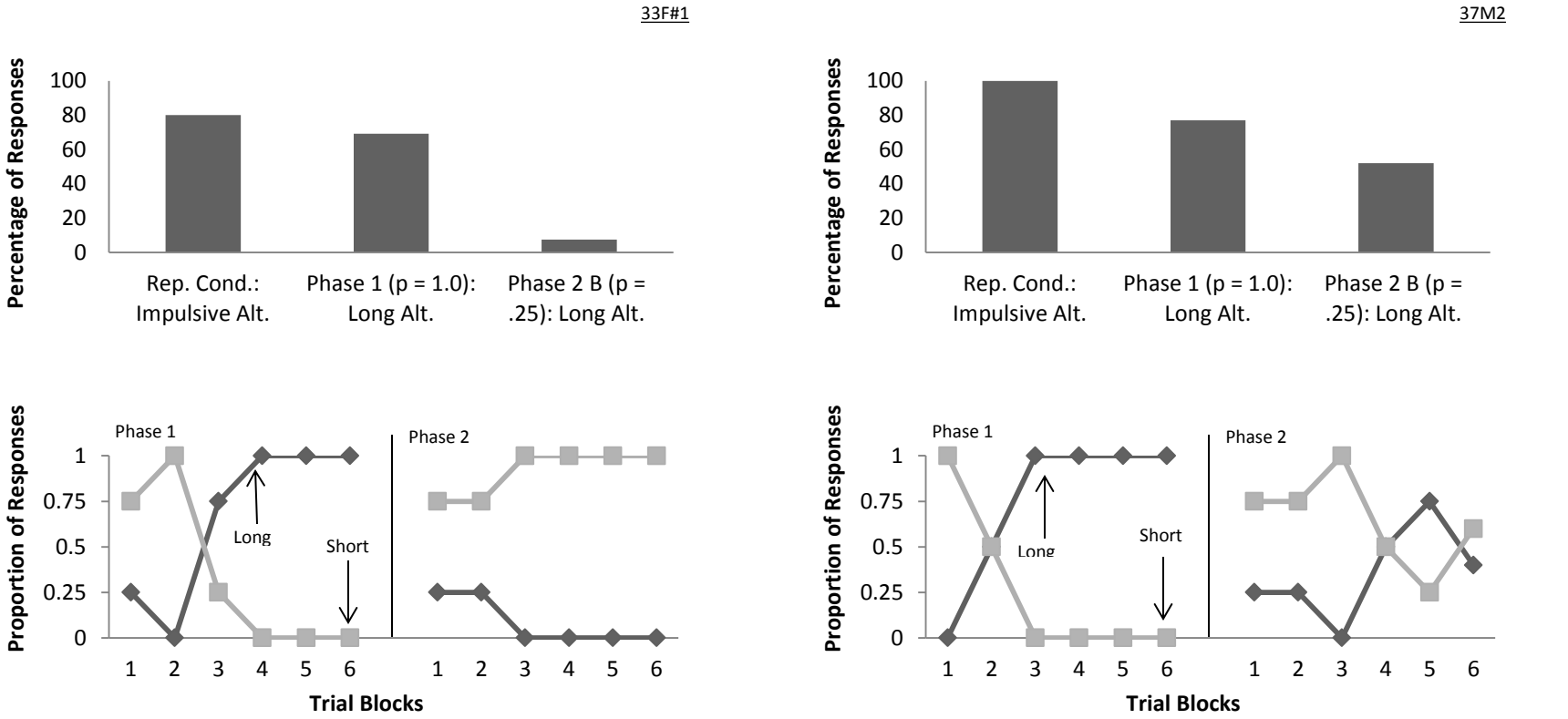


Figure 23. Individual participant data for Experiment 2. The top panel represents the percentage of responses allocated to the smaller-sooner alternative (Replication Condition) or immediate alternative (Phases 1 and 2). The bottom panel represents within session patterns of responding. The dark and light lines represent the proportion of responses made to the immediate and delayed alternatives respectively, during Phases 1 and 2 of Experiment 1. Sessions were divided into blocks of 4 trials in order to calculate proportions. The last trial black in each session includes 4 trials and any remainder. There are 6 trials included in the last trial block of Phase 1 and 7 for Phase 2 in the left panel, and 6 in Phase 1 and 5 in Phase 2 for the middle and right panels.

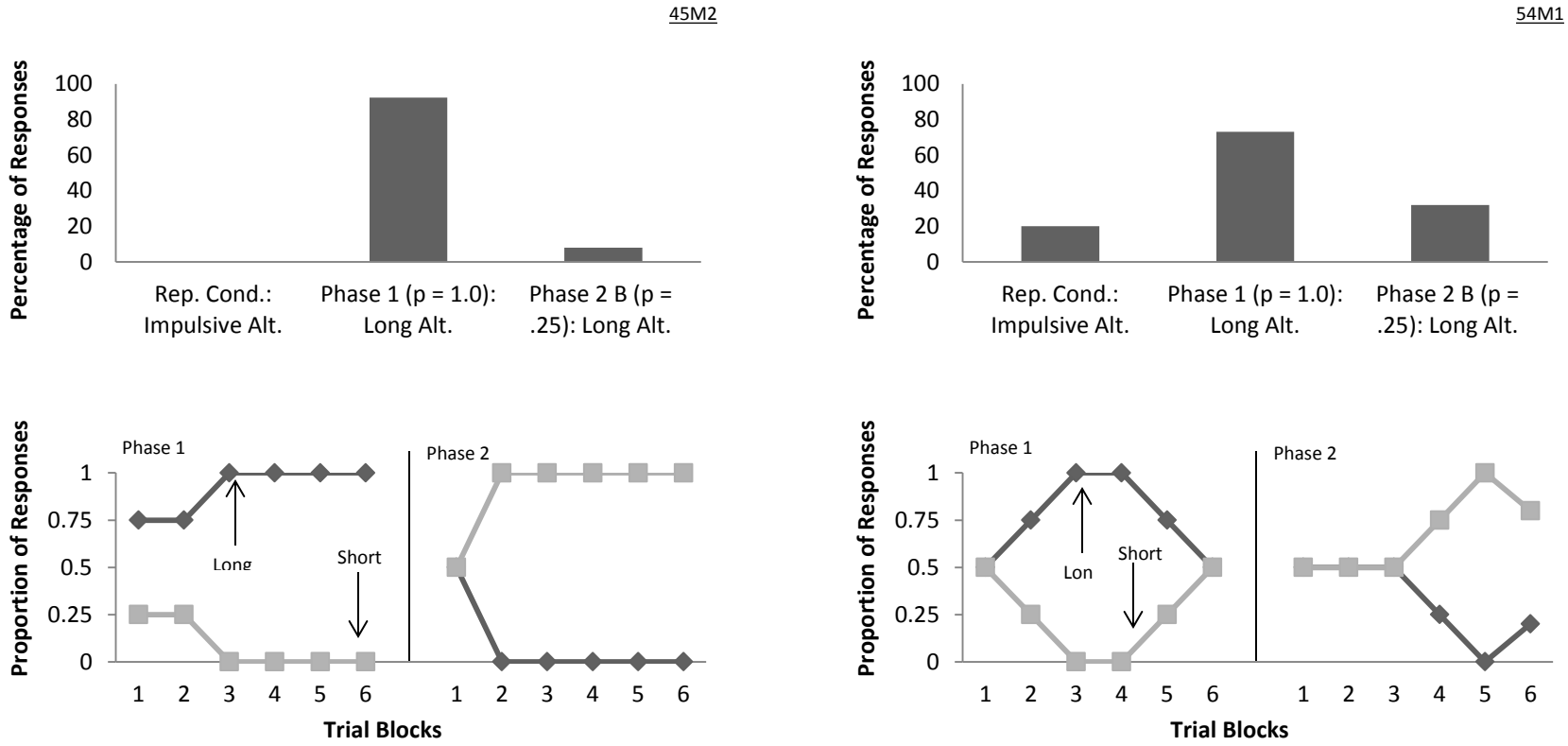


Figure 24. Individual participant data for Experiment 2. The top panel represents the percentage of responses allocated to the smaller-sooner alternative (Replication Condition) or immediate alternative (Phases 1 and 2). The bottom panel represents within session patterns of responding. The dark and light lines represent the proportion of responses made to the immediate and delayed alternatives respectively, during Phases 1 and 2 of Experiment 1. Sessions were divided into blocks of 4 trials in order to calculate proportions. The last trial black in each session includes 4 trials and any remainder. There are 6 trials included in the last trial block of Phase 1 and 5 for Phase 2 in both panels.

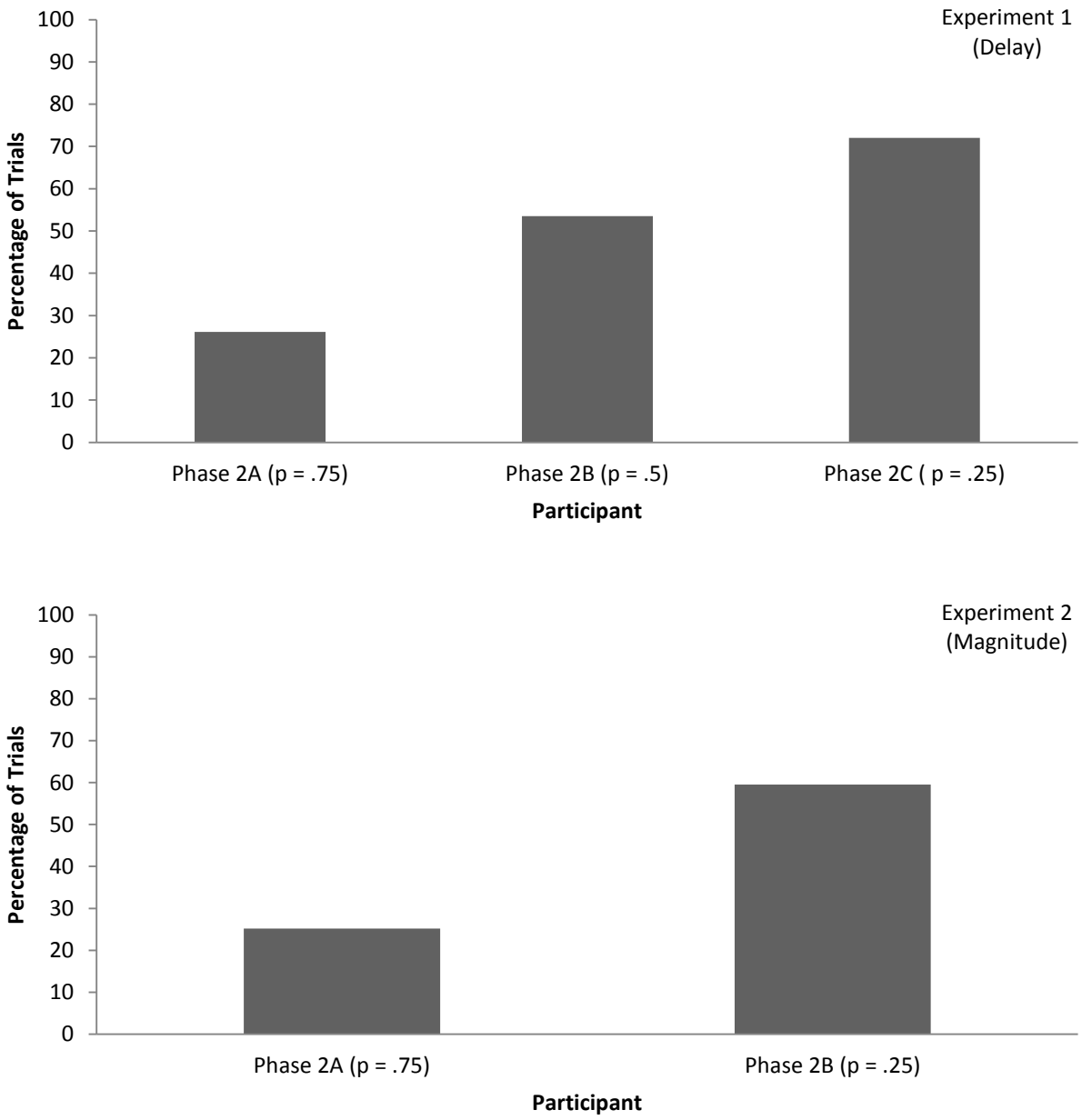


Figure 25. The aggregate percentage of unreinforced trials across phases in Experiments 1 and 2.

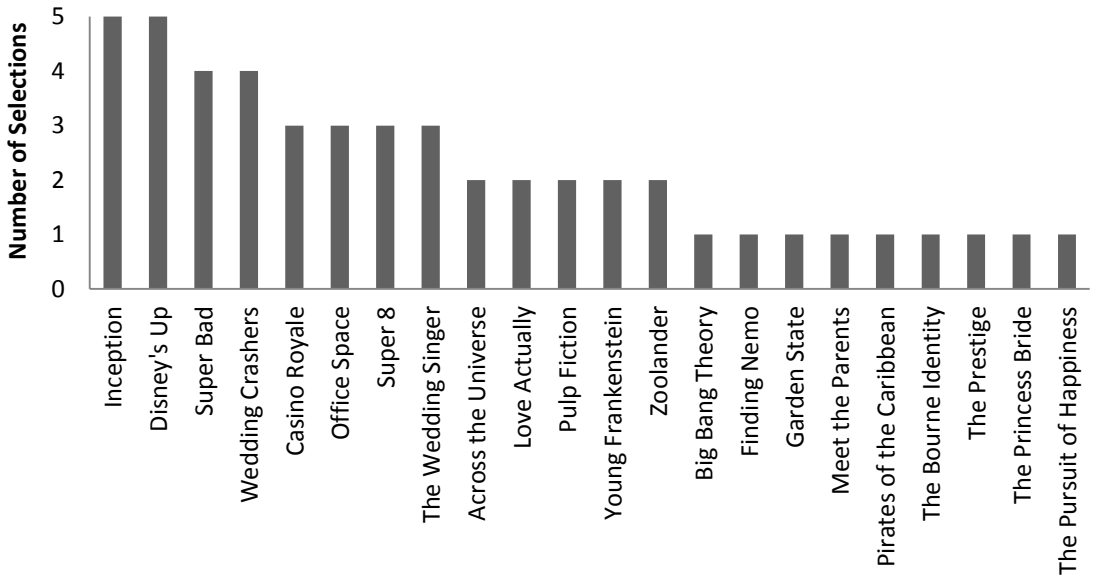


Figure 26. The frequency of participant movie selections by title.