

University of Nevada, Reno

**A Comparison of the Effects of Loss Avoidance and Positive Reinforcement
Contingencies**

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

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Abstract

Two experiments were conducted with undergraduate students to compare the effects of reinforcement and extinction in gain (positive reinforcement) and loss avoidance (negative reinforcement) contingencies. In experiment #1, participants were assigned to one of three groups: Loss, Gain, or Control ($N = 36$ per group). Participants completed math worksheets during the session. Reinforcement was contingent upon the duration in which participants completed each worksheet with respect to a changing criterion. In the Loss group, participants lost \$1 for each trial in which the trial duration exceeded the current criterion, while participants in the Gain condition earned \$1 for each trial in which the trial duration was less than the current criterion. Data were collected on the change in relative duration following instances of both reinforcement and extinction in each contingency. Results indicated that the effects of extinction in the loss avoidance contingency (Losses) were nearly identical to those of extinction in the gain contingency (No-Gains). The same results were obtained in comparing the effects of instances of reinforcement in the loss avoidance contingency (No-Losses) and the gain contingency (Gains). In experiment #2, a within-subject ($N = 43$) comparison of the effects of loss avoidance and gain contingencies was conducted across Loss-Gain and Gain-Loss groups. Results indicated that no significant difference existed between the effects of reinforcement and those of extinction across the two contingencies, as with experiment #1. Results are discussed in terms of how they may contribute to an understanding of the loss avoidance contingency, and further, to provide a behavior-analytic investigation of behavioral economics' concept of loss aversion.

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A Comparison of the Effects of Loss Avoidance and Positive Reinforcement Contingencies

A great deal of research conducted over the past 80 years has demonstrated that the probability of operant behavior is impacted by its consequences. One concept that is used to understand the relationship between behavior and its environmental consequences is the contingency. The contingency describes the relations between a stimulating environment (S), the response that occurs in its presence (R), and the resulting changes in the environment or consequences (C). Consequences come to affect the probability of subsequent occurrences of the behavior under similar stimulating conditions. It is understood that this environment-behavior interaction leads to the behavior of interest occurring, continuing, or ceasing to occur.

Reinforcement contingencies describe the interaction in which the probability of a behavior increases as a result of its consequences. There are two basic reinforcement contingencies regularly explored in behavior analysis: positive and negative reinforcement. Positive reinforcement contingencies (S^{R+}) involve the presentation of particular stimuli contingent upon behavior, resulting in an increase in the probability of that class of behavior. Negative reinforcement contingencies (S^{R-}) involve the removal of aversive stimuli contingent upon behavior, resulting in an increase in the probability of that class of behavior. While these reinforcement contingencies effectively describe most instances of behavior-environment interactions that increase the probability of behavior, they do not exhaust the possibilities. One contingency that is not reflected in these descriptions is the loss avoidance contingency.

Loss Avoidance Contingency Description

Malott and Shane (2016) defined the loss avoidance contingency as the immediate, response-contingent prevention of the loss of a reinforcing stimulus resulting in an increased probability of that class of responses¹. The loss avoidance contingency describes situations in which the consequence contingent upon behavior is the maintenance of a reinforcing stimulus. With this contingency, responses serve to maintain existing reinforcing stimuli; while failing to respond results in the loss of these stimuli (see table 1).

The loss avoidance contingency commonly occurs in many aspects of our lives. Consider a situation in which a person purchases a vehicle (i.e., a reinforcing stimulus) through the use of a monetary loan. The individual may drive the vehicle as long as she/he pays the monthly payments. In the event that the individual does not make the necessary payments, the car will be repossessed and lost. This contingency generally maintains the individual's routine payments in order to avoid losing the vehicle that she/he currently possess.

Despite the commonality of the loss avoidance contingency, it has received limited attention within the behavior-analytic literature (Malott & Shane, 2016). This may be due to the fact that features of the loss avoidance contingency are present in other contingencies. As a result, its differentiation from other contingencies may have been neglected. These similarities and differences between the loss avoidance and other contingencies are discussed below.

¹ Malott and Shane (2016) referred to this contingency as the “avoidance of loss” contingency rather than “loss avoidance,” however the description is the same. The term “loss avoidance contingency” was selected for this work based on the majority of work on this contingency that has used this term.

Distinguishing the Loss Avoidance Contingency

In order to fulfill the defining characteristics of the loss avoidance contingency, the following features must be present: (1) a reinforcer must be present prior to the occurrence of the response, (2) a response must be required to maintain access to this reinforcer, (3) failing to engage in this response within a specified period of time results in loss of the reinforcer, and (4) the behavior that avoids the loss must be maintained or increased along some dimension as a result. The two primary components of the loss avoidance contingency are the (1) avoidance of an event and (2) the loss of a stimulus. Taken separately and with differing effects compared to loss avoidance, these components are widely discussed in the literature in the procedures of avoidance contingencies (avoidance of an event) and negative punishment (loss of a stimulus). However, traditional avoidance contingencies and negative punishment are different procedures and produce different effects upon behavior when compared to the loss avoidance contingency. These procedures and others are discussed below to highlight these differences.

Conjugate Reinforcement Schedules

Some forms of conjugate reinforcement schedules, although not normally categorized as either an avoidance or negative punishment procedure, share similarities with the loss avoidance contingency. Conjugate reinforcement schedules are those in which the rate or intensity of a response is proportional to the magnitude of the reinforcement (Rapp, 2008). For example, low-force or slow responding produces low-magnitude reinforcement whereas high-force or rapid responding produces high-magnitude reinforcement.

While this description of conjugate reinforcement does not appear similar to loss avoidance, in some cases of conjugate schedules, a particular response rate is required to maintain access to certain magnitude of a reinforcer. For example, Lovitt (1968) utilized a conjugate reinforcement schedule to assess preference for music options. A preference assessment across musical selections was conducted at the start of the study. Participants were provided with a hand-switch on which they could respond to indicate preference and/or maintain access to selected musical pieces. Following the preference assessment, participants were presented with their preferred musical selection that could be maintained so long as the participant responded on the hand switch 120 times per minute. If the participant failed to meet this response requirement, the non-preferred musical stimulus would be presented. This arrangement not only assessed the extent to which participants would respond in order to access previously selected stimuli, but also preference through responding or not-responding. Results indicated that the participants' preference for various musical pieces was demonstrated by their responding to maintain (avoid loss) of one selection or their failure to respond to access the alternative option. Other studies (i.e., Fagen & Rovee, 1976; MacAleese, Ghezzi, & Rapp, 2015; Mira, 1969) have employed similar forms of conjugate schedules of reinforcement in which responding avoided the loss of a stimulus. Each of these studies showed that contingencies preventing the loss of a stimulus increased or maintained responding.

While these studies resemble the loss avoidance contingency, it is important to recognize the differences. Traditionally, as mentioned above, conjugate reinforcement schedules involve a relation between some dimension of the response and some dimension of the reinforcement. In most cases of the loss avoidance contingency, this is

not the case. The stimulus involved in a loss avoidance contingency typically does not vary along a dimension in relation to features of the response; its presence is simply maintained through the engagement of the response. Therefore, while some variations of conjugate reinforcement schedules resemble the loss avoidance contingency, the two are considered different.

Avoidance (from aversive stimuli) Contingencies

Avoidance contingencies, a form of negative reinforcement contingencies (S^{R-}), involve the presentation of an aversive stimulus, followed by a behavior that serves to avoid further presentations of that stimulus. By effectively avoiding the presentation of the aversive stimulus, the behavior is negatively reinforced and therefore its probability is increased. In the event that a behavior that has historically avoided the presentation of the aversive stimulus occurs and the stimulus is presented despite the behavior's occurrence, the behavior will likely be extinguished (S^{R-}_{EXT}) (Murray, Herrnstein, & Conrad, 1957).

Hineline and Rachlin (1969) presented a simple means of producing avoidance and escape responding of this nature. In their study, pigeons' escape-responding in the presence of shock was pre-trained. During experimental trials, pigeons were exposed to a 475s inter-trial period in which no shocks were delivered, and response keys were neither illuminated nor operative. At 475s, the response key light was illuminated and became operative to function as a warning stimulus. At 500s, if the pigeon had not yet responded, a shock was delivered and increased in intensity until the response occurred. If the pigeon engaged in a key-peck response during the presentation of the warning stimulus, the shock would be avoided for an additional 475s inter-trial interval. The results indicated

that these procedures effectively produced moderate to high frequencies of avoidance responding.

Procedures and results similar to Hineline and Rachlin (1969) can be found in abundance in the behavior-analytic literature. The loss avoidance contingency maps on well to these procedures, however there are differences worth noting. In standard avoidance arrangements, the response functions to avoid the presentation of an aversive stimulus. In loss avoidance contingencies, the response functions to maintain the presence of a stimulus. While both contingencies produce increased or maintained response rates, it is the stimulus change produced by the behavior that differentiates the two contingencies.

Response-Cost Procedures

The concept of “loss” within the behavior-analytic literature has traditionally referred to the loss of a reinforcer contingent upon the occurrence of specified behavior, also referred to as “response-cost” (e.g., Raiff, Bullock, & Hackenberg, 2008; Weiner, 1962). In these procedures, the loss of a reinforcer is contingent upon a particular behavior and the effect is a reduction in the probability of that behavior (Kazdin, 1972).

For example, Capriotti, Brandt, Ricketts, Espil, and Woods (2012) found that response-cost procedures (i.e., the removal of points contingent upon a response) effectively reduced the tic behaviors of individuals with Tourette syndrome. Conyers et al. (2004) found that response-cost procedures (i.e., contingent loss of stars on a board) effectively reduced disruptive behavior in preschool children. Studies have also shown that response-cost procedures are effective with nonhuman subjects. Pietras and Hackenberg (2005) found that token-loss (i.e., lights that had been conditioned as

reinforcers) was an effective procedure to reduce previously trained key-pecking behavior in pigeons.

Response-cost procedures involve the loss of a reinforcer like loss avoidance contingencies; however, these contingencies differ in two prominent ways. First, loss is contingent upon the occurrence of a behavior in response-cost, and upon the absence of behavior in loss avoidance. Second, response-cost produces a decrease in response probability while loss avoidance produces an increase in response probability.

Loss Avoidance Procedures

Some researchers have investigated behavior that operates to avoid the loss of a reinforcer², like that in loss avoidance. For example, D'Andrea (1971) utilized a variation of the time-out (TO) from positive reinforcement procedure using rats as subjects. Food pellets were delivered every 15s provided that the rat pressed the lever at least once within that interval. If the rat failed to respond within the interval, a one-minute period of TO from reinforcement occurred (food pellet delivery stopped). The results of the study were that response contingent avoidance of TO from reinforcement produced consistently high rates of responding.

Similarly, Baron and Kaufman (1966) presented four college students with an avoidance from TO from monetary reinforcement contingency. Participants were presented with a green light that blinked every four seconds, on average, and participants earned 63¢ per blink. During baseline, there was no interruption in the blinking light and there was no response requirement for the participants. During experimental trials, a TO

² In the studies reviewed, these procedures are often referred to as “avoidance from negative punishment.”

period of 15s occurred every 10s in which the green light would stop blinking and the participant stopped earning money. Key-press responses made during the 10s TO-TO interval avoided the presentation of the subsequent TO period. During baseline, minimal responding occurred across all participants. During experimental trials, all participants displayed a marked increase in responding to the point that nearly all TOs were successfully avoided.

Baer (1960) also implemented a procedure similar to the loss avoidance contingency to increase the responding of young children. The participants were presented with the opportunity to view cartoons. During experimental sessions, the cartoons were interrupted and if the participant pressed a bar during the interruption, the cartoon would be re-introduced. Participants could avoid the interruptions by pressing the bar before the interruptions and each bar-press produced 3s of avoidance from the interruption. Essentially, participants could “save up” viewing time through repeated and rapid bar-pressing. Results indicated that the contingency effectively produced avoidance responding, which was maintained for prolonged periods of time.

Stone (1961) compared the effects of an avoidance from aversive stimuli procedure to a loss avoidance procedure with undergraduate students. During the first condition, participants were exposed to shocks delivered through electrodes placed on the forearm every 20s. During the second condition, participants were given 100 pennies and every 20s, one penny would be removed if the participant failed to respond by pulling a response plunger. Results indicated that both procedures produced effective avoidance responding, although the shock procedure produced the most efficient rate of responding in slightly more participants than the loss procedure. This study was significant because it

showed the effects of a loss avoidance procedure as one that produces high rates of behavior and it compared these effects to those of a standard avoidance from aversive stimuli procedure.

Weiner (1962) employed a loss avoidance procedure with adult participants. Each participant was given 99,999 points at the start of the experiment. Every 10s, 20s point-loss periods (PLPs) were scheduled to occur in which participants would lose 86 points if they failed to engage in a key-press response to avoid the PLP. If the participant pressed the key during the 10s interval, no PLP occurred. The conditions were then switched to a response-cost contingency in which participants lost points for responding. The results indicated that the point-loss procedure during avoidance conditions produced higher response rates; much higher than were necessary to effectively avoid PLPs. Further, when conditions were altered wherein responses resulted in a response-cost rather than avoidance, responding was effectively reduced to near zero-levels for most participants.

The studies discussed above display loss avoidance contingencies as they are being presented here, although they are usually described by different names. All procedures used in these studies fulfill the defining characteristics of the loss avoidance contingency, described above. Further, many of these studies contrast the loss avoidance contingency with those that are most likely to be confused with loss avoidance. D'Andrea (1971) and Baron and Kaufman (1966) presented comparisons of the loss avoidance contingency to time-out, Stone (1961) compared loss avoidance to an avoidance from aversive stimuli, and Weiner (1962) compared loss avoidance to response-cost. These studies not only distinguish the loss avoidance contingency from others, but they all show

that the loss avoidance contingency is an effective means to increase or maintain responding.

Given that loss avoidance contingencies are a form of avoidance contingencies, they share the most commonalities with standard avoidance from aversive stimuli contingencies and are therefore considered to be forms of negative reinforcement. However, as discussed above, there are clear differences between loss avoidance and avoidance from aversive stimuli contingencies. While no aversive stimuli are present in loss avoidance contingencies, it is assumed that the event of loss (i.e., the experiences related to the removal of the relevant stimulus) has aversive properties, given that behavior occurs that serves to avoid this event. Therefore, loss avoidance contingencies will be discussed as a form of negative reinforcement, while keeping in mind that differences exist in this preparation compared to those commonly present in other negative reinforcement contingencies.

Comparison Studies

In most cases in which behavior is targeted for an increase or maintenance, positive reinforcement contingencies (hereafter referred to as “gain”) are in place. The literature discussed above illustrates that the loss avoidance contingency may also be an effective means to increase or maintain behavior, but limited research has been conducted within the behavior-analytic literature comparing the effects of these two contingencies.

Fryer, Levitt, List, and Sadoff (2012) conducted a study to compare loss and gain contingencies within a school district. Teachers in the district were placed in either the Loss group or the Gain group. Teachers in the Loss group were provided with \$4,000 at the start of the school year and signed a contract stating that if their students’ math scores

did not improve to a certain standard by the end of the year, they had to return the money. Teachers in the Gain group were given the opportunity to receive \$4,000 at the end of the school year if their students' math scores improved to the same standard. The results indicated that students of teachers in the Loss group performed significantly better than those in the Gain group. These findings suggest that loss avoidance contingencies may be more effective at increasing or improving behavior when compared to positive reinforcement contingencies.

Hirst, Dozier, and Payne (2016) also conducted a study that compared the effects of similar procedures. Preschool-aged children were assigned to either a differential reinforcement of other behavior (DRO) group or response-cost (more accurately described as loss avoidance) group. The target response for both groups was on-task behavior. Students in the response-cost group were given 10 tokens at the start of the sessions that they were working to maintain while students in the DRO group were given no tokens at the start but with the opportunity to earn up to 10 tokens. If students were on-task during observations that occurred, on average, every 30s, they were able to earn one token if in the DRO group or avoid the loss of one token if in the response-cost group. If the students were not on-task during the observations, they did not earn a token if in the DRO group or they lost a token if in the response-cost group. Results indicated both DRO and avoidance of response-cost procedures (loss avoidance) were equally effective in producing on-task behavior for most students.

Some researchers within behavior analysis have compared gain and loss contingencies with the use of concurrent reinforcement schedules. Concurrent reinforcement schedules are commonly used to assess the allocation of the participants'

response rate or time allocation across various operating contingencies. For example, Ruddle, Bradshaw, Szabadi, and Foster (1982) presented three adult human participants with concurrent variable-interval (VI) loss avoidance/positive reinforcement contingencies. Participants were presented with an array of different colored lights, each corresponding with various schedules of losses or gains. The participants were given a button switch in which pressing constituted a response within the various operating contingencies. Participants responded within a variety of VI-loss avoidance contingencies in component A and a standard VI-positive reinforcement (gain) schedule in component B of the concurrent schedule. Pressing the button while in the loss avoidance component avoided a loss of 1¢ while pressing the button in positive reinforcement component earned 1¢. The results indicated that as the frequency of signaled losses increased in component A, the response rate in component A increased while the response rate in the positive reinforcement component B decreased. The results were then applied to the matching law equation which indicated that response rates across alternatives “matched” the relative rate of negative (loss)/positive (gain) reinforcement. These findings support the notion that negative (loss) and positive (gain) reinforcement contingencies are functionally symmetrical; meaning, the two contingencies produce similar effects on responding.

Similarly, Magoon and Critchfield (2008) presented four undergraduate students with concurrent loss and gain schedules of reinforcement to assess if a bias existed across reinforcement type (i.e., negative vs. positive). Participants were presented with a display on a computer screen divided in half, each side corresponding with one of the two operating contingencies. The type of schedules employed were cycle schedules, in which

only the first response that occurs within an interval contacts reinforcement and if a response does not occur during the interval, no reinforcement is contacted. Under the gain contingency, if participants responded within the interval, they earned 1.5¢. In the loss contingency, if participants responded within the interval, they avoided the loss of 1.5¢. The values of the cycle schedule and proportion of reinforcement delivered across the concurrent contingencies varied across sessions. The operating schedules were either homogeneous (both positive) or heterogeneous (one positive, one negative). Results indicated that while rates of responding on heterogeneous concurrent schedules were slightly higher than on homogeneous schedules, no bias was observed between gain and loss contingencies.

Loss Aversion

Comparisons of the effects of losses versus gains have been addressed more substantially in the field of behavioral economics. The concept of loss aversion in behavioral economics states that a loss has a greater psychological impact than an equal gain (Baumeister, Bratslavsky, Finkenauer, & Vohs, 2001; Kahneman & Tversky, 1979). However, the research methods generally employed in behavioral economics related to such concepts are unlike those utilized in behavior analysis.

In most economic research exploring the concept of loss aversion, participants are presented with hypothetical loss and gain scenarios in a questionnaire-type format and asked to select which scenario they would rather experience (i.e., Chang & Chang, 2013; Kahneman & Tversky, 1979; Nishiyama, 2016). While this research has provided useful insight into phenomena of interest, it is unclear as to what feature of the participants' behavior is affected given such a selection of options. More specifically, from this

research, it is not evident as to how these contingencies affect behavior over time. Consider the popular claim based on loss aversion that, “Losses loom greater than gains.” (Kahneman & Tversky, 1984; Tversky & Kahneman, 1991). It is not apparent how this difference between losses and gains is observed in behavior. In the questionnaire-type format used in these studies, it appears what is actually being assessed is a preference for a potential situation.

In contrast, in most behavior-analytic research, the interactions between contingencies and behavior are assessed over time. Commonly, various features of contingencies are altered and the resulting changes in behavior are measured. From these types of analyses, conclusions regarding the effects of contingencies can be made with more confidence rather than being based on selections of single events. Without analyses regarding which features of a contingency and which features of behavior are producing an observed effect, an understanding of such phenomena is limited.

Purpose of the Present Study

Within any contingency outside of continuous reinforcement contingencies, there are occurrences of the related response that do not contact reinforcement. This may be due to intermittent schedules or changes in reinforcement frequency. Nonetheless, given a history of reinforcement, these instances can be considered that of extinction. The interaction of extinction and reinforcement has been considered to be an important variable of investigation in many phenomena such as contrast (Reynolds, 1961), resistance to extinction (Williams, 1938), features of the reinforcement history affecting the form of the response in extinction (Kelly & Hake, 1970; Margulies, 1961), and more.

Considering that both loss avoidance and gain contingencies are reinforcement contingencies, although of different type, (loss avoidance = S^{R^-} , gain = S^{R^+}), it may be the case that the effects of extinction in both contingencies may also reveal important information as to how these contingencies compare. In S^{R^+} contingencies, responses that contact reinforcement are positively reinforced while responses that fail to contact reinforcement are extinguished ($S^{R^+_{EXT}}$). In contrast, in avoidance contingencies, behavior that avoids the presentation of a stimulus is negatively reinforced (S^{R^-}), while instances in which the behavior fails to avoid the presentation of the stimulus contacts extinction ($S^{R^-_{EXT}}$) (de Villiers, 1972). Likewise, in loss avoidance contingencies, those responses that effectively avoid a loss are reinforced (S^{R^-}), and responses that experience a loss contact extinction ($S^{R^-_{EXT}}$). In comparing the effects of losses and gains, from a behavioral perspective, it appears that such a comparison should be made based on the function of the consequences. Meaning, the effects of instances of reinforcement in gain contingencies (Gains (S^{R^+})) should be compared to instances of reinforcement in loss contingencies (No-Losses (S^{R^-})). Also, instances of extinction in gain contingencies (No-Gains ($S^{R^+_{EXT}}$)) should be compared to instances of extinction in loss contingencies (Losses ($S^{R^-_{EXT}}$)) (see Idson, Liberman, & Higgins, 2000, for related discussion). While the studies described above presented comparisons of the effects of losses and gains (Fryer et al., 2012; Hirst, et al., 2016) and response allocation within concurrent arrangements of loss and gain contingencies (Magoon & Critchfield, 2008; Ruddle et al., 1982), no study to our knowledge has assessed the differences in the effects of instances of extinction and reinforcement within loss and gain contingencies. Therefore, the purpose of the present research is to provide such a comparison within a group design.

Experiment #1

Participants, Setting, and Materials

A total of 130 undergraduate students were recruited for the study through the University of Nevada's SONA system. Participants were offered one extra credit point in their course as well as monetary reimbursement (up to \$10.00³) based on their performance. Participants were randomly assigned to one of three groups: Loss, Gain, or Control.

Sessions took place in a room used for human operant experiments. The room contained a cubicle that prevented the participants from viewing the activities of the experimenter. The participants worked at a desk prepared with blank scrap paper, a pencil, and a bell. Experimenters used a desktop computer to collect data into an Excel file that calculated the time and percent correct for each trial, changes in criteria, and also informed the experimenter which, if any, consequence to deliver for each trial (see figures 1-3). Experimenters were provided with iPhones⁴ equipped with a voice-recording app able to record audio and display a visual representation of the sound waves recorded along with a time signature (figure 4).

Experimenters were also provided with worksheets to use for each trial throughout the study. The worksheets contained 16 addition and subtraction math problems (figure 5). Each worksheet contained two addition problems that required the use of carrying (addition-carry), four addition problems that did not require carrying (addition-non-carry), two subtraction problems that required borrowing (subtraction-

³ The U.S. minimum wage at the time of the study was \$8.25 per hour.

⁴ iPhones were purchased and used solely for this experiment.

borrow), four subtraction problems that did not require borrowing (subtraction-non-borrow), two single-integer addition problems, and two single-integer subtraction problems. These problem types were distributed randomly on the worksheets (figure 6). Each worksheet was numbered and delivered in the same order for each participant in every group. The experimenters were given answer sheets that were numbered the same as the worksheet with which they corresponded.

General Baseline Procedures

Upon starting the session, the experimenter read participants in all groups the following instructions:

“You will be completing simple math worksheets today. I will give you one worksheet and sit down on the other side of the wall to give you privacy and tell you when you may begin. Please wait for my “okay” to begin. When you are ready to begin, ring the bell and turn the worksheet over. Please do your best to answer correctly. There is scrap paper for you to use if needed. When you have completed the worksheet, ring the bell again and I will collect it and deliver your next worksheet. Please do not use your phone for a calculator or any other calculator. Please turn your phone off to prevent any distractions. Do you have any questions?”

Following the instructions, participants were delivered the first baseline trial worksheet faced-down. Once the experimenter returned to her/his seat and started recording, the experimenter said, “You may begin.” The participant rang the bell, turned the worksheet over, completed the worksheet, rang the bell again, and the experimenter stopped the recording. The experimenter entered the start and end times of the trial based on the spikes in the sound signature on the recording into the Excel file. The experimenter collected the completed worksheet, delivered the subsequent baseline worksheet faced-down, returned to her/his seat, started the recording, and instructed the participant to begin, as before.

While the participant completed the second worksheet, the experimenter graded the first worksheet using the answer sheet and entered the number of incorrect answers into the file, which calculated the percent correct for that trial. Once the participant rang the bell to indicate she/he completed the second baseline worksheet, the experiment repeated these steps until the participant completed three baseline worksheets. Following baseline trials, with the exception of Control sessions, participants were read the experimental instructions that corresponded to the group (Loss or Gain) they were assigned.

Loss Group Procedures

Prior to the start of Loss sessions, the experimenter placed 13⁵ one-dollar bills on a shelf at eye-level for the participant. The participants in the Loss group were read the following instructions:

“Here is your money for participating. It is \$13. You will now be working to maintain this money. If you do not complete the worksheet fast enough, you will lose \$1. If you complete the worksheet fast enough, you will not lose money. The amount that you have maintained at the end of the study, you will be able to take with you. Please do your best to answer correctly. Do you have any questions?”

An adjusting schedule (Mazur, 1986) was employed during all experimental trials. In the present study, the criterion for reinforcement adjusted for a subsequent trial if the participant satisfied the criterion for the previous trial. A criterion change value was set for the first loss trial that was 5%⁶ less than the participants' average duration during the

⁵ The number of 13 one-dollar bills was selected due to the fact that if participants experienced more than 12 losses, this would exclude their data set based on the exclusion criteria described below.

⁶ The criterion change value of 5% was determined by pilot research in which over the course of pilot sessions, participants who experienced nearly the same number of consequences as no-consequences reduced duration by roughly 5% per trial.

three baseline trials. Below is an example of how the criterion for loss trial #1 was calculated:

<i>Trial</i>	<i>Duration</i>
Baseline #1	50s
Baseline #2	45s
Baseline #3	58s
Baseline Average Duration	51s
Loss Trial #1 Criterion	48.45s

The experimenter conducted loss trials as she/he did during baseline. The file calculated if the participant completed the trial in a duration less than or greater than the criterion based on the baseline average. If the participant completed loss trial #1 in a duration less than the criterion (5% less than baseline average), the file calculated this difference, a cell changed color and stated, “NO LOSS,” the participant did not lose \$1, and the criterion for loss trial #2 would reduce by 5% from the previous criterion (see figure 1).

Trial #1 Criterion	48.45s	NO LOSS
Trial #1 Duration	45s	
Trial #2 Criterion	46.03s	

If the participant completed the trial in a duration greater than the criterion, the file calculated this difference, a cell changed color and stated, “LOSS,” and the experimenter removed \$1 from the participant’s funds, and the criterion for loss trial #2 remained the same. Following these outcomes, the worksheet for the next trial was delivered (see figure 1).

Trial #1 Criterion	48.45s	LOSS
Trial #1 Duration	54s	
Trial #2 Criterion	48.45s	

For every trial in which participants satisfied the criterion set by their performance on the previous trial, they did not lose \$1 and the criterion for the subsequent trial reduced by 5% of the previous criterion. For every trial in which participants did not satisfy the criterion, they lost \$1 and the criterion remained the same for the subsequent trial.

Trials continued in this manner until participants completed 19 Loss trials. Since the primary measure for the study is a trial comparison (described below), an odd number of experimental trials was required for the opportunity for participants to have an equal number of trial comparisons of consequences to no-consequences. In sum, participants completed 22 total trials in Loss sessions (three baseline, 19 Loss trials). Participants were able to take the money they had maintained during the study when they completed all 19 Loss trials.

Gain Group Procedures

Upon completing baseline trials, participants in the Gain group were read the following instructions:

“You will now be working to earn \$1.00 for each worksheet that you complete. If you complete the worksheet fast enough, you will earn \$1.00. If you do not complete the worksheet fast enough, you will not earn anything. At the end of the study, you will be able to take the money you have earned with you. Please do your best to answer correctly. Do you have any questions?”

As with the Loss group, the schedule employed during Gain sessions was an adjusting schedule within a changing criterion design. The criterion for the first gain trial following baseline was set at 5% less than the participants' baseline average, as in Loss group sessions. For each trial participants completed in a duration less than the criterion,

the file calculated this difference, a cell changed color and stated, “GAIN”, the criterion for the subsequent trial reduced by 5%, and the experimenter placed \$1 on the participants’ eye-level shelf (see figure 2).

Trial #1 Criterion	48.45s	GAIN
Trial #1 Duration	45s	
Trial #2 Criterion	46.03s	

If participants completed the trial in a duration greater than the criterion, the file calculated this difference, a cell changed color and stated, “NO GAIN”, they did not earn \$1 for the trial, and the criterion remained the same for the subsequent trial (see figure 2).

Trial #1 Criterion	48.45s	NO GAIN
Trial #1 Duration	54s	
Trial #2 Criterion	48.45s	

Trials continued in this manner until participants completed all 19 Gain trials, at which point, the session ended, and participants were able to take the money they earned. Participants in the Gain group completed 22 total trials, as those in the Loss group (three baseline, 19 Gain trials).

Control Group Procedures

Participants in the Control group were read the baseline instructions at the start of the session, as was the case for those in Loss and Gain groups. During control sessions, the experimenter entered trial duration and percent correct measures into the file, as was done in Loss and Gain sessions (see figure 3). Control participants completed all 22 worksheets in the same fashion as baseline trials. Meaning, after the initial three baseline trials, the experimenter did not read any additional instructions and no money was given during the trials. Once participants completed all 22 worksheets, the session ended, and

participants were given \$5 for participation. Participants in the control group were not informed of the receipt of \$5 prior to or during the session, but reimbursement based on performance was indicated in the SONA listing for recruiting participants.

Interobserver Agreement

Interobserver agreement (IOA) measures were collected to ensure the accuracy of data collection across experimenters. During supervised sessions, one research assistant was assigned to operate as the experimenter while another research assistant operated as the supervisor. A file was used in which the supervisor entered the trial duration and percent correct she/he recorded for each trial (figure 7). For trial duration measures, the supervisor recorded start and end times on a different iPhone for each trial separately from the experimenter and entered these times into the file. The file required the supervisor to enter a start and end time for each trial, which the file calculated the trial duration, similar to the file used by the experimenter. This function prevented the supervisor from simply copying the trial duration that was entered by the experimenter. A margin of error of $\pm 0.5s$ was applied to the difference of the experimenter's trial duration and the supervisor's trial duration and within which, the file calculated that the two were in agreement.

At the end of each trial, the experimenter wrote the trial duration she/he recorded for the trial and the number of incorrect problems on the worksheet and passed the worksheet to the supervisor to grade. The supervisor entered this information into the corresponding cells in the file and the file calculated if the supervisor and experimenter agreed or disagreed.

Data Collection

The following measures were collected during each session:

1. **Trial duration** – The start and end times for each trial were recorded and calculated as the trial duration. This was the critical measure as consequences for both Loss and Gain groups were contingent upon the participants' trial duration in relation to the current criterion.
2. **Percent correct** – The percent of correct math problems per trial was collected. Once sessions were completed, the average of each trials' percent correct was calculated for the total session percent correct. The participants' measures on percent correct did not affect the consequences that occurred during the session, however, this measure was part of the exclusion criteria for the data set (described below).
3. **Number of consequences and no-consequences per session** – For each type of session that involved consequences (Loss and Gain groups), the total number of consequences and no-consequences (Losses and No-Losses in the Loss group; Gains and No-Gains in the Gain group) were recorded. Since there were 19 experimental trials and the data of interest were trial comparisons, it was possible for participants to have any ratio of consequences to no-consequences that would total 18 trial comparisons at the end of their session.
4. **Percent change in relative duration by consequence type** – The percent change in relative duration between trials by consequence type was the primary dependent measure in the study. For this measure, the change in duration between two trials was calculated as a percent. For example, if a participant completed trial

#1 in a duration of 50s and trial #2 in a duration of 40s, this would constitute a 20%⁷ change in duration from trial #1 ($50 - 40 = 10$; $10/50 = .2 \times 100 = 20\%$). If the participant completed trial #1 in a duration of 50s and trial #2 in a duration of 60s, this would constitute a -20% change in duration from trial #1 ($50 - 60 = -10$; $-10/50 = -.2 \times 100 = -20\%$). This number was then categorized based on the consequence the participant received following the first trial in the comparison. If the participant experienced a loss following trial #1 and displayed a 20% change in duration on trial #2, this would constitute a 20% change in duration following a loss. In other words, a loss resulted in the participant completing the subsequent trial 20% faster than the previous trial.

Trial #1 Criterion	48s	Loss
Trial #1 Duration	50s	
Trial #2 Duration	40s	
Duration Difference	+20%	
Measure	Loss +20%	
Interpretation	Participant reduced duration by 20% from previous trial following a Loss.	

Trial #1 Criterion	55s	No-Loss
Trial #1 Duration	50s	
Trial #2 Duration	60s	
Duration Difference	-20%	
Measure	No-Loss -20%	
Interpretation	Participant increased duration by 20% from previous trial following a No-Loss.	

⁷ Reductions in duration are listed as a positive change due to the fact that in this type of change, the participant completed the subsequent trial faster than the preceding trial. Increases in duration are listed as negative changes because for these changes, the participant worked slower on the subsequent trial.

Exclusion criteria. Exclusion criteria were set to remove those data sets in which the participant failed to respond with some degree of accuracy to the math problems or the participant's responding was not affected by the operating contingencies. Response patterns that were considered to not be affected by the contingencies were observed in sessions in which the participants' duration remained the same or became slower over the course of the session, which was evident by the ratio of consequences to no-consequences that the participant experienced. The exclusion criteria were:

1. **The participant must achieve an average of at least 70% correct or higher over the course of the session.** This criterion was set to remove data sets in which participants submitted irrelevant answers (i.e., answering all questions with "1", answering by drawing shapes, turning in blank worksheets, etc.).
2. **The participant must have experienced between a 2:1 or 1:2 ratio of consequences to no-consequences over the course of the session.** In order to be included in the data set, participants must have experienced at least a 2:1 or 1:2 ratio of consequences to no-consequences. Since a total of 18 trial comparisons were recorded during sessions, the participant could not experience more than 12 or less than six of any consequence type to meet this criterion. This criterion was to ensure that comparisons made based on consequence type were being drawn from relatively equivalent pool sizes.

Experiment #1 Results

Twenty-two of 130 data sets (20% of the total data pool) did not meet the exclusion criteria. Therefore, the remaining data pool consisted of the 108 participants'

data that met the exclusion criteria. The majority of participants who failed to meet the exclusion criteria did so by either substantially reducing duration following the experimental instructions resulting in contacting reinforcement following the majority (i.e., >12) trials, or failing to reduce duration following instances of extinction resulting in a disproportionate number (i.e., >12) of extinguished trials. Interobserver agreement measures were collected on 35.2% of the total number of data sets collected across the three groups. The average score for the experimenters' agreement on trial duration was 97% and the average score for percent correct was 99%.

Within-Subjects Comparisons

Loss group. Data for the loss group ($N = 36$) are summarized in table 2 and displayed in figure 8. Data from the Loss group were divided based on the participants' change in relative duration following Losses (L) and No-Losses (NL). On average, participants experienced nearly the same number of Losses and No-Losses per session ($L = 9.3$, $NL = 8.7$). A paired T-test was performed to assess the within-subject differences in the mean percent change in relative duration following Losses and No-Losses. The results indicate that the difference following Losses ($M_L = 5.2\%$, $SD = .03$) compared to No-Losses ($M_{NL} = -6.3\%$, $SD = .04$) is significant ($t(35) = 12$, $p = <.001$).

Participants in the Loss group generally displayed similar trends and patterns in their data (see figure 9 for example of individual data set). The first pattern noted was a substantial reduction in duration following baseline trials and receiving the experimental instructions. This is contributed to the effects of rules being that the experimental instructions included the statement, "If you do not complete the worksheet fast enough, you will lose \$1." This reduced duration following baseline generally maintained over the

course of a roughly three to five trials, resulting in these trials avoiding losses. At this point, the criterion had reduced to a value in which participants began contacting losses, which resulted in a reduced duration on subsequent trials (see figure 10 for example). Throughout the remainder of trials, most losses produced a reduction in duration on the subsequent trial. Alternatively, trials that avoided losses (no-losses) produced a greater duration on the subsequent trial.

Gain group. Data for the Gain group ($N = 36$) are summarized in table 2 and displayed in figure 11. Like the Loss group, data from the Gain group were divided based on the percent change in relative duration following Gains (G) and No-Gains (NG). On average, participants experienced the same number of Gains and No-Gains during sessions ($G = 9$, $NG = 9$). As with the Loss group, a paired T-test was performed to assess the within-subject differences in the mean percent change in relative duration following Gains and No-Gains. The results of the paired T-test indicate that the difference following Gains ($M_G = -6.2\%$, $SD = .04$) compared to No-Gains ($M_{NG} = 5.6\%$, $SD = .04$) is significant ($t(35) = -9.4$, $p = <.001$).

Participants in the Gain group generally displayed similar trends and patterns in their data as those in the Loss group (see figure 12 for example of individual data set). Participants generally displayed the same substantial reduction in duration following baseline and receiving the experimental instructions. This reduced duration following baseline generally maintained over the course of a roughly three to five trials resulting in these trials earning gains, at which point, the criterion had reduced to a value in which participants failed to gain following trials, which resulted in a reduced duration on subsequent trials. Throughout the remainder of trials in the session, most trials followed

by a No-Gain produced a reduction in duration on the subsequent trial, while trials that were followed by a Gain produced a greater duration on the subsequent trial. The same experimental control displayed in the Loss group was observed in the Gain group (see figure 13 for example).

Control group. Data for the Control group ($N = 36$) are displayed in figure 14. The results from the mean percent change in relative duration for the control group was -0.81% ($SD = .016$). Unlike Loss and Gain groups, data collected from the Control group were not divided based on the occurrence of consequences, as no consequences occurred in control sessions. Therefore, measures collected from the Control group display the effect the task had on participants' behavior in the absence of consequences.

Participants in the Control group displayed distinct patterns when compared to the trends present in the data from the Loss and Gain groups. No substantial change in duration was observed in the first few trials as there was for Loss and Gain groups (figure 15). Additionally, rather than reducing duration over the course of the study in response to a changing criterion, participants in the Control group generally maintained similar or longer durations per trial over the course of the session (see figure 16 for an example of an individual data set).

Between-Groups Comparisons

A one-way ANOVA was conducted to compare the effects of each consequence in both experimental groups (L, NL, G, NG) and the control group on percent change in relative duration (table 3). There was a significant difference between groups and within groups at the $p < .05$ level [$F(4, 175) = 98.92, p < .001$].

The data selected for comparison across groups is based on the function of the various consequences. The data from trials following instances of extinction in both groups were compared: Losses (S^{R-}_{EXT}) in the Loss group were compared to the data from trials following No-Gains (S^{R+}_{EXT}) in the Gain group. Alternatively, data from trials following instances of reinforcement in both groups were compared: No-Losses (S^{R-}) in the Loss group were compared to the data from trials following Gains (S^{R+}) in the Gain group.

In order to assess these differences, independent T-tests were conducted. The results indicate that differences between Gains (S^{R+}) and No-Losses (S^{R-}) were not significant, $t(70) = -.07, p = .944$. The differences between Losses (S^{R-}_{EXT}) and No-Gains (S^{R+}_{EXT}) were also not significant, $t(70) = -.51, p = .612$. These data indicate that no significant difference is observed between the effects of instances of reinforcement or between the effects of instances of extinction in gain and loss avoidance contingencies (figure 17).

Experiment #1 Discussion

The purpose of experiment #1 was to compare the effects of instances of both reinforcement and extinction within loss avoidance and gain contingencies. The gain contingency implemented in the study was a positive reinforcement contingency while the loss avoidance contingency was a negative reinforcement contingency. The effects produced by reinforcement and those by extinction within each group were nearly identical, despite the contingencies being opposite in nature. These results are in line with previous works related to the comparison of loss and gain contingencies that have been

conducted within behavior-analysis. As outlined above, Hirst et al. (2016) compared the effects of DRO (gain) and avoidance of response-cost (loss) procedures on the on-task behavior of school-aged children and found the two procedures to be equally effective. Additionally, these results are similar to those found in studies assessing loss and gain under concurrent schedules of reinforcement (Magoon & Critchfield, 2008; Ruddle et al., 1982).

An aspect of these results that warrants discussion is the change in duration following both reinforcement and extinction. It is traditionally understood that instances of reinforcement increase the frequency of a response by which it was produced. However, as is evident in the results of this study, instances of reinforcement (No-Losses and Gains) generally produced a negative change in duration in which the participant completed the subsequent trial whereas instances of extinction (Losses and No-Gains) produced a positive change in duration in which the participant completed the subsequent trial. There are a number of potential reasons as to why this effect occurred.

First, these effects may be related to issues of rule-governance. The instructions at the start of each experimental condition made reference to the contingencies (“If you do not work fast enough...”). While no further information was given to the participant, instances of extinction may have served a discriminative function over a reduced duration on subsequent trials. During the first few trials following these instructions, most participants contacted reinforcement. Generally, the first trial was completed in a much shorter duration than the baseline average and gradually increased over the next few trials as participants continued to contact reinforcement. Once participants experienced extinction for the first time, their duration quickly reduced. Traditionally speaking,

instances of reinforcement provided no information regarding the current criterion whereas instances of extinction signified some aspect of the criterion. Future research should investigate the role of rule governance in loss avoidance and gain contingencies to provide more information on this issue.

Second, an initial increase in intensity and/or rate is a well-established characteristic of behavior undergoing extinction (e.g., Kelly & Hake, 1970; Margulies, 1961; Pierce & Cheney, 2008). This effect is evident in the data following trials in which the participant experienced a Loss as well as those following No-Gains, demonstrating that these consequences, as they occur within relevant contingencies, are instances of extinction. Being that participants only experienced extinction following generally up to three to five consecutive trials, it is not evident how these effects would sustain over an extended number of trials. It is likely, given repeated instances of extinction, the participant would stop responding entirely. However, this effect of extinction generally allowed for participants to contact reinforcement on subsequent trials, therefore, an extended number of extinguished trials was prevented. These results might contribute to the literature related to the immediate increasing effects of extinction.

Experiment #2

Purpose, Participants, Setting, and Materials

There were two purposes of experiment #2. The first purpose was to produce within-subjects comparisons of the effects of reinforcement and extinction components of loss avoidance and gain contingencies across the same measures in experiment #1. This comparison assessed if participants displayed unique patterns of responding across the

two contingencies. The second purpose was to investigate any differences that existed between each consequence type (G, NG, L, NL) based on the sequence of their presentation in relation to the opposing contingency.

Forty-three participants were recruited for experiment #2 through UNR's SONA system. Participants were randomly assigned to one of two groups: Loss-Gain group (LG) or Gain-Loss (GL) group⁸. Twenty-one participants were assigned to the GL group and 22 participants were assigned to the LG group. Participants were provided with one extra credit point for their course, and up to \$10 reimbursement based on their performance. Sessions for experiment #2 took place in the same experimental room as in experiment #1.

The materials for experiment #2 were the same as for experiment #1, with the exception of the worksheets used for trials. The worksheets used in experiment #2 were of the same format as those in experiment #1, however, participants were required to complete three baseline worksheets, 11 worksheets for experimental condition #1, and 11 worksheets for experimental condition #2. Therefore, participants in experiment #2 completed 25 worksheets per session instead of the 22 worksheets completed per session in experiment #1.

The worksheets used for experiment #2 were printed on different colored paper corresponding to the different conditions (baseline, condition #1, condition #2). Baseline worksheets were printed on white paper, condition #1 worksheets were printed on pastel orange paper, and condition #2 worksheets were printed on pastel blue paper. The

⁸ In order to combat potential sequence effects (Gast, 2010), the groups were divided based on opposing sequences of the conditions.

different colored paper was used to aid in discrimination across the diverse contingencies that were presented across experimental conditions. The colors of the worksheets were not assigned to particular conditions; instead the order of the color of the worksheets was always white, orange, then blue regardless of the group.

General Baseline Procedures

At the start of sessions for both groups, participants were read the same baseline instructions as experiment #1. Three baseline trials were conducted as they were in experiment #1.

Loss-Gain Group Procedures

Following baseline trials, participants in the LG group were presented with the Loss condition.

Loss condition #1 description. Prior to sessions beginning for the LG group, the experimenter placed seven \$1 bills on the eye-level shelf at the participant's workspace, as was done in experiment #1. Following the submission of the third baseline worksheet, the experimenter read the same instructions as the Loss group in experiment #1 and began running trials in the same manner.

Establishing criterion change value. In experiment #1, a pattern was evident in which after receiving experimental instructions following baseline trials, most participants' trial duration substantially reduced. This occurred prior to any consequence and was likely an effect produced by the portion of the instructions that read, "If you do not complete the worksheet fast enough..." While this effect did not appear to be an issue in experiment #1, with the reduced number of experimental trials in experiment #2 across

the two conditions, this reduction in duration may have allowed participants to avoid consequences following the majority of trials in condition #1.

To resolve this issue, the criterion change value was conditional upon the percent difference between the participants' baseline average (BL) and their first experimental trial time (T_1). As the difference between the participants' baseline average and first experimental trial ($\frac{BL}{T_1}$) increased, the greater the criterion change value for condition #1.

If $\frac{BL}{T_1} < 10\%$, the criterion change value was set at 5%. If $10\% \leq \frac{BL}{T_1} < 20\%$, the criterion change value was set at 7.5%. If $\frac{BL}{T_1} \geq 20\%$, the criterion change value was set at 10%.

Participants completed 11 loss trials following baseline that were carried out similarly to the Loss group in experiment #1. Eleven experimental trials allowed for a potential even number of trial comparisons (i.e., five losses, five no-losses). Once the participant completed 11 Loss trials, the Gain condition began.

Gain condition #2 description. At the start of the Gain condition, the experimenter read the same experimental instructions as the Gain group in experiment #1.

Establishing criterion change value for condition #2. In order to establish the criterion change value for condition #2, a different method had to be used than that used for condition #1. The baseline condition that was used to establish an initial criterion for condition #1 could not be repeated for condition #2 because participants' duration had substantially reduced during condition #1, which would affect their performance on a second baseline condition. Therefore, the trial durations for the last three trials in

condition #1 (C_1 trials #9-11) were used to produce an average time upon which to base the criterion change value for the first trial in condition #2.

In order to compensate for the effects of the condition #2 instructions, as in condition #1, the criterion change value was conditional based on the difference in trial duration between the first trial in condition #2 (C_{2_1}) and the average of the last three trials of condition #1 ($C_{1_{9:11}}$). The percent difference between C_{2_1} and $C_{1_{9:11}}$ and was calculated as $(100\% - (\frac{C_{2_1}}{C_{1_{9:11}}}))$. If $(100\% - (\frac{C_{2_1}}{C_{1_{9:11}}})) \geq 15\%$ ⁹, the criterion change value was set at 5%; if $(100\% - (\frac{C_{2_1}}{C_{1_{9:11}}})) < 15\%$, the criterion change value was set at 2.5%. The purpose of this strategy was the same as in condition #1 in which its use prevented participants from contacting reinforcement following the majority of trials so as to produce as equal comparison of consequence to no-consequence experiences as possible. Participants completed 11 Gain trials in a similar fashion to those in the Gain group in experiment #1, at which point, the session ended, and the participant was able to take the money that was acquired throughout the course of the session.

Gain-Loss Group Procedures

Gain condition #1 description. If participants were assigned to the GL group, they were read the Gain instructions from experiment #1 after baseline trials. The trials for the Gain condition were carried out in the same manner as the Gain group in experiment #1. The method for establishing the criterion change value was the same as

⁹ The value of $\frac{C_{2_1}}{C_{1_{9:11}}}$ being greater or less than 15% was determined through pilot research in which participants who reduced duration by 15% or more on C_{2_1} avoided extinction in the majority trials in condition #2, while those who reduced duration by less than 15% on C_{2_1} experienced extinction following the majority of trials in condition #2.

the LG group, described above. After participants completed 11 trials in the Gain condition, the Loss condition began.

Loss condition #2 description. At the start of the Loss condition, the experimenter placed seven \$1 bills on the participant's shelf and read the same Loss instructions as the Loss group in experiment #1. The criterion change value for the Loss condition was calculated in the same manner as it was for the Gain condition for the LG group. Trials were conducted the same as in Loss conditions described above.

Participants completed 11 trials in the Loss condition, at which point, the session ended, and participants were allowed to take the money they had acquired over the course of the session.

Interobserver Agreement

Interobserver agreement measures were taken in the same manner as experiment #1.

Data Collection

The measures recorded during experiment #2 were the same as experiment #1: (1) trial duration, (2) percent correct, (3) number of consequences and no-consequences per session, and (4) percent change in relative duration by consequence type.

Experiment #2 Results

The results from experiment #2 are summarized in tables 5-6 and displayed in figures 18-24. Interobserver agreement measures were taken on 38% of all sessions conducted in experiment #2. The average IOA measures were 98% for trial duration and 96% for percent correct.

Within-Subjects Comparisons

Within-subject comparisons were made in order to assess any differences that existed between the effects of reinforcement across both contingencies and the effects of extinction across both contingencies. Independent T-tests were conducted to assess these differences.

Loss-Gain group. As was performed in experiment #1, the reinforcement (No-Loss and Gain) and extinction (Loss and No-Gain) components of the LG group were compared (figure 18). On average, participants in the LG group experienced nearly the same number of each type of consequence per session (L = 5.6, NG = 5.3, NL = 4.4, G = 4.7). For the reinforcement components, no significant difference was observed in the mean percent change in relative duration between No-Losses in condition #1 ($M_{NLI} = -6.8\%$, $SD = .08$) and Gains in condition #2 ($M_{G2} = -7.4\%$, $SD = .09$), $t(42) = .24$, $p = .811$. For the extinction components, no significant difference was observed in the mean percent change in relative duration between Losses in condition #1 ($M_{LI} = 4.3\%$, $SD = .06$) and No-Gains in condition #2 ($M_{NG2} = 6.3\%$, $SD = .05$), $t(42) = -1.21$, $p = .233$.

At the level of the individual, the trial duration for each participant in the LG group systematically reduced with the changing criterion, as was observed in experiment #1 (see figure 19 for example of individual data set). Another pattern that was observed in the LG group was that the participants' percent change in relative duration by consequence type was similar to that in experiment #1. Following instances of reinforcement (No-Losses (C₁) and Gains (C₂)), participants' duration increased, while following instances of extinction (Losses (C₁) and No-Gains (C₂)), participants' duration reduced, as in experiment #1 (see figure 20 for example of individual data set).

Gain-Loss group. Reinforcement and extinction components were also compared for the GL group (figure 21). Similar to the LG group, on average, participants in the GL group experienced nearly the same number of each type of consequence per session (NG = 5.2, L = 5.4, G = 4.8, NL = 4.6). For the reinforcement components, no significant difference in the mean percent change in relative duration was observed between Gains in condition #1 ($M_{GI} = -7.0\%$, $SD = .07$) and No-Losses in condition #2 ($M_{NL2} = -6.6\%$, $SD = .06$), $t(40) = -.2$, $p = .842$. For the extinction components, no significant difference in the mean percent change in relative duration was observed between No-Gains in condition #1 ($M_{NG1} = 7.8\%$, $SD = .07$) and Losses in condition #2 ($M_{L2} = 8.3\%$, $SD = .07$), $t(40) = -.26$, $p = .796$.

At the level of the individual, the trial duration for each participant in the GL group systematically reduced with the changing criterion, as was observed in experiment #1 (see figure 22 for example of individual data set). Participants in the GL group also displayed the same patterns following each consequence type as the LG group and in experiment #1. Following instances of reinforcement (Gains (C_1) and No-Losses (C_2)), participants' duration increased, while following instances of extinction (No-Gains (C_1) and Losses (C_2)), participants' duration reduced, as in experiment #1 (see figure 23 for example of individual data set).

These results indicate that no significant difference existed between reinforcement components (Gains (S^{R+}) and No-Losses (S^{R-})) regardless of the sequence in which the contingencies were presented. The same was true for the extinction components of each contingency (Losses (S^{R-EXT}) and No-Gains (S^{R+EXT})), regardless of the sequence in which the relevant contingencies were presented.

Between-Groups Comparisons

Independent T-tests were performed to assess any differences observed in the effects of each consequence types between groups based on the order in which they occurred.

In comparing the effects of Gains in condition #1 in the GL group ($M_{G1} = -7.0\%$, $SD = .07$) and Gains in condition #2 in the LG group ($M_{G2} = -7.4\%$, $SD = .09$), no significant difference was observed ($M_{G1}-M_{G2} = .44\%$, $t(41) = .18$, $p = .858$). For the effects of No-Gains in condition #1 in the GL group ($M_{NG1} = 7.8\%$, $SD = .07$) and No-Gains in condition #2 in the LG group ($M_{NG2} = 6.3\%$, $SD = .05$), no significant difference was observed ($M_{NG1}-M_{NG2} = 1.4\%$, $t(41) = .79$, $p = .434$).

In comparing the effects of No-Losses in condition #1 for LG group ($M_{NL1} = -6.8\%$, $SD = .08$) and No-Losses in condition #2 for the GL group ($M_{NL2} = -6.6\%$, $SD = .06$), no significant difference was observed ($M_{NL1}-M_{NL2} = -.25\%$, $t(41) = -.12$, $p = .905$). In assessing the effect of Losses in condition #1 in the LG group ($M_{L1} = 4.3\%$, $SD = .06$) and Losses in condition #2 in the GL group ($M_{L2} = 8.3\%$, $SD = .07$), differences observed were significant ($M_{L1}-M_{L2} = 4.0\%$, $t(41) = -2.05$, $p = .047$).

These results indicate that across each consequence type (G, NG, L, NL), no significant difference existed based on whether the contingency was operating during condition #1 or #2, with the exception of Losses (see figure 24). When participants experienced Losses in condition #2 in the GL group, after operating within the gain contingency, participants' duration reduced nearly twice as much as in those who experienced Losses in condition #1 in the LG group ($M_{L1} = 8.3\%$, $M_{L2} = 4.3\%$). These findings suggest that given an immediate history of operating within a positive

reinforcement (gain) contingency, losses produce a greater effect on participants' responding than losses without such a history.

Experiment #2 Discussion

The purpose of experiment #2 was to provide a within-subject comparison of the effects reinforcement and extinction across gain and loss avoidance contingencies. The results per consequence type, in terms of change in relative duration, are similar to those that were found in experiment #1. The effects of instances of reinforcement and extinction were similar across both gain and loss contingencies, regardless of the sequence in which the contingencies were presented. In sum, participants' responding was not found to be more or less sensitive to the effects of gains or losses.

An interesting finding of this study was that Losses produced significantly greater effects on participants' responding when the loss avoidance contingency was presented following a gain contingency. One potential reason as to why this difference occurred is related to the amount of funds the participant received at the start of the Loss conditions. Participants in the LG group were given \$7 at the start of the loss condition #1. Participants were given the same amount at the start of the loss condition #2 in the GL group, however, these participants had already earned funds from the initial Gain condition, although these funds were not affected by the loss condition #2. Further, losses in the LG group also produced a less significant effect than those in experiment #1, who were also presented with the loss avoidance contingency without a previous gain contingency. Participants in experiment #1, however, were given \$13 at the start of the study, almost twice the amount (\$7) of those in the LG group in experiment #2. This may

be due to the effects of various reference points in which the amount of funds participants had acquired prior to loss conditions impacted the effect of losses on their behavior.

One feature of this study that should be investigated in future research is how the funds earned during Gain as condition #1 were not able to be lost during the subsequent Loss condition in the Gain-Loss group. If the funds earned in an initial Gain condition were subject to loss in a subsequent loss contingency, this may produce diverse effects following instances of Loss. Future research should investigate how participants respond to Losses when the reinforcers that are lost are delivered non-contingently, as in this study, versus those that have been earned.

Given these results, it is concluded that loss avoidance and gain contingencies produce similar effects on individual participant's responding. Further, from these results, it is concluded that individuals' responding is not more sensitive to losses compared to gains, and vice versa. Instead, it is assumed that individuals tend to respond similarly to instances of reinforcement and extinction, regardless of the type (positive or negative reinforcement) of contingency operating.

General Discussion

There were a number of aims of the present line of research. First, these studies were conducted in order to direct attention to an otherwise overlooked contingency in behavior analysis: the loss avoidance contingency. The loss avoidance contingency may be argued to naturally occur as commonly as other contingencies, although with limited empirical or theoretical investigation. The results of the present experiments indicate that

not only does the loss avoidance contingency effectively maintain behavior, it does so to the same degree as positive reinforcement contingencies.

Another purpose of the present line of research was to provide a comparison of the effects of losses and gains. In order to make such a comparison, consequences were interpreted based on their function. When taken from a functional perspective, it was observed that effects of reinforcement were nearly identical across loss and gain contingencies, as were the effects of extinction.

The last purpose of these experiments was to provide a behavior-analytic account of the economic concept of loss aversion. As discussed above, claims related to loss aversion state that losses have a greater psychological impact than equal gains. However, the methods used in this research and interpretation of related results differ from those in behavior analysis. The present studies offered means to assess behavior related to the events of losses and gains from a behavior-analytic methodology. Surprisingly, the results of the present studies, replicated across two separate arrangements, did not support the assumptions of loss aversion. These differences may be due to a few reasons.

First, in the present studies, the effects of losses and gains upon responding were interpreted from a functional perspective, as discussed above. Through this perspective, we find that the relevant aspects of the comparison are not between the effects of losses and gains, but rather effects of reinforcement (No-Losses (S^{R-}) to Gains (S^{R+})) and the effects of extinction (Losses (S^{R-EXT}) to No-Gains (S^{R+EXT})). In contrast, in research related to loss aversion, losses and gains were compared. As presented in the results of the present studies, the comparisons of losses and gains did in fact produce substantially different results, in line with the conclusions of the economists (figure 17). However,

from a functional perspective, these were not the appropriate data to be compared. Instead, it is more appropriate to make comparisons across groups based on the effects of reinforcement and extinction. When interpreted from this perspective, the effects of the contrasting contingencies are nearly identical.

Second, in the work related to loss aversion, participants responded to verbal statements (textual) related to hypothetical scenarios of losses and gains. However, no measures related to the actual events of losses and gains upon behavior were measured. From a behavioral perspective, these measures are related to the stimulus control exerted from a choice arrangement of textual options. The present studies differ from those regarding loss aversion in that they were not assessments of stimulus control across alternatives, but instead, assessments of the effects of the contrasting contingencies on responding over time. This issue also relates to the difference in effects produced by verbal rules and direct-acting contingencies with respect to losses and gains. Substantial research in behavior analysis has indicated that behavior operates differently when under the control of verbal rules than under direct-acting contingencies (e.g., Galizio, 1979; Hayes, Brownstein, Zettle, Rosenfarb, & Korn, 1986). Further research should investigate how individuals respond to verbal rules related to losses and gains and compare these findings to the effects of the direct-acting contingencies upon the individuals' responding. Also, future research should investigate participants' preference for the opposing contingencies. For example, in experiment #2 of the present research, this could have been achieved by asking the participants which condition (i.e., orange or blue worksheets) they preferred. The results of an assessment of this type may be more relevant for a comparison to the results related to loss aversion.

A third possible contributing factor to the differences observed in the current research compared to the findings related to loss aversion is in the occurrence and immediacy of actual consequences. In the loss aversion research, the scenarios were hypothetical in nature and no actual consequences occurred. In contrast, participants in the present research experienced consequences following each trial and these trials occurred at a high frequency (i.e., the average trial duration for most participants was less than one minute). This high frequency also allowed for minimal delay between the participants' performance and the consequence, which might have also contributed to the diverse results as it has been shown that gains and losses are discounted differently across delays (McKerchar, Pickford, & Robertson, 2013; Murphy, Vuchinich, & Simpson, 2001).

Fourth, the magnitude of the consequences may have contributed to these differences. In studies regarding loss aversion, the scenarios often include large sums of money or other highly valuable outcomes. In the present study, however, the magnitude of reinforcement per trial was relatively small (\$1.00). Harinck, Dijk, Beest, and Mersmann (2007) displayed that the magnitude of losses and gains directly affects the display of loss aversion. In their study, they found that when losses and gains were based on small monetary amounts (i.e., €0.10 and €0.50) that gains produced a stronger effect than equal losses and that the "happiness" participants experienced after receiving a small gain was greater than the "unhappiness" that was experienced after an equivalent loss.

There were a number of limitations, beyond those mentioned above, in the present studies that should be considered. First, procedural integrity measures were not taken during supervised sessions. During pilot research, procedural integrities measures were

attempted to be taken, in addition to IOA measures, however, doing so interfered with the experimental procedures. For future research, a potential solution for this problem would be the use of video recording sessions. Through the use of video, supervisors could observe the recording of the session and grade the procedural integrity of the experimenter and provide feedback contingent upon her/his performance.

Second, those in the control group did not receive the same experimental instructions as those in the Loss and Gain groups. This is a confound due to the fact that the experimental instructions appear to have produced a substantial effect on participants' responding after their presentation. Future research should investigate the effects of the same instructions in the Loss and Gain groups delivered to the control group, although without any actual consequences occurring during control sessions.

The experiences of losses and gains can be complex issues in human behavior. The results of the present research display effects that directly contrast those of more popular views. These differences in findings emphasize the complexity of these issues. Being such common experiences, much is left to be understood about these issues. Researchers in behavior analysis should continue to investigate the effects of losses and gains so as to further contribute to our understanding of these events.

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Tables

<i>Contingency</i>	<i>Antecedent</i>	<i>Behavior</i>	<i>Consequence</i>	<i>Effect on Behavior</i>
Positive Reinforcement	Absence of reinforcing stimulus	Behavior	Presentation of reinforcing stimulus	Increase in probability
Negative Reinforcement	Presence of aversive stimulus	Behavior	Avoidance or termination aversive stimulus	Increase in probability
Loss Avoidance	Presence of reinforcing stimulus	Behavior	Maintenance of reinforcing stimulus	Increase in probability

Table 1: Description of positive and negative reinforcement contingencies compared to the loss avoidance contingency.

<i>Group</i>	<i>Consequence</i>	<i>M</i>	<i>SD</i>	<i>t</i>	<i>df</i>	<i>p</i>
Loss	Losses	5.2%	.03	12	35	<.001
	No-Losses	-6.3%	.04			
Gain	Gains	-6.2%	.04	-9.4	35	<.001
	No-Gains	5.6%	.04			

Table 2: Within-subjects comparisons (paired T-tests) of each consequence type in Loss and Gain groups in experiment #1.

	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>p</i>
Between Groups	0.49	4	0.1214	98.92	<.001
Within Groups	0.21	175	0.0012		
Total	0.70	179			

Table 3: Results of the one-way ANOVA conducted for each consequence type and control conditions in experiment #1.

<i>Consequence</i>	<i>fx</i>	<i>M</i>	<i>SD</i>	<i>t</i>	<i>df</i>	<i>p</i>
Losses	S ^{R-EXT}	5.2%	.03	-.51	70	.612
No-Gains	S ^{R+EXT}	5.6%	.04			
No-Losses	S ^{R-}	-6.3%	.04	-.07	70	.944
Gains	S ^{R+}	-6.2%	.04			

Table 4: Results of the Independent T-tests for between groups comparisons of extinction components (Losses & No-Gains) and reinforcement components (No-Losses & Gains) in experiment #1.

<i>Group</i>	<i>Consequence</i>	<i>fx</i>	<i>Condition</i>	<i>M</i>	<i>SD</i>	<i>t</i>	<i>df</i>	<i>p</i>
Loss-Gain	No-Losses	S ^{R-}	1	-6.8%	.08			
	Gains	S ^{R+}	2	-7.4%	.09	.24	42	.811
	Losses	S ^{R-EXT}	1	4.3%	.06			
	No-Gains	S ^{R+EXT}	2	6.3%	.05	-1.21	42	.233
Gain-Loss	Gains	S ^{R+}	1	-7.0%	.07			
	No-Losses	S ^{R-}	2	-6.6%	.06	-.2	40	.842
	No-Gains	S ^{R+EXT}	1	7.8%	.07			
	Losses	S ^{R-EXT}	2	8.3%	.07	-.26	40	.796

Table 5: Results of the Independent T-tests for both the reinforcement and extinction components for LG and GL groups in experiment #2.

<i>Consequence</i>	<i>Condition</i>	<i>M</i>	<i>SD</i>	<i>M₁-M₂</i>	<i>t</i>	<i>df</i>	<i>p</i>
Gains	1	-7.0%	.07				
	2	-7.4%	.09	.44%	.18	41	.858
No-Gains	1	7.8%	.07				
	2	6.3%	.05	1.4%	.79	41	.434
No-Losses	1	-6.8%	.08				
	2	-6.6%	.06	-.25%	-.12	41	.905
Losses	1	4.3%	.06				
	2	8.3%	.07	4.0%	-2.05	41	.047*

Table 6: Results of Independent T-tests for the comparison of each consequence type based on condition order in GL and LG groups in experiment #2. *Indicates statistically significant difference ($p < .05$).

Figures

Participant #	28						
Baseline	Time (s)	# wrong	% correct		Start	End Min.	End Sec.
#1	63.19	0	100%		3.83	1	7.02
#2	56.08	0	100%		2.15		58.23
#3	60.99	0	100%		2.45	1	3.44
Baseline AVG	60.1						
#1 Criterion	57.08	# wrong	% correct	Loss?	Start	End Min.	End Sec.
#1 Time	44.74	0	100%	NO LOSS	2.2		46.94
#2 Criterion	54.23	# wrong	% correct	Loss?	Start	End Min.	End Sec.
#2 Time	48.91	0	100%	NO LOSS	2		50.91
#3 Criterion	51.52	# wrong	% correct	Loss?	Start	End Min.	End Sec.
#3 Time	46.47	1	94%	NO LOSS	1.68		48.15
#4 Criterion	48.94	# wrong	% correct	Loss?	Start	End Min.	End Sec.
#4 Time	47.70	1	94%	NO LOSS	2.5		50.2
#5 Criterion	46.49	# wrong	% correct	Loss?	Start	End Min.	End Sec.
#5 Time	52.77	0	100%	LOSS	2.72		55.49
#6 Criterion	46.49	# wrong	% correct	Loss?	Start	End Min.	End Sec.
#6 Time	49.19	0	100%	LOSS	1.92		51.11
#7 Criterion	46.49	# wrong	% correct	Loss?	Start	End Min.	End Sec.
#7 Time	43.09	1	94%	NO LOSS	1.91		45
#8 Criterion	44.17	# wrong	% correct	Loss?	Start	End Min.	End Sec.
#8 Time	52.01	0	100%	LOSS	1.77		53.78
#9 Criterion	44.17	# wrong	% correct	Loss?	Start	End Min.	End Sec.
#9 Time	43.37	0	100%	NO LOSS	1.76		45.13
#10 Criterion	41.96	# wrong	% correct	Loss?	Start	End Min.	End Sec.
#10 Time	37.81	0	100%	NO LOSS	1.95		39.76
#11 Criterion	39.86	# wrong	% correct	Loss?	Start	End Min.	End Sec.
#11 Time	43.73	2	88%	LOSS	2.19		45.92
#12 Criterion	39.86	# wrong	% correct	Loss?	Start	End Min.	End Sec.
#12 Time	48.17	0	100%	LOSS	1.71		49.88

Figure 1: Excel file used to compute consequences and criteria during Loss sessions. Green cells are those in which the experimenter completed during trials. Blue cells are automatically generated based on the information inputted into the green cells. Cells indicating “LOSS” or “NO LOSS” are automatically generated and change colors to indicate the consequence for the experimenter.

Participant #	18						
Baseline	Time (s)	# wrong	% correct		Start	End min.	End Sec.
#1	64.04	0	100%		2.54	1	6.58
#2	70.00	0	100%		2.11	1	12.11
#3	63.87	0	100%		1.66	1	5.53
Baseline AVG	65.97						
#1 Criterion	62.67	# wrong	% correct	Gain?	Start	End min.	End Sec.
#1 Time	60.14	0	100%	GAIN	1.88	1	2.02
#2 Criterion	59.54	# wrong	% correct	Gain?	Start	End min.	End Sec.
#2 Time	63.79	0	100%	NO GAIN	1.66	1	5.45
#3 Criterion	59.54	# wrong	% correct	Gain?	Start	End min.	End Sec.
#3 Time	76.98	0	100%	NO GAIN	1.55	1	18.53
#4 Criterion	59.54	# wrong	% correct	Gain?	Start	End min.	End Sec.
#4 Time	60.17	0	100%	NO GAIN	2.69	1	2.86
#5 Criterion	59.54	# wrong	% correct	Gain?	Start	End min.	End Sec.
#5 Time	55.67	0	100%	GAIN	2.98		58.65
#6 Criterion	56.56	# wrong	% correct	Gain?	Start	End min.	End Sec.
#6 Time	54.92	0	100%	GAIN	1.63		56.55
#7 Criterion	53.73	# wrong	% correct	Gain?	Start	End min.	End Sec.
#7 Time	53.15	1	94%	GAIN	1.87		55.02
#8 Criterion	51.05	# wrong	% correct	Gain?	Start	End min.	End Sec.
#8 Time	54.35	1	94%	NO GAIN	1.64		55.99
#9 Criterion	51.05	# wrong	% correct	Gain?	Start	End min.	End Sec.
#9 Time	49.43	0	100%	GAIN	2.54		51.97
#10 Criterion	48.49	# wrong	% correct	Gain?	Start	End min.	End Sec.
#10 Time	43.62	1	94%	GAIN	2.38		46
#11 Criterion	46.07	# wrong	% correct	Gain?	Start	End min.	End Sec.
#11 Time	42.48	0	100%	GAIN	2.54		45.02
#12 Criterion	43.77	# wrong	% correct	Gain?	Start	End min.	End Sec.
#12 Time	44.53	0	100%	NO GAIN	3.14		47.67

Figure 2: Example of Excel file used in Gain sessions. Cell functions were the same as those in the Loss file.

Participant #	31					
Baseline	Time (s)	# wrong	% correct	Start	End Min	End Sec.
#1	75.6	0	100%	9.02	1	24.57
#2	63.6	0	100%	3.92	1	7.54
#3	75.8	1	94%	3.92	1	19.75
		# wrong	% correct	Start	End Min	End Sec.
#1 Time	67.0	0	100%	3.4	1	10.37
		# wrong	% correct	Start	End Min	End Sec.
#2 Time	78.9	1	94%	3.52	1	22.46
		# wrong	% correct	Start	End Min	End Sec.
#3 Time	65.8	1	94%	3.36	1	9.2
		# wrong	% correct	Start	End Min	End Sec.
#4 Time	86.7	0	100%	3.4	1	30.08
		# wrong	% correct	Start	End Min	End Sec.
#5 Time	61.3	0	100%	3.97	1	5.26
		# wrong	% correct	Start	End Min	End Sec.
#6 Time	78.4	0	100%	3.96	1	22.39
		# wrong	% correct	Start	End Min	End Sec.
#7 Time	79.9	1	94%	3.12	1	22.99
		# wrong	% correct	Start	End Min	End Sec.
#8 Time	68.9	0	100%	3.28	1	12.17
		# wrong	% correct	Start	End Min	End Sec.
#9 Time	66.8	0	100%	2.75	1	9.5
		# wrong	% correct	Start	End Min	End Sec.
#10 Time	75.2	0	100%	3.55	1	18.74
		# wrong	% correct	Start	End Min	End Sec.
#11 Time	71.7	0	100%	3.4	1	15.06
		# wrong	% correct	Start	End Min	End Sec.
#12 Time	51.3	0	100%	3.19		54.52
		# wrong	% correct	Start	End Min	End Sec.
#13 Time	61.8	0	100%	3.78	1	5.59

Figure 3: Example of Excel file used in Control sessions. Relevant cell functions were the same as those in the Loss and Gain files.



Figure 4: Display of audio recording device and sound wave produced by pressing the bell.

$$\begin{array}{r} 34 \\ + 71 \\ \hline \end{array}$$

$$\begin{array}{r} 37 \\ - 22 \\ \hline \end{array}$$

$$\begin{array}{r} 57 \\ + 44 \\ \hline \end{array}$$

$$\begin{array}{r} 3 \\ + 6 \\ \hline \end{array}$$

$$\begin{array}{r} 63 \\ - 41 \\ \hline \end{array}$$

$$\begin{array}{r} 61 \\ - 38 \\ \hline \end{array}$$

$$\begin{array}{r} 9 \\ - 7 \\ \hline \end{array}$$

$$\begin{array}{r} 43 \\ + 51 \\ \hline \end{array}$$

$$\begin{array}{r} 74 \\ + 27 \\ \hline \end{array}$$

$$\begin{array}{r} 4 \\ + 2 \\ \hline \end{array}$$

$$\begin{array}{r} 83 \\ + 24 \\ \hline \end{array}$$

$$\begin{array}{r} 35 \\ - 14 \\ \hline \end{array}$$

$$\begin{array}{r} 4 \\ - 3 \\ \hline \end{array}$$

$$\begin{array}{r} 51 \\ + 33 \\ \hline \end{array}$$

$$\begin{array}{r} 93 \\ - 61 \\ \hline \end{array}$$

$$\begin{array}{r} 73 \\ - 47 \\ \hline \end{array}$$

Figure 5: Example of a trial worksheet used in the studies.

N	N	A	SI
C	B	C	A
1	2	3	4
N	S	SI	N
B	B	S	C
2	3	4	1
A	SI	N	N
C	A	C	B
3	4	1	2
SI	N	N	S
S	C	B	B
4	1	2	3

Figure 6: Matrix used in the development of trial worksheets across problem type.

NC = Addition-non-carry

AC = Addition-carry

SIA = Single-integer addition

NB = Subtraction-non-borrow

SB = Subtraction-borrow

SIS = Single-integer subtraction

Part #	22	Super.	AT	RA	ET	S. Type	GAIN			
Baseline	Time (s)	Start	End	RA Time	Agree?	+	-	Sup. #wrong	RA #wrong	Agree?
#1	94.72	5.43	100.2	94.73	YES	95.23	94.23	1	1	YES
#2	112.83	2.17	115	112.85	YES	113.35	112.35	1	1	YES
#3	93.44	2.24	95.68	92.66	YES	93.16	92.16	1	1	YES
		Start	End	RA Time	Agree?	+	-	Sup. #wrong	RA #wrong	Agree?
#1 Time (s)	89.2	2.47	91.63	89.1	YES	89.60	88.60	0	0	YES
		Start	End	RA Time	Agree?	+	-	Sup. #wrong	RA #wrong	Agree?
#2 Time (s)	87.3	2.22	89.5	87.3	YES	87.80	86.80	0	0	YES
		Start	End	RA Time	Agree?	+	-	Sup. #wrong	RA #wrong	Agree?
#3 Time (s)	91.1	1.84	92.89	91	YES	91.50	90.50	1	1	YES
		Start	End	RA Time	Agree?	+	-	Sup. #wrong	RA #wrong	Agree?
#4 Time (s)	78.1	1.92	80.06	86	NO	86.50	85.50	1	1	YES
		Start	End	RA Time	Agree?	+	-	Sup. #wrong	RA #wrong	Agree?
#5 Time (s)	77.7	2.48	80.2	77.7	YES	78.20	77.20	0	0	YES
		Start	End	RA Time	Agree?	+	-	Sup. #wrong	RA #wrong	Agree?
#6 Time (s)	94.5	2.04	96.52	94.5	YES	95.00	94.00	1	1	YES
		Start	End	RA Time	Agree?	+	-	Sup. #wrong	RA #wrong	Agree?
#7 Time (s)	103.8	2.02	105.8	103.4	YES	103.90	102.90	4	3	NO
		Start	End	RA Time	Agree?	+	-	Sup. #wrong	RA #wrong	Agree?
#8 Time (s)	83.88	2.19	86.07	83.88	YES	84.38	83.38	0	0	YES
		Start	End	RA Time	Agree?	+	-	Sup. #wrong	RA #wrong	Agree?
#9 Time (s)	74.65	2	76.65	74.66	YES	75.16	74.16	1	1	YES
		Start	End	RA Time	Agree?	+	-	Sup. #wrong	RA #wrong	Agree?
#10 Time (s)	78.45	1.97	80.42	78.49	YES	78.99	77.99	1	1	YES
		Start	End	RA Time	Agree?	+	-	Sup. #wrong	RA #wrong	Agree?
#11 Time (s)	104.12	1.89	106	104.11	YES	104.61	103.61	0	0	YES
		Start	End	RA Time	Agree?	+	-	Sup. #wrong	RA #wrong	Agree?
#12 Time (s)	99.37	2.85	102.2	99.38	YES	99.88	98.88	3	3	YES

Figure 7: Example of the file used by the supervisor during IOA sessions.

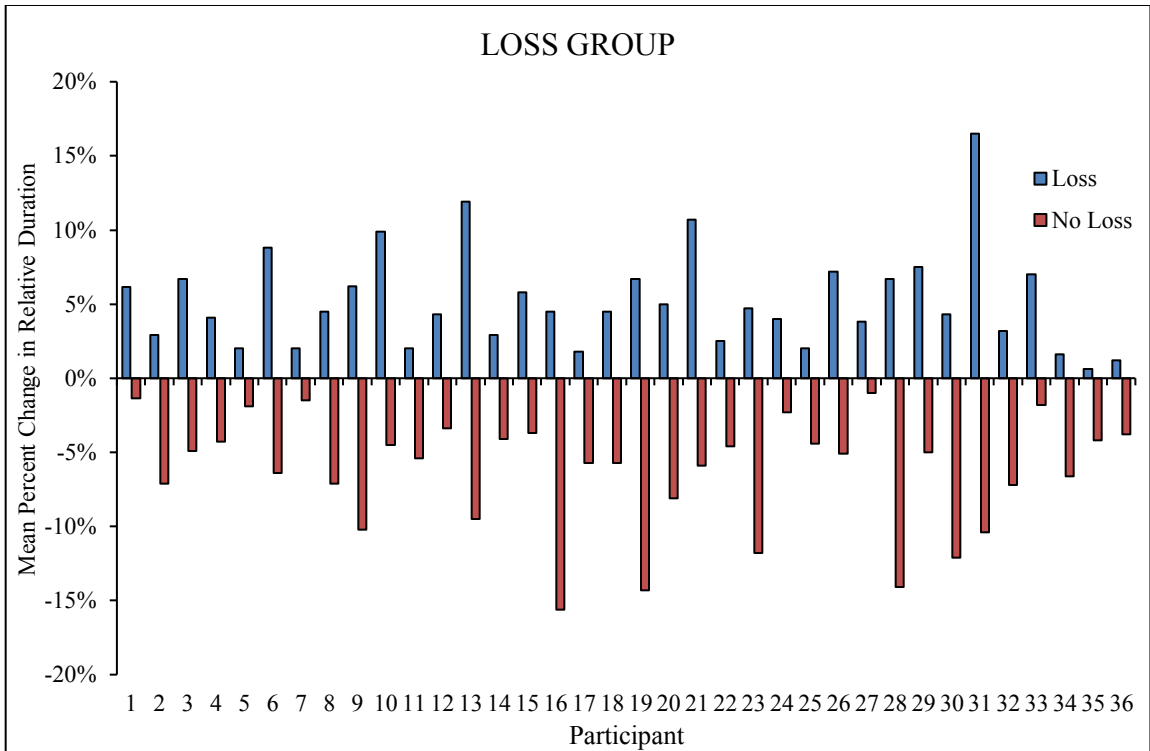


Figure 8: Mean percent change in relative duration following losses and no-losses in the Loss group.

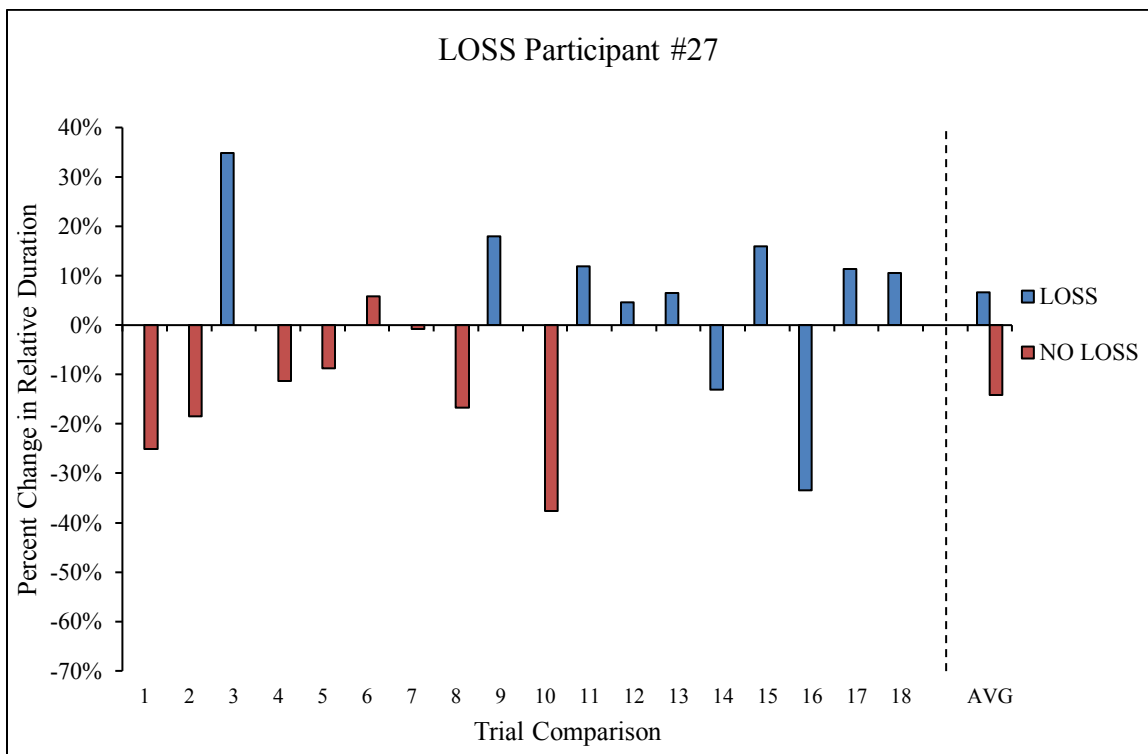


Figure 9: Individual data set for participant's percent change in relative duration following losses and no-losses in the Loss group.

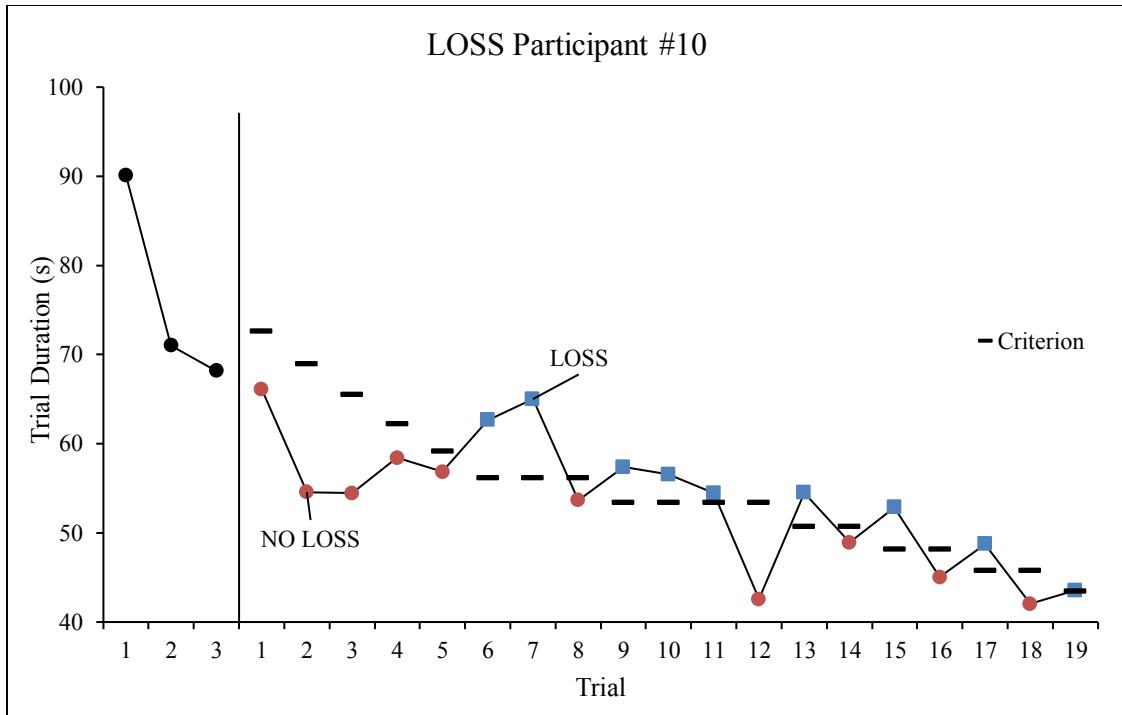


Figure 10: Example of a participant's trial duration in relation to the changing criterion over the course of a session in the Loss group.

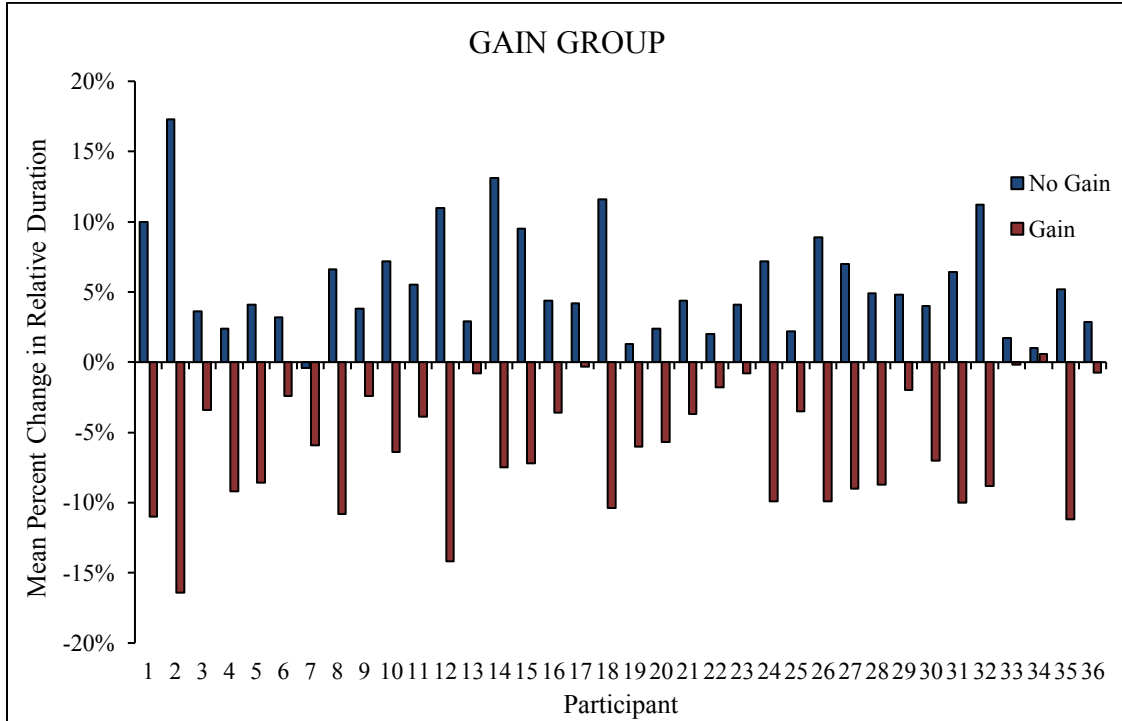


Figure 11: Mean percent change in relative duration following no-gains and gains in the Gain group.

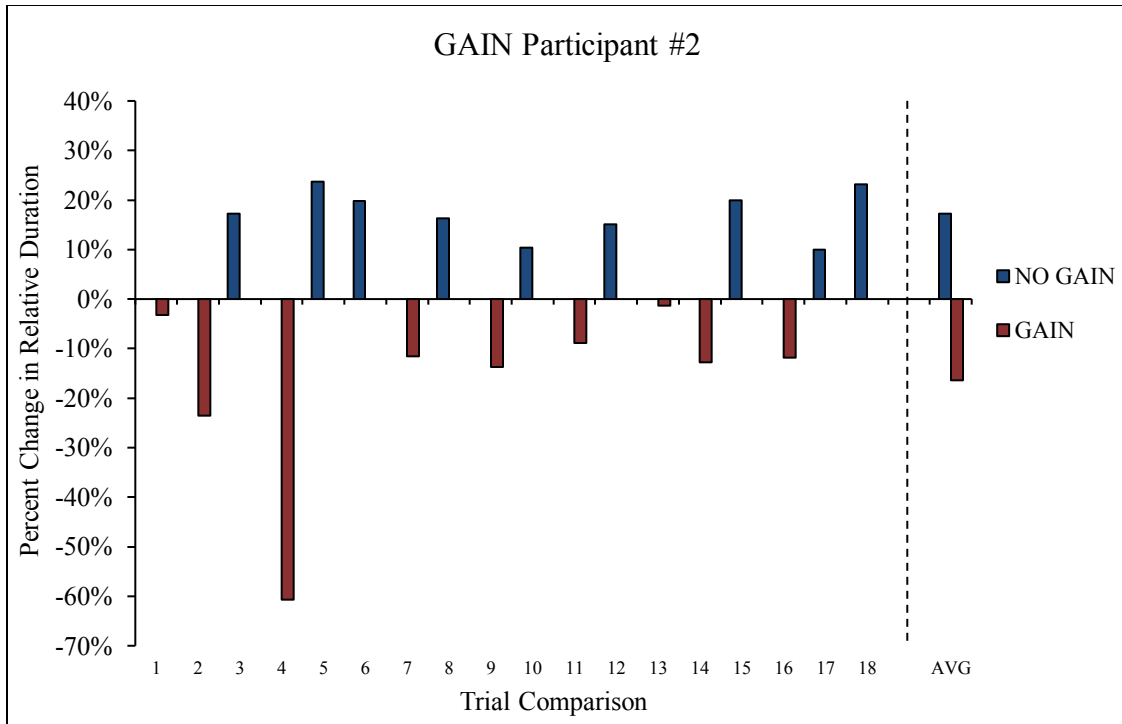


Figure 12: Individual data set for participant's percent change in relative duration following no-gains and Gains in the Gain group.

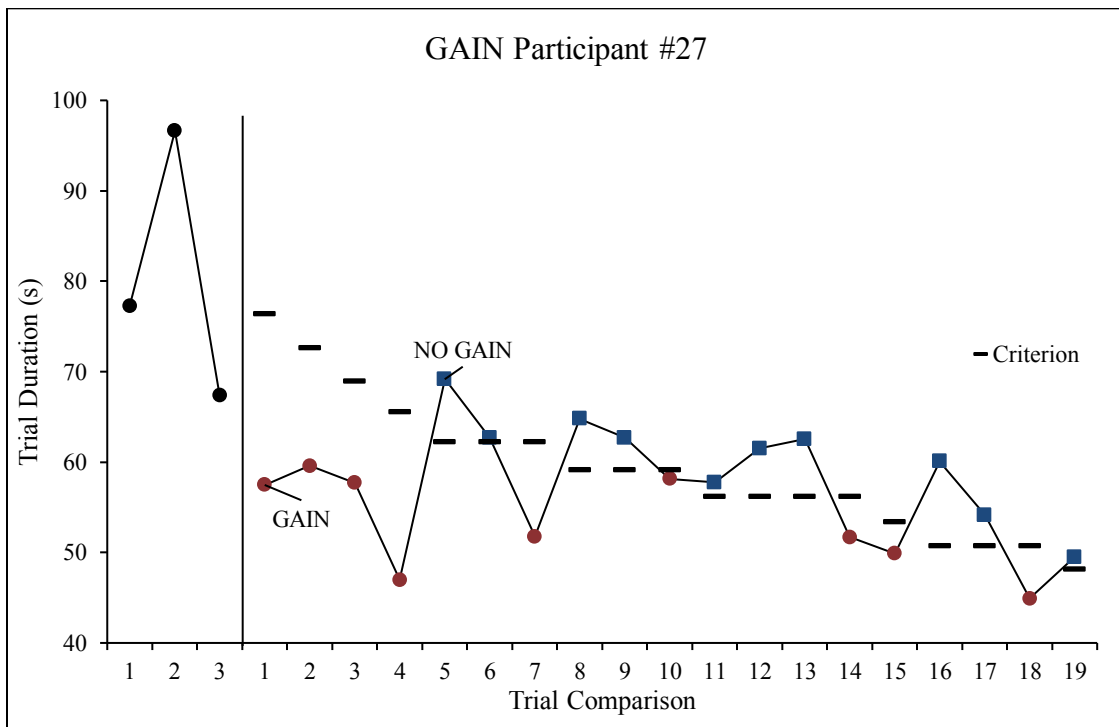


Figure 13: Example of a participant's trial duration in relation to the changing criterion over the course of a session in the Gain group.

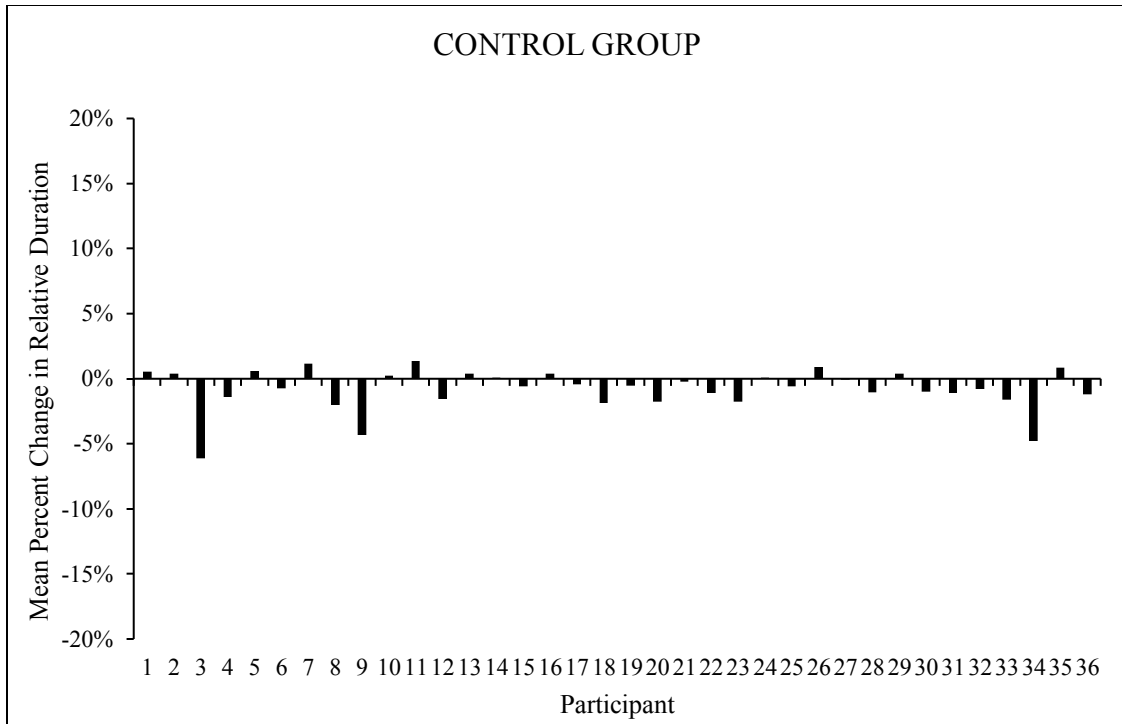


Figure 14: Mean percent change in relative duration in the Control group.

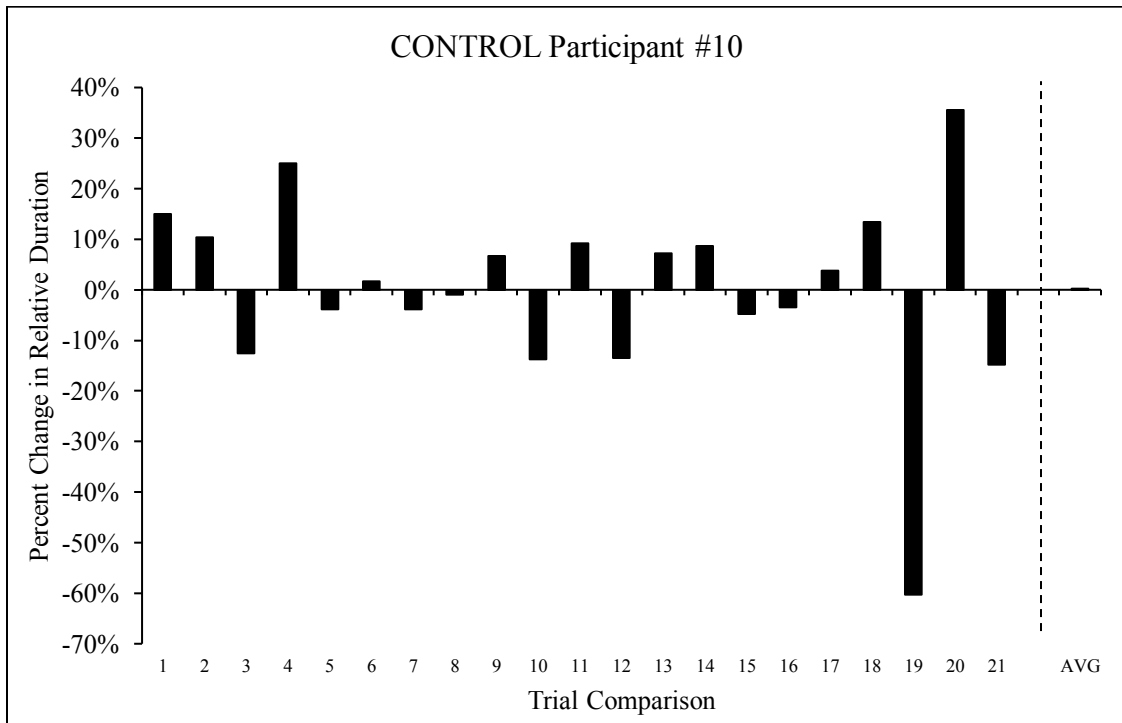


Figure 15: Individual data set for participant's percent change in relative duration in the Control group.

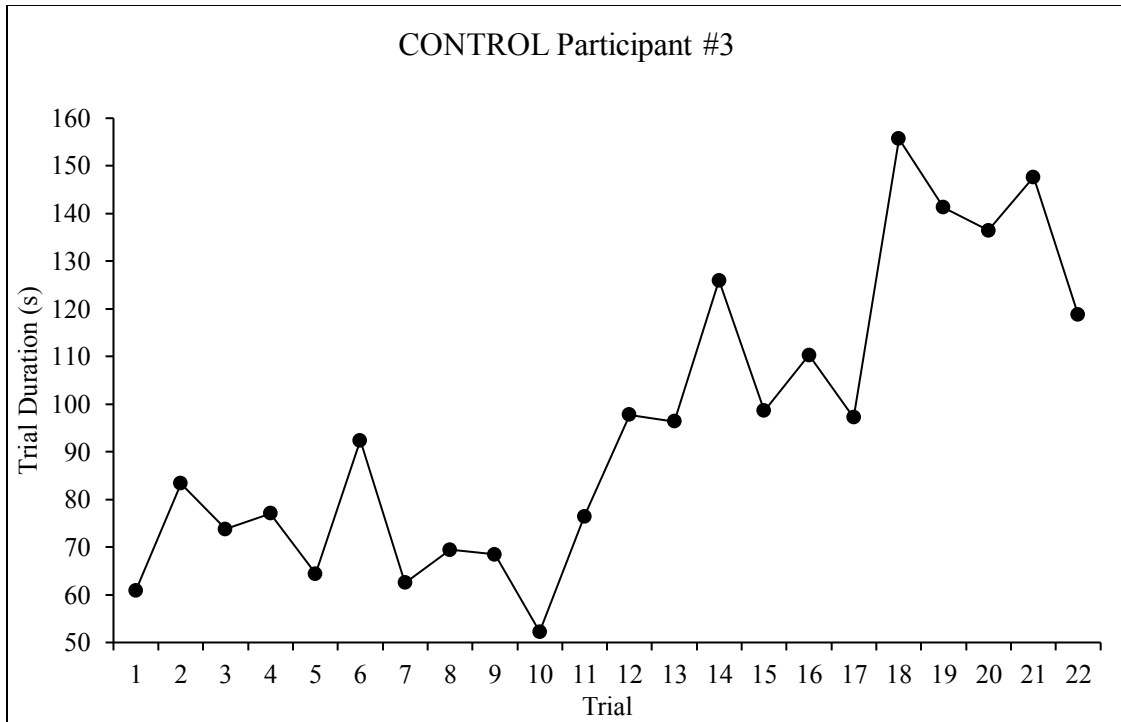


Figure 16: Example of a participant's trial duration over the course of a session in the Control group. *Y-axis is scaled to display the full data set.*

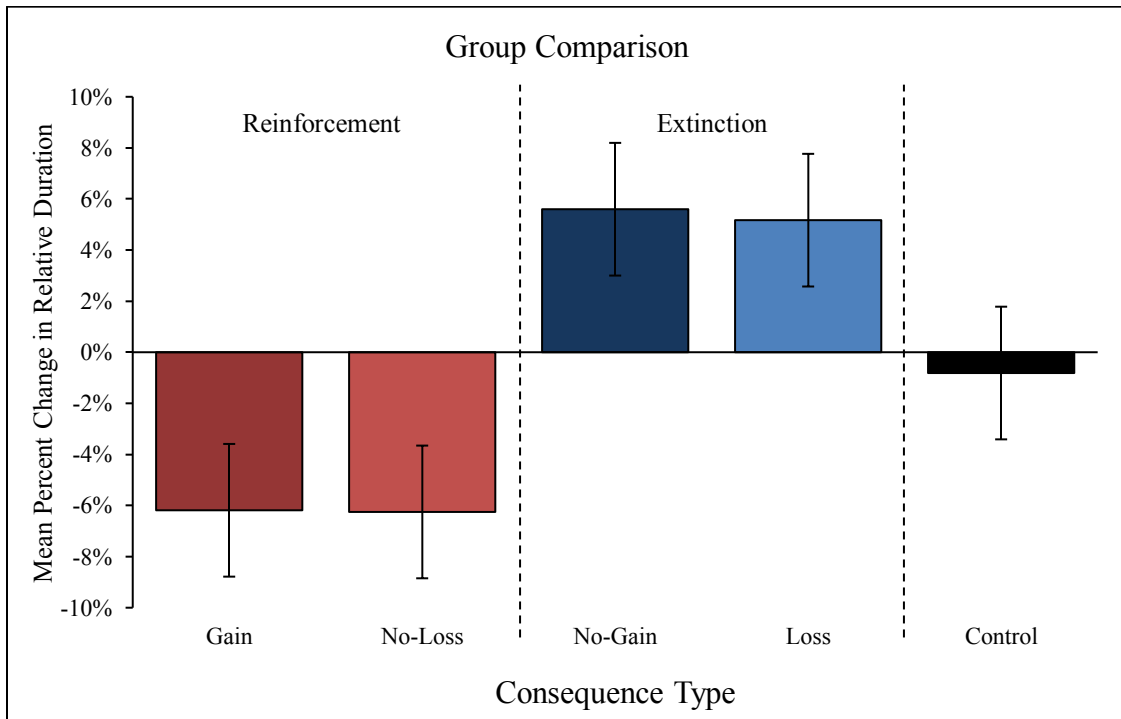


Figure 17: Comparisons across the three groups of the effects of the reinforcement components (Gains & No-Losses), extinction components (No-Gains & Losses), and Control.

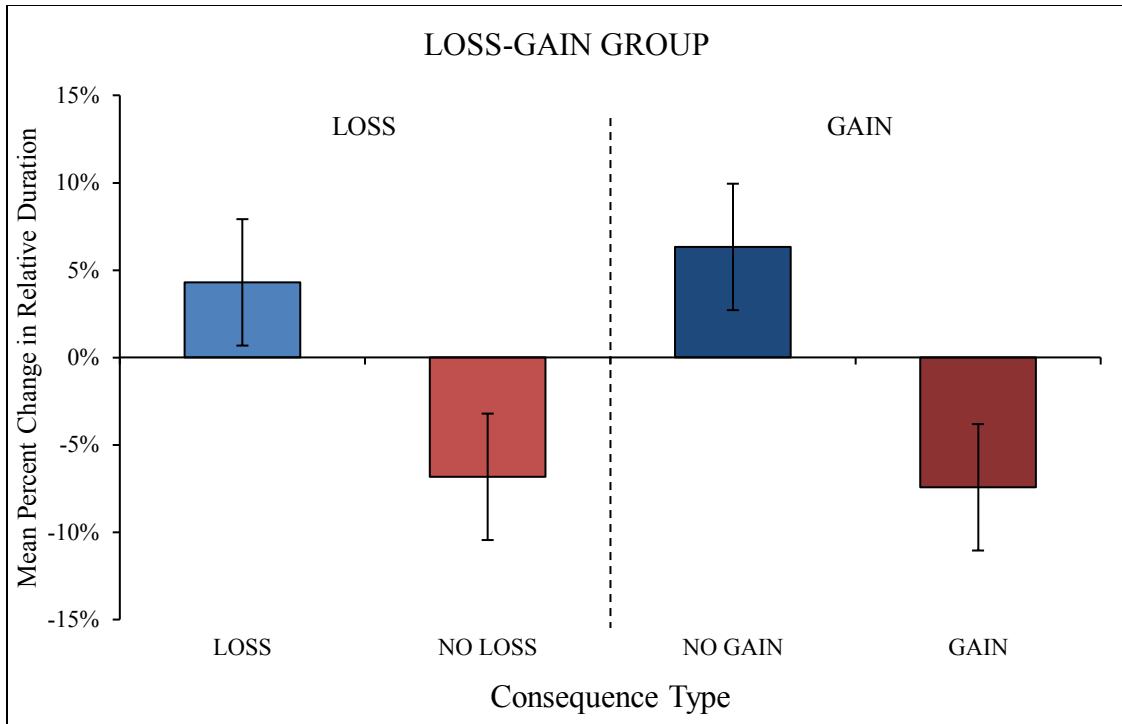


Figure 18: Mean percent change in relative duration by consequence type within the Loss-Gain group.

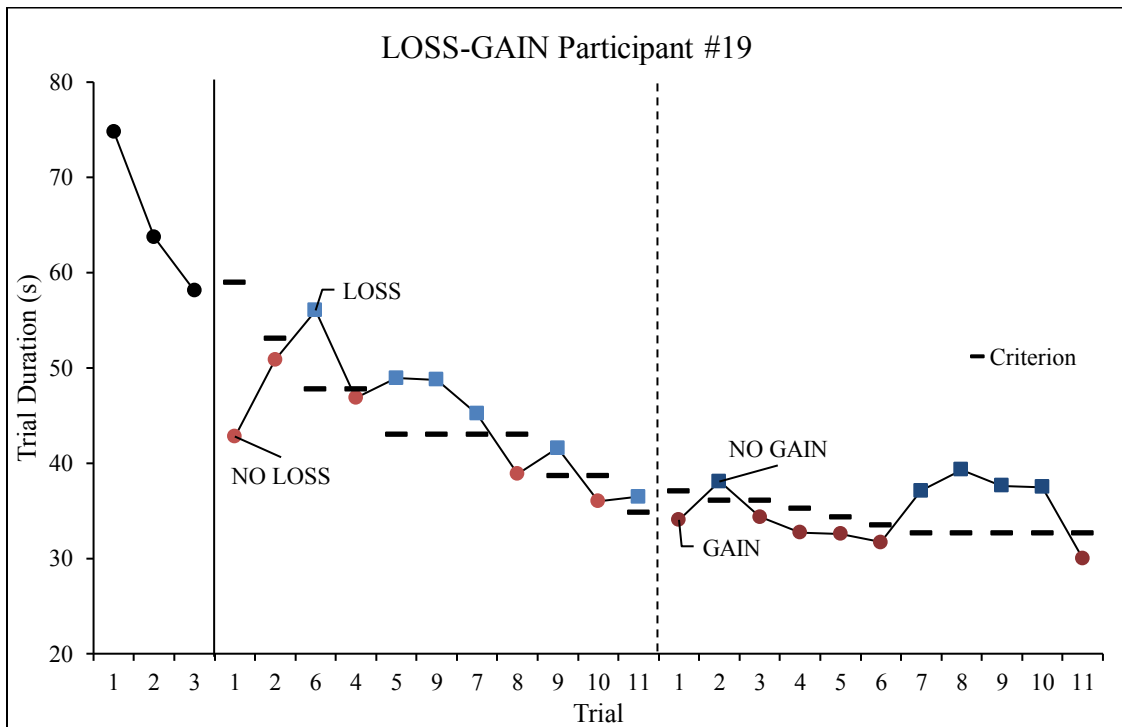


Figure 19: Trial duration data from a participant in the Loss-Gain group. Y-axis scaled to better display changes in duration.

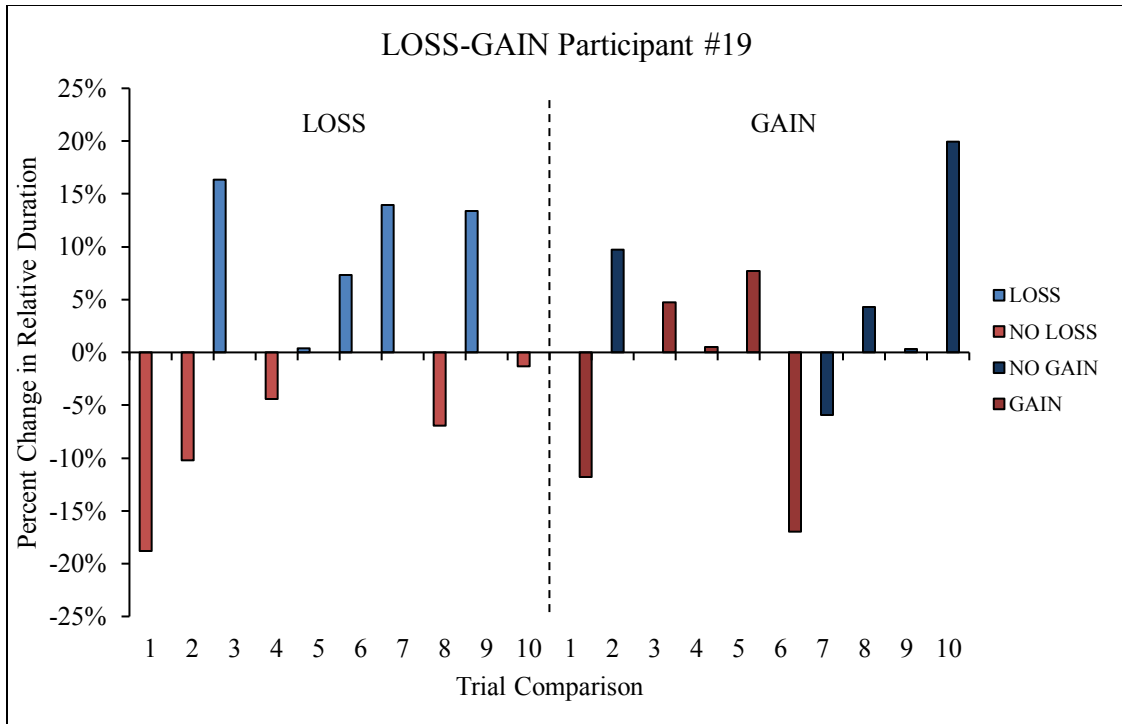


Figure 20: Change in relative duration by consequence type data from a participant in the Loss-Gain group.

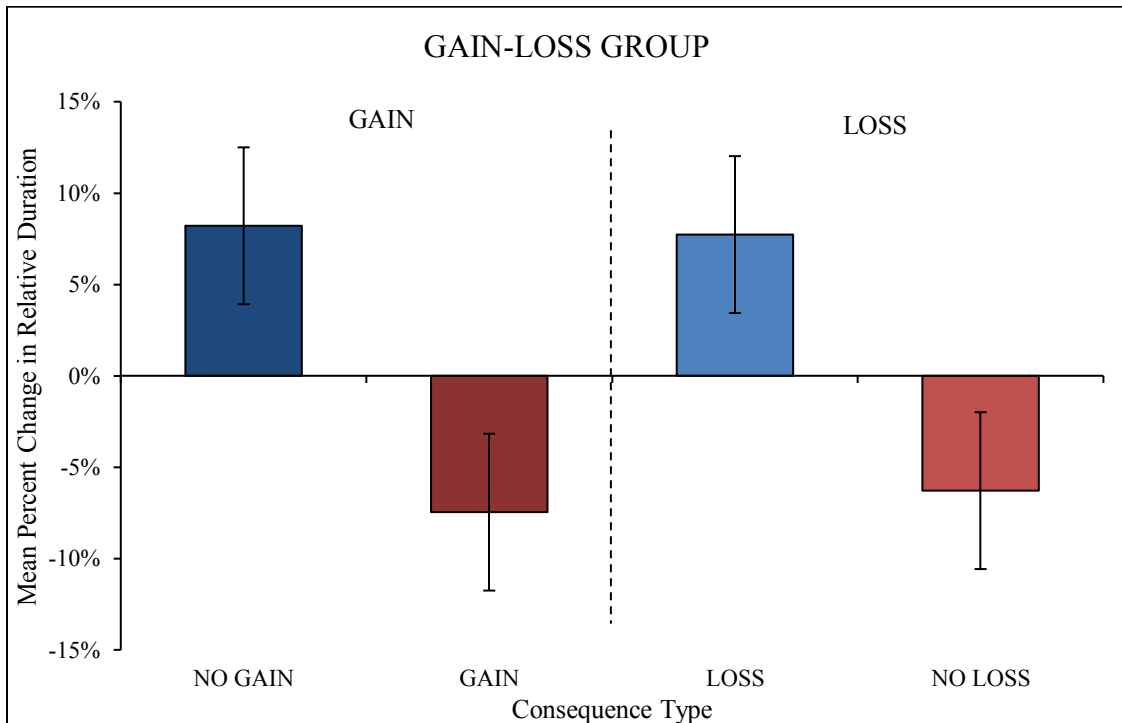


Figure 21: Mean percent change in relative duration by consequence type within the Gain-Loss group.

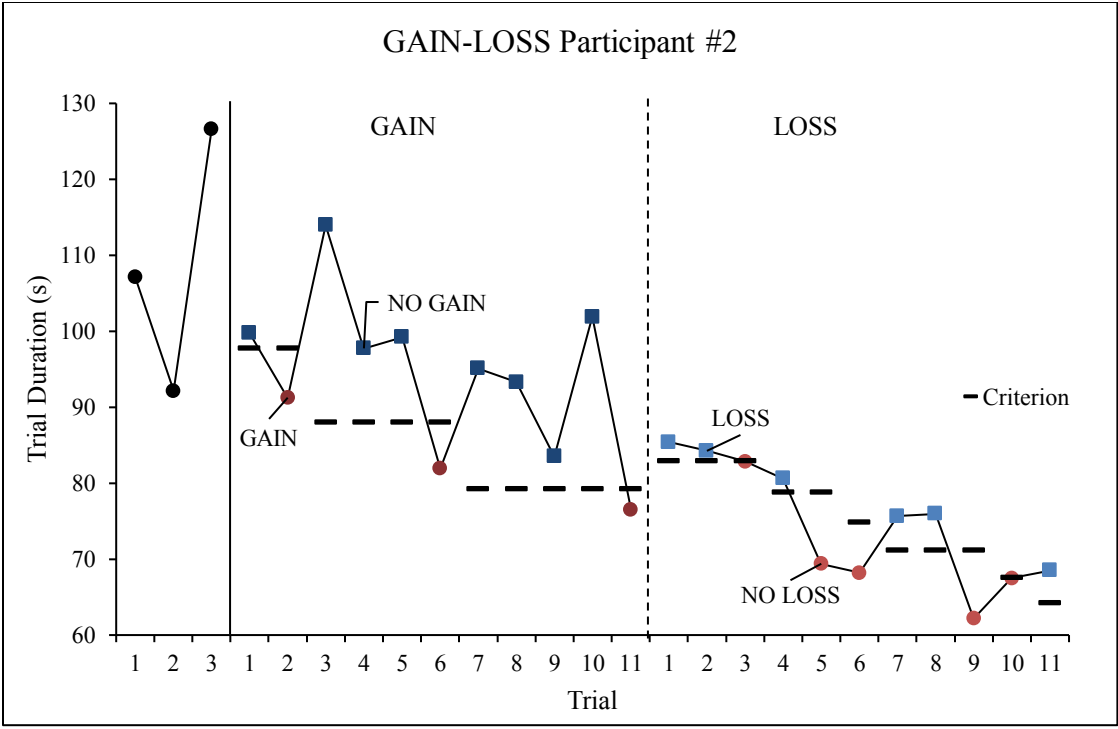


Figure 22: Trial duration data from a participant in the Gain-Loss group. *Y-axis scaled to better display changes in duration.*

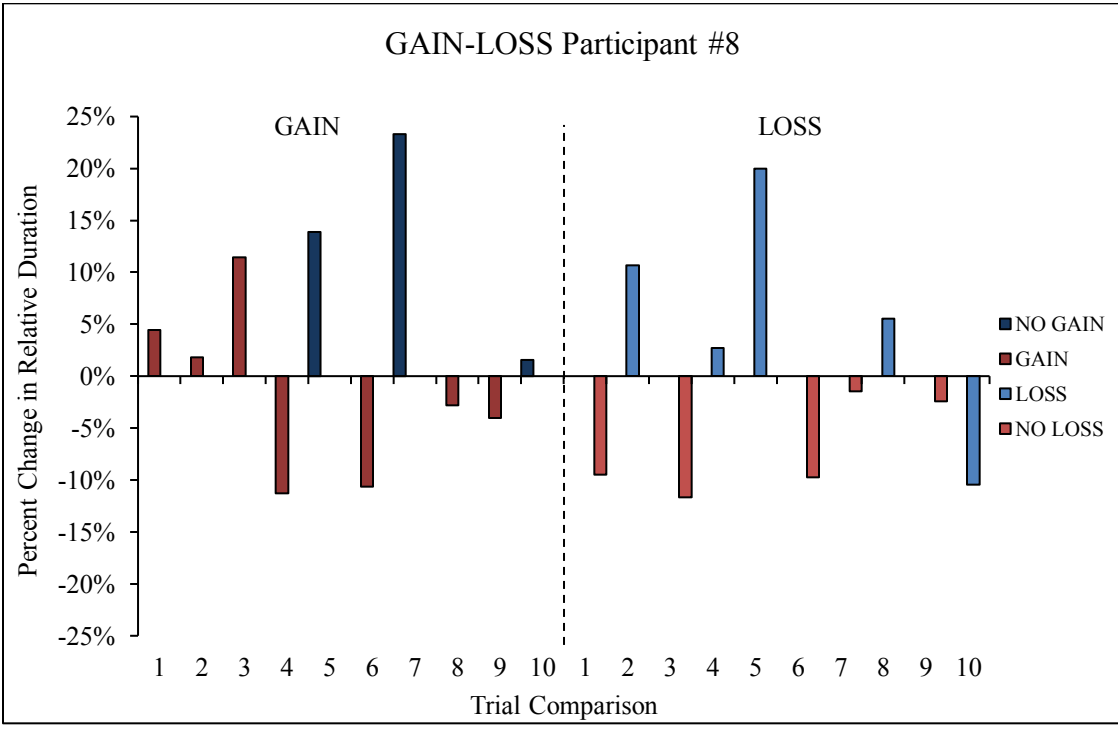


Figure 23: Percent change in relative duration by consequence type data from a participant in the Gain-Loss group.

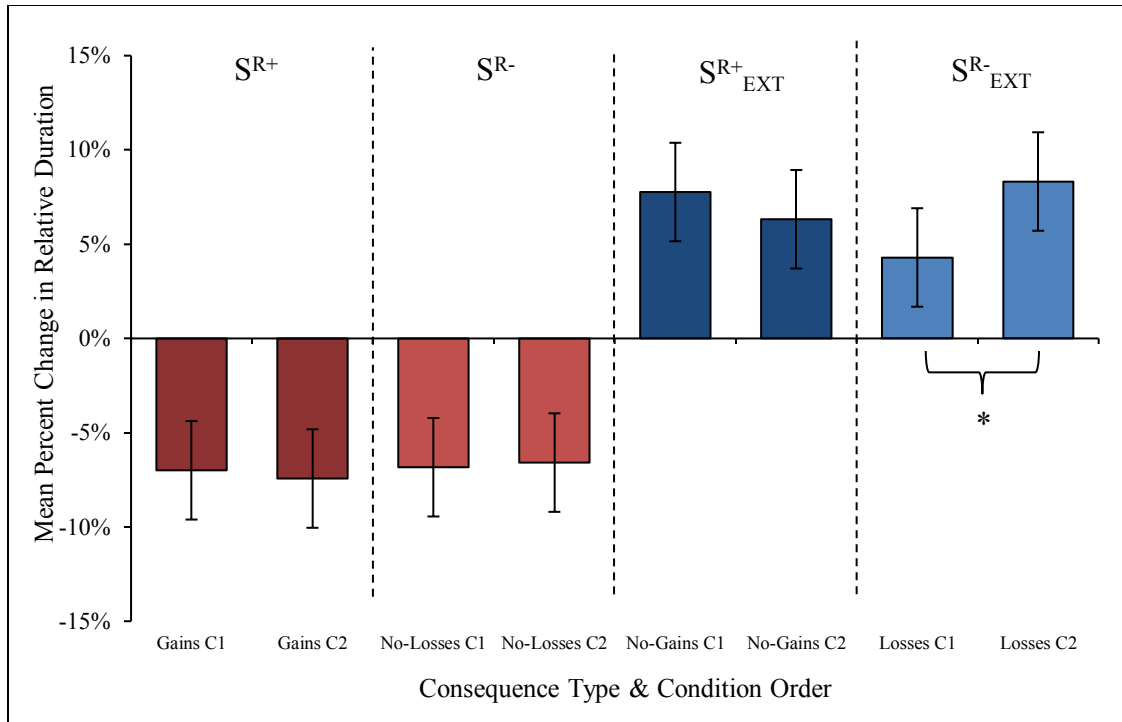


Figure 24: Comparisons of the effects of consequence types across condition 1 and condition 2 between LG and GL groups in experiment #2. *Indicates statistically significant difference ($p = <.05$).