EFFECTS OF THE RELATIVE VALUES OF ALTERNATIVES ON CHOICE PREFERENCES IN HUMANS

by

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Abstract

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Kristen A. Rost

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Under concurrent-chains schedules of reinforcement, organisms often prefer conditions that allow selection among multiple alternatives (free-choice) to conditions that do not (forced-choice). Researchers have observed robust preferences for freedom of choice when all available alternatives in free- and forced-choice produce equally rewarding outcomes, or when free choice includes greater rewards than the forced-choice option. Choice preferences under concurrent-chains schedules are more varied, however, when free choice offers a mix of rewarding and aversive outcomes (e.g., Hayes, Kapust, Leonard, & Rosenfarb, 1981; Hori & Shimazaki, 2010). In the present study, a concurrent-chains procedure was used to examine human subjects' preferences when the alternatives in free-choice produced: (a) rewards equal to the forced-choice option, (b) rewards equal to and greater than the forced-choice option, and (c) rewards equal to the forced-choice option as well as relatively undesirable outcomes. Fourteen college undergraduates participated in one experimental session during which they gained or lost points for selecting images of cards on a computer screen. Participants selected between two sets of cards: a single-card set (forced-choice) and a three-card set (free-choice). A

within-subjects design was used to evaluate preferences when one of the cards in the free-choice set was always equal in point value to the forced-choice card, and the remaining two cards were associated with point values equal to, greater than, or less than the forced-choice card. While it was always possible to obtain the same number of points across free- and forced-choice, preferences for free-choice decreased substantially as the number of points associated with two of the cards in free-choice were reduced. These results demonstrate that, in the context of a concurrent-chains procedure, choice preferences are a function of the outcomes associated with *all* available alternatives in the free-choice situation, and that the inclusion of aversive outcomes substantially diminishes preference for free-choice.

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Introduction

Catania (1975) argued that an individual who does not have the freedom to choose cannot be called free; and thus defined freedom, in part, as the opportunity to choose among alternatives. He further suggested that if organisms do in fact value freedom, they should prefer situations where they are free to choose among alternatives to situations where they have no choice. Following the conception of freedom offered by Catania, basic and applied researchers in behavior analysis have estimated the value of choice by measuring organisms' preferences between conditions that allow selection among alternatives (free-choice) to conditions that do not (forced-choice) (Fisher & Mazur, 1997).

The main obstacle in isolating choice as an independent variable is that an expressed preference for free-choice is often confounded with the differential outcomes associated with free- and forced-choice. For example, if free-choice is associated with more desirable outcomes than forced-choice, one could argue that choice preferences are a function of those differential outcomes and not the *act of choosing itself* (Fisher, Thompson, Piazza, Crosland, & Gotjen, 1997; Karsina, Thompson, & Rodriguez, 2011; Tiger, Hanley, & Hernandez, 2006). Therefore, the direct study of choice as an independent variable requires the control of all variables except for the presence or absence of the opportunity to choose among multiple alternatives. To do this, researchers in behavior analysis typically study choice preferences under concurrent-chains schedules of reinforcement. Operant experiments of this type are unique because they directly

measure preference for the *means* by which rewards or reinforcers are obtained, rather than a preference for the outcomes themselves (Hutchinson, 2005).

Concurrent-chains schedules have been used to effectively isolate preference for free-choice because the procedure allows researchers to equate the outcomes produced by subjects' responses across free- and forced-choice situations. In a typical concurrent-chains procedure, the initial link in the chain begins with the simultaneous appearance of two stimuli, which represent two choice situations (free-choice and forced-choice) available in the second link of the chain (terminal link). Subjects' selection of a stimulus in the initial link results in access to the associated choice situation in the terminal link. That is, if the stimulus selected in the initial link is associated with free-choice, multiple stimuli will be presented and if the stimulus selected in the initial link is associated with forced-choice, a single stimulus will be presented. Stimulus selection in the terminal link then produces a terminal-link reinforcer, which is held constant across free- and forced-choice. Because the terminal-link reinforcer is equated across free- and forced-choice, initial link responding is maintained, or reinforced, exclusively by access to either free-choice or forced-choice in the terminal link. Thus, relative responding in the initial link provides a direct measure of preference for *access* to free- and forced-choice in the terminal link.

For example, suppose a research participant is presented with a red button and a yellow button and is asked to choose between the two buttons. If the red button is pressed, the participant is presented with a choice of three green buttons to press (free-choice). A press on any one of the three green buttons will result in a $1 reward for the

participant and the termination of the trial. On the other hand, if the participant presses the yellow button, only one green button appears (forced-choice). Pressing this green button will result in a $1 reward and the termination of the trial. If the participant presses the red button (associated with free-choice) more often than the yellow button (associated with forced-choice), why would this be so? Access to reward cannot adequately explain this preference because the same amount of money ($1) is available for pressing either the red or the yellow button. Assuming an experimental design that controls for potential confounding variables such as side and color preferences, the only difference between pressing red and pressing yellow is the number of alternatives (green buttons) that differ between the two possibilities. All else being equal, selecting red more than yellow would indicate a preference for being given a choice over not being given a choice.

Researchers have used the concurrent-chains schedule to demonstrate that organisms do often prefer gaining access to free-choice when forced-choice is the opposing option. Free-choice preferences have been observed in rats (e.g., Voss & Homzie, 1970), pigeons (e.g., Catania, 1975; Catania & Sagvolden, 1980; Cerutti & Catania, 1997), monkeys (e.g., Suzuki, 1999), and humans (e.g., Hori & Shimazaki, 2010; Schmidt, Layer, & Hanley, 2009; Suzuki, 1997, 2000, 2002; Tiger et al., 2006). Foremost, researchers have successfully isolated choice as a reinforcer in conditions where the outcomes associated with free- and forced-choice are equal. The literature provides a number of examples where subjects readily express preference for free-choice over forced-choice when presented with an array of identical choices; that is, when all selection responses in free-choice produce the same outcomes (e.g., Catania, 1975;

Catania & Sagvolden, 1980; Cerutti & Catania, 1997; Schmidt et al., 2009; Suzuki, 2000; Tiger et al., 2006). Furthermore, researchers have primarily studied preference for freedom of choice when all choice responses result in equally *reinforcing* or *desirable* consequences.

Catania (1975) was one of the first to use a concurrent-chains arrangement to demonstrate that subjects (i.e., pigeons) preferred the opportunity to choose when that choice was among an array of equally reinforcing outcomes (i.e., access to food). Catania's findings have been supported by a number of researchers who have observed preference for choice situations that provide access to two or more identical reinforcers (e.g., Cerutti & Catania, 1997; Schmidt et al., 2009; Suzuki, 2000; Tiger et al., 2006). Researchers have reported relatively inconsistent preferences for free-choice, however, when subjects are presented with situations that offer a variety of choices, which result in a variety of desirable *and* relatively undesirable outcomes (e.g., Fisher et al., 1997; Hayes, Kapust, Leonard, & Rosenfarb, 1981; Hori & Shimazaki, 2010; Suzuki, 1997, 1999). The inconsistencies in the literature suggest that, in the context of a concurrent-chains procedure, preference for free-choice is not universal and seems to be sensitive to the variety outcomes made available in the choice situation.

Some researchers have reasoned that subjects likely prefer to choose among equally desirable alternatives because it is impossible to make a "mistake" or make the "wrong choice" under such conditions (Hayes et al., 1981; Lockhart, 1979). For example, Catania's (1975) pigeons were never at risk of exposing themselves to undesirable consequences in the free-choice situation, as all available outcomes were equally

reinforcing (Lockhart, 1979). Thus, several researchers have elected to examine choice preferences when the variety of alternatives in free-choice make it possible for subjects to make selections that may limit their access to desirable outcomes, or expose them to undesirable outcomes (Lockhart, 1979). Hayes et al. (1981) were among the first researchers to examine preferences for free-choice in conditions that included the opportunity to access both desirable and undesirable consequences. Hayes et al.'s findings stand out as a counterpoint to the observations of robust free-choice preference in the literature. In fact, Hayes et al.'s research is often cited to make the point that free-choice is not always preferred, and in some circumstances, may actually be avoided (e.g., Hutchinson, 2005; Ono, 2000; Suzuki, 1999).

In a series of experiments with pigeons, Hayes et al. (1981) used a concurrent-chains procedure to isolate the effects of choice as a reinforcer. In the initial link of the concurrent chain, two keys were lit white. A single peck (FR 1) on either white key produced a terminal link in which one key (forced-choice terminal link) or both keys (free-choice terminal link) were illuminated. If the peck in the initial link was on the key associated with forced-choice, one key was lit green in the terminal link. A subsequent peck (FR 1) on the green key produced delayed access to the food hopper (i.e., 4-s blackout and then 4-s access to the food hopper). If the peck in the initial link was on the key associated with free-choice, one key in the terminal link was lit green and another was lit red. A single peck (FR 1) on the green key produced the same outcome available in the forced-choice terminal link (i.e., delayed food access). A single peck (FR 1) on the

red key produced immediate access to the food hopper for a given time period (*T*). Figure 1 provides a diagram of Hayes et al.'s concurrent-chains procedure.

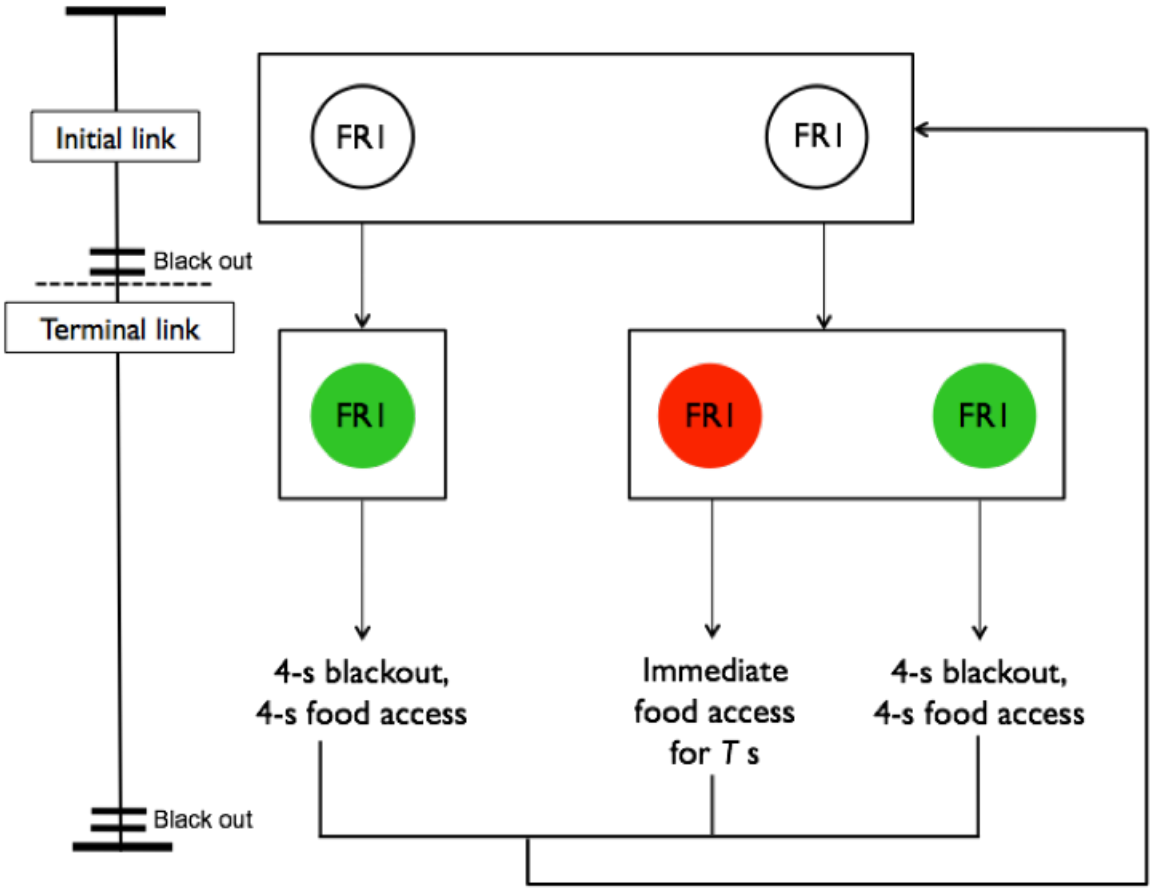

Figure 1. Concurrent-chains procedure used in Hayes, Kapust, Leonard, & Rosenfarb (1981).

Hayes et al.'s (1981) major purpose was to test choice preferences when free-choice included the opportunity to access (a) an outcome *identical* to the outcome available in forced-choice (i.e., delayed food access for 4 s), and (b) an outcome that *differed* from the outcome available in forced-choice (i.e., immediate access to food for *T* s). To do this, delayed access to food (green key) was always available in both the forced-

and free-choice terminal links, while pecks on the red key in the free-choice terminal link produced immediate food access for relatively shorter durations. The duration of immediate food access for pecks on the red key (*T*) was first set at 2 s, and was then progressively reduced to 1 s, 0.5 s, and 0.25 s. (It should be noted that Hayes et al. did not control for effects that could potentially be produced by the order with which the pigeons were exposed to the different values of *T*.) When *T* was set at 0.5 s and 0.25 s, the interval was so brief that pigeons could not successfully obtain food from the hopper. Thus, the subjects were given the opportunity to access the same outcome (i.e., delayed food access for pecks on green) across free- and forced-choice terminal links, but accessing the green key in free-choice meant doing so in the presence of a second key that was associated with a different contingency. At the highest values of *T* (2 s and 1 s), when food could be obtained after pecking red, pigeons preferred the free-choice situation. But, at relatively lower values of *T* (0.5 s and 0.25 s), when food could not be obtained after pecking red, pigeons uniformly avoided free-choice and showed strong preferences for forced-choice.

Hayes et al. (1981) demonstrated that pigeons avoided free-choice when an undesirable option was included that did not allow access to food (i.e., red key when *T* was set at 0.5 s and 0.25 s). Interestingly, subjects avoided free-choice even though they did not have to select the undesirable option, as they always had access to the green key in free-choice as well. This avoidance persisted when controls were in place for positional preference, relative temporal efficiency of responding (i.e., latency to peck) in free- versus forced-choice, and yoking was in place to control for possible differential food access across free- and forced choice. Hayes et al. also posited that avoidance of

free-choice might have been due to the presence of another lit key (red) in the free-choice situation, regardless of the outcome associated with that key. But, the researchers observed only positional preferences when free-choice included a key that was associated with no programmed consequences (i.e., the trial did not terminate and no food access was granted).

Finally, Hayes et al. (1981) examined the possibility that subjects' avoidance of free-choice was accompanied by a high probability of selecting the undesirable option in the free-choice terminal link. In addition to the concurrent-chains trials where subjects controlled their exposure to the free- and forced-choice terminal links, the researchers included a condition where subjects were required to enter the free-choice terminal link. In this condition, birds were presented with only one white key in the initial link, and a single peck (FR 1) on this key always produced the free-choice terminal link. This condition measured a subject's probability of selecting delayed food access for 4 s (green key) versus immediate food access (red key) at the different durations of *T* (2 s, 1 s, 0.5 s, and 0.25 s). In this condition, all three pigeons selected immediate food access (red key) over delayed access (green key) 100% of the time when immediate access lasted for 2 s. Two of the three pigeons selected immediate food access (red key) over delayed access (green key) 100% of the time when immediate access lasted for 1 s. At the shorter durations of immediate food access (0.5 s and 0.25 s), however, all three birds overwhelmingly chose delayed food access (green key). Thus, subjects were not likely to select the red key when it was not associated with ready access to food. In light of these observations, Hayes et al. emphasized that subjects avoided a free-choice situation, which

included an undesirable option, even though they almost never selected the undesirable option when given the opportunity.

Overall, Hayes et al.'s findings suggest that providing subjects with a variety of possible outcomes in a free-choice situation will likely lead to indifference or active avoidance if those outcomes are not of sufficient value to the organism (Hayes et al., 1981). In other words, Hayes et al. argued that avoidance or indifference would likely be observed when an undesirable outcome (e.g., the termination of a trial without a reinforcer) is included in a free-choice situation. The researchers also noted that this avoidance of free-choice did not seem dependent upon subjects' frequent exposure to the undesirable outcome.

Several researchers have used similar arrangements to Hayes et al. (1981) to test choice preferences when a combination of desirable and relatively undesirable outcomes are available in free-choice (e.g., Fisher et al., 1997; Hori & Shimazaki, 2010; Suzuki, 1997, 1999). The findings of these studies are mixed. A few researchers have reported indifferent preferences for free-choice versus forced-choice (e.g., Suzuki, 1997, 1999), but none has observed the active avoidance of free-choice as seen by Hayes et al. (Hutchinson, 2005). In addition, a few studies have reported robust free-choice preferences when both desirable and undesirable consequences were options in free-choice (e.g., Fisher et al., 1997; Hori & Shimazaki, 2010).

In a study with adult humans, Suzuki (1997) used a concurrent-chains procedure to test preferences for a multi-alternative task (free-choice) versus a single-alternative task (forced-choice). Participants in the study pressed keys on a computer keyboard to

select images of colored rectangular cards on a computer screen, and each card was worth a certain number of points that could be exchanged for money at the end of the experiment. Under these conditions, Suzuki used a mixed design to test participants' preferences for free- versus forced-choice when the number of available cards, and the point outcomes associated with those cards, were manipulated. In the initial link of the concurrent-chain, participants selected between two sets of cards that appeared on screen. The first card set (forced-choice) was represented by an image of one green card worth 10 points. One green card worth 10 points, and one or two additional cards worth 20, 15, 10, 5, or 1 point(s) represented the second card set (free-choice). If participants clicked the forced-choice card set, a single card appeared on screen in the subsequent terminal link of the chain, and if participants clicked the free-choice card set, two or three cards appeared on screen. Participants' card selections in the terminal link produced a message on screen indicating the number of points earned for choosing that card (e.g., "You earned 10 points."). The probability of point delivery was fixed at 0.4 throughout the experiment. Figure 2 provides an example of Suzuki's concurrent-chains procedure.

Suzuki (1997) assigned subjects to three groups. Groups 1 and 2 were both exposed to a free-choice terminal link that included a choice between two cards. Group 3 was exposed to a free-choice terminal link that included a choice among three cards. All participants experienced three conditions (in random order) across which the number of points available in free-choice was varied. In all three conditions, the color (green) and point value (10 points) of one of the cards in free-choice was held constant to match the value of the forced-choice card. Thus, participants always had the chance to obtain the

same number of points across the free- and forced-choice terminal links. Suzuki named each condition in the experiment by indicating the number of points participants could obtain for selecting each of the cards that appeared on screen in the given condition.

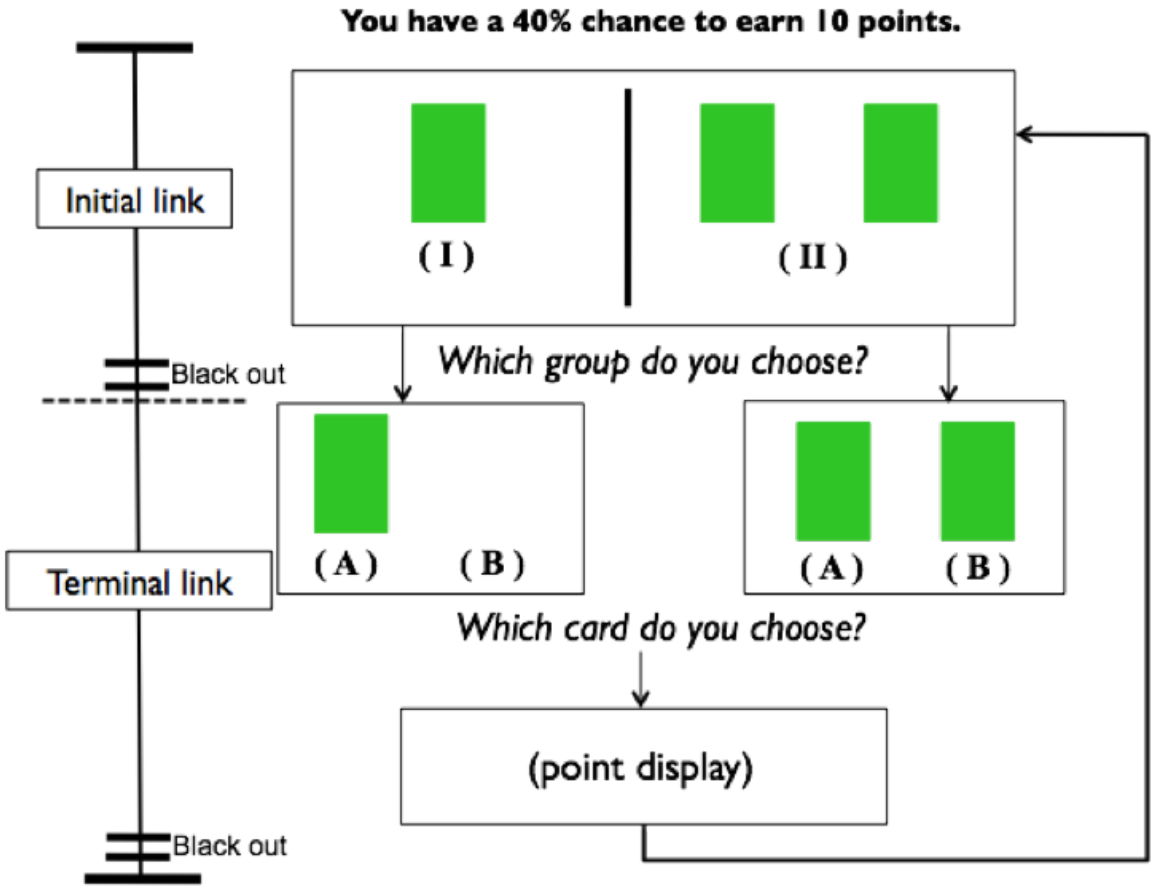

Figure 2. Concurrent-chains procedure used in Suzuki (1997) and Hori and Shimazaki (2010). This is a diagram of the (10)/(10|10) condition used in both studies. (10)/(10|10), and (10)/(10|5).

For example, if a participant was asked to select between one card worth 10 points (forced-choice) and two cards worth 10 points (free-choice), Suzuki (1997) named the condition (10)/(10|10). If a participant was asked to select between one card worth 10 points (forced-choice) and one card worth 10 points and two worth 15 points (free-choice

task), the condition was named (10)/(10|15|15). Group 1 was exposed to the following conditions: (10)/(10|15), (10)/(10|10), and (10)/(10|5). Group 2 was exposed to conditions (10)/(10|15|15), (10)/(10|10|10), and (10)/(10|5|5), and Group 3 to conditions (10)/(10|20), (10)/(10|10), and (10)/(10|1).

Within each group, participants' free-choice preferences decreased significantly as the number of points available for selecting one or two of the cards in free-choice decreased. Not surprisingly, participants in Groups 1, 2, and 3 expressed the highest preferences for free-choice in conditions (10)/(10|15), (10)/(10|15|15), (10)/(10|20), respectively, where more points could be obtained in the free-choice terminal link relative to forced-choice. Groups 1 and 2 also preferred free-choice in conditions (10)/(10|10) and (10)/(10|10|10), respectively, where all cards produced the same number of points. All groups' preferences were indifferent when free-choice included one card worth the same number of points as forced-choice and one or two additional cards worth fewer points relative to forced-choice [i.e., conditions (10)/(10|5), (10)/(10|5|5), (10)/(10|1)]. Finally, Suzuki (1997) assessed the effect of the number of available cards in free-choice across Groups 1 and 2. The three-card task resulted in significantly higher free-choice preferences than the two-card task for conditions (10)/(10|15|15) versus (10)/(10|15) only.

Suzuki's (1997) findings are similar to Hayes et al. (1981) in that participants' preferences for free-choice were lowest when at least one option in free-choice was associated with an undesirable outcome. At the same time, however, Suzuki's participants did not display the level of free-choice avoidance that Hayes et al. observed. That is, free-choice preferences in Suzuki's study did not differ significantly from chance level, while

Hayes et al.'s subjects' preferences were well below this mark. Suzuki did not report an analysis of participants' responses in the free-choice terminal links, so no conclusions can be made about the relation between terminal-link selections among the desirable and undesirable options and preference for free-choice.

In a similar study to Suzuki (1997), Hori and Shimazaki (2010) further examined choice preferences in conditions where participants' selections in free-choice could result in undesirable consequences. Like Suzuki, Hori and Shimazaki used a concurrent-chains procedure, manipulated the number of points available in free-choice, and measured the effects on choice preferences. In addition, Hori and Shimazaki manipulated the valence of the choice task by testing participants' preferences for choice-making that resulted point gains or point losses. With this manipulation, Hori and Shimazaki aimed to determine if preferences for free-choice would be lower for participants who engaged in a loss-avoidance task. The researchers also tracked responses in the free-choice terminal links of the concurrent-chain.

Hori and Shimazaki's (2010) concurrent-chains procedure was similar to Suzuki's (1997) (see Figure 2). Participants used a mouse to select images of cards on a computer screen, and each card was worth a certain number of points that were exchanged for money at the end of the experiment. The researchers used a mixed design to test participants' preferences in gain and loss choice contexts and across three conditions. In the gain group, cards carried positive point values and participants were instructed to accumulate as many points as possible. For example, in the initial link of the concurrent-chain, the gain group selected between an image of one card worth positive 10 (+10)

points (forced-choice) and an image of two cards worth +10 points (free-choice). If participants clicked the one-card image, one card appeared on screen in the terminal link of the chain. If participants clicked the two-card image, two cards appeared on screen in the terminal link. Participants' card selections in the terminal link produced a message on screen indicating the number of points gained for choosing that card and the probability of point delivery was fixed at 0.4 throughout the experiment. The procedure was similar for the loss group, except that participants selected among cards that carried negative values and were instructed to retain as many points as they could throughout the task.

In addition to the between-groups, gain/loss manipulation, Hori and Shimazaki (2010) exposed all participants to three conditions across which the number of points available in free-choice was varied. In all three conditions, the color (green) and point value (+10 or -10 for the gain and loss groups, respectively) of one of the two cards in free-choice was held constant to match the value of the forced-choice card. Thus, participants always had the chance to gain or lose the same number of points in free- and forced-choice. Participants in the gain group experienced the following three conditions: (a) (10)/(10|15), (b) (10)/(10|10), and (c) (10)/(10|5). Participants in the loss group experienced similar conditions, except point values were negative: (a) (-10)/(-10|-5), (b) (-10)/(-10|-10), and (c) (-10)/(-10|-15) (notation analogous to Suzuki, 1997; see description above).

Hori and Shimazaki (2010) found that the valence of the choice task (gain versus loss) did not differentially affect choice preferences across groups, and participants in both the gain and loss groups preferred free-choice over forced-choice in all conditions.

Hori and Shimazaki concluded that access to free-choice functioned as a reinforcer when participants engaged in a task that resulted in a gain of reinforcers (points) and when the task required participants to avoid losing reinforcers. Although participants preferred free-choice in all three conditions, preferences were significantly higher in conditions in which participants could gain more, or lose fewer, points relative to the forced-choice situation [i.e., conditions (10)/(10|15) and (-10)/(-10|-5)]. Preferences dropped significantly in conditions in which the number of points available for one of the two cards in free-choice was fewer [i.e., conditions (10)/(10|5) and (-10)/(-10|-15)] or equal to [i.e., conditions (10)/(10|10) and (-10)/(-10|-10)] the forced-choice card. This drop in preference is intuitive in that free-choice in the (10)/(10|10), (10)/(10|5), (-10)/(-10|-10), and (-10)/(-10|-15) conditions did not offer more rewarding outcomes than the forced-choice situation; and thus it is logical that preferences would reduce to some degree in comparison to the (10)/(10|15) and (-10)/(-10|-5) conditions. Interestingly, however, no substantial decreases in free-choice preferences were observed from (10)/(10|10) to (10)/(10|5) or (-10)/(-10|-10) to (-10)/(-10|-15), even though the reduction in available points in free-choice was proportionate.

Hori and Shimazaki (2010) also reported participants' card selections in free-choice terminal links to examine the relation between terminal-link card selection and free-choice preference. When undesirable options were included in free-choice [i.e., in conditions (10)/(10|5) and (-10)/(-10|-15)], participants' probability of selecting the lower-valued cards (5 in gain and -15 in loss) was approximately 20% and 30% in gain and loss, respectively. Thus, participants' preferences for free-choice and their tendencies

to select the undesirable options in free choice were negatively correlated (i.e., free-choice preferences were high and selections of undesirable options in free-choice were low). These observations do not align with Hayes et al.'s (1981) predictions that subjects will likely avoid free-choice, or will express indifference, when the probability of selecting the undesirable outcome in free-choice is low.

In summary, only a few studies have used the concurrent-chains schedule of reinforcement to test human subjects' choice preferences when free-choice offers a mix of desirable *and* relatively undesirable outcomes (i.e., Hori & Shimazaki, 2010; Suzuki, 1997). Taken together, the findings of Suzuki and Hori and Shimazaki differ with respect to the persistence of free-choice preferences under conditions where it is possible for participants to make choices that result in undesirable consequences. In both studies, the conditions of particular interest are those in which free-choice included a card worth the same number of points as the forced-choice (desirable outcome), and an additional card(s) worth fewer points (undesirable outcome). Researchers in both studies analyzed free-choice preferences in two ways: (a) by comparing the proportion of free-choice selections in the initial link to chance level (0.5), and (b) comparing free-choice selection proportions between conditions across which the outcomes available in free-choice differed. Hori and Shimazaki demonstrated that free-choice preferences remained above chance level when one relatively undesirable outcome was available in free-choice [i.e., conditions (10)/(10|5), (-10)/(-10|-15)]. These results conflict with Suzuki's who observed indifference in conditions where one or two undesirable outcomes were available in the free-choice situation [i.e., conditions (10)/(10|5), (10)/(10|1), (10)/(10|5|5)]. In addition,

Suzuki found that preferences for free-choice were significantly lower in conditions where free-choice included at least one undesirable outcome compared to conditions where all available outcomes were identical. Hori and Shimazaki did not observe these differences. Finally, these studies do not provide sufficient information to make conclusions about the extent to which participants' differential terminal-link selections in free-choice correlate with levels of preference for free-choice.

The major aim of the present study was to extend Suzuki's (1997) and Hori and Shimazaki's (2010) research to further examine the robustness of human subjects' free-choice preferences when a mix of desirable and undesirable outcomes are available in the free-choice situation. A concurrent-chains procedure similar to Suzuki's and Hori and Shimazaki's was used, in which participants chose among images of stimuli on a computer screen, gained or lost points for their choices, and exchanged the points for money at the end of the experiment.

I systematically replicated Hori and Shimazaki's (2010) reinforcer-gain and reinforcer-loss contexts, but assessed the effects with a more powerful within-subjects research design to increase the likelihood that I would observe an effect of the manipulation if one exists. In addition, I tested participants' choice preferences in the reinforcer-gain and reinforcer-loss contexts across five conditions. Like Suzuki, I presented participants with a choice between a one-alternative task (forced-choice) and a three-alternative task (free-choice) in the initial link of the concurrent-chain. One of the three alternatives in free-choice was always equal in point value to the forced-choice option, and the other two alternatives were associated with point values *greater than*

(desirable outcomes), *equal to* (equal outcomes), or *less than* (undesirable outcomes) the forced-choice option.

In both the gain and loss contexts, participants were exposed to five conditions where two of the three alternatives in free-choice were either: (a) 15 points greater than forced-choice (+15 condition), (b) 5 points greater than forced-choice (+5 condition), (c) equal to forced-choice (equal condition), (d) 5 points fewer than forced-choice (-5 condition), and (e) 15 points fewer than forced-choice (-15 condition). Thus, I reproduced Suzuki's +5 [(10)/(10|15|15)], equal [(10)/(10|10|10)], and -5 [(10)/(10|5|5)] conditions in the reinforcer-gain context, and added two additional conditions in which I further increased the magnitude of point increases and decreases in free-choice in conditions +15 [(10)/(10|25|25)] and -15 [(10)/(10|-5|-5)]. The conditions in the reinforcer-loss context were similar, except that point values were mostly negative. The reinforcer-loss conditions were: +15 [(-10)/(-10|5|5)], +5 [(-10)/(-10|-5|-5)], equal [(-10)/(-10|-10|-10)], -5 [(-10)/(-10|-15|-15)], and -15 [(-10)/(-10|-25|-25)]. Furthermore, a detailed analysis of participants' terminal-link responding was conducted to provide a comprehensive description of the relation between participants' card selections in free-choice and their levels of preference for choice. Hayes et al.'s (1981) logic would predict that the level of participants' free-choice preferences would correspond with their probability of selecting the options available in the free-choice terminal link.

In summary, the present experiment extends previous choice research with human subjects (Hori & Shimazaki, 2010; Suzuki, 1997) by (a) systematically replicating a test of participants' choice preferences in reinforcer-gain and reinforcer-loss contexts,

(b) evaluating the effects of increasing the magnitude of reinforcer gains and losses in comparison to previous studies, and (c) providing a detailed analysis of participants' responding in the terminal link of the concurrent-chain. Although Hori and Shimazaki found no significant differences between gain and loss choice contexts, I included some alterations intended to increase the likelihood that I would observe an effect if one exists. The major differences between the present research and Hori and Shimazaki's experiment are (a) experimental design and (b) number of alternatives available in the choice situation. It is possible that Hori and Shimazaki's between-subjects design was not sufficiently powerful to detect effects of gain and loss. If this is the case, the within-subjects manipulation used in this study could increase the likelihood of detecting an effect. In addition, if my results do contradict Hori and Shimazaki's findings this could also be due to the inclusion of a greater number of alternatives associated with undesirable outcomes in the free-choice task.

Based on previous research (Hori & Shimazaki, 2010; Suzuki, 1997), I expected to readily observe preference for free-choice in the +15, +5, and equal conditions. I also expected to observe free-choice avoidance or indifference by including alternatives in the free-choice situation that result in undesirable outcomes (i.e., -15 and -5 conditions). Based on Hori and Shimazaki's observations, I predicted that participants would sample all available options (desirable and undesirable) in free-choice to some degree. I included an analysis of participants' terminal link responses to examine the extent to which choice preferences correlated with card selections in free-choice.

Method

Participants, Setting, and Apparatus

Fourteen college undergraduates participated in the study. Participants were from the psychology department subject pool at Queens College, City University of New York. Individuals in the pool were informed that participation in an experiment was one way to fulfill a research requirement in introductory psychology. Students signed up for the experiment using the psychology department's on-line system and were pre-screened for colorblindness. Individuals who reported colorblindness were not eligible to participate.

Experimental sessions took place in one of two small rooms in a research laboratory on campus. The rooms contained a desk, chair, and personal computer. Participants sat in front of the computer screen on which images of stimuli were presented and they selected stimuli by clicking with a mouse. A computer program controlled experimental sessions and the data were automatically stored on the hard drive.

General Procedure

Students participated in one experimental session that lasted approximately 3 hrs. A concurrent-chains procedure was used to test participants' preferences for a three-alternative choice task (free-choice) versus a single-alternative choice task (forced-choice). Preferences were tested separately in two choice contexts: gain and loss. In the gain context, participants accumulated points by selecting stimuli on the computer screen, and in a proportionate loss context, participants lost points for selecting stimuli. Both the gain and loss contexts included five choice conditions across which the number points

available in free-choice was manipulated. At the start of gain and loss, participants completed a 5-min instruction and training period followed by the five choice conditions. Training included four practice trials after which the researcher obtained verbal confirmation that the participant understood the task (Suzuki, 1997). Each of the five choice conditions was made up of 72 trials and trials lasted approximately 10 s each. Participants took a 1-min break after each choice condition and took a 5-min break between the gain and loss contexts.

For all trials, participants sat in front of a computer screen on which images of colored rectangular cards were presented. Messages on screen prompted participants to select from the cards. Depending on the choice context (gain or loss), participants gained or lost points for selecting cards and the points were exchangeable for money at the end of the session. The point values of the cards differed according to card color and the values were either positive or negative.

Choice Context

Gain. In the gain context, participants could accumulate a maximum of 2,520 points and were instructed to gain as many points as possible (see Appendix A for gain instructions). Because points were delivered for 50% of the trials, two types of trials were presented: (1) gain/point trials and (2) gain/no-point trials. For example, if a participant selected a card worth positive five (+5) points a message appeared on screen that read either, “You gained 5 points,” (gain/point trial) or “You gained 0 points,” (gain/no-point trial). A message indicating the number of points that could be gained for selecting each card and the chance of gaining those points was displayed on the upper-right portion of

the screen for the duration of each trial (e.g., “GREEN card = 50% chance to gain 10 points.”).

Loss. The loss context was similar to gain except that participants started with 2,520 points and were instructed to avoid losing as many of those points as possible (see Appendix B for loss instructions). Two types of trials were presented: (1) loss/point trials and (2) loss/no-point trials. For example, if a participant selected a card worth negative five (-5) points a message appeared on screen that read either, “You lost 5 points,” (loss/point trial) or “You lost 0 points,” (loss/no-point trial).

Choice Conditions

In the following descriptions, the names of the conditions refer to the number of points participants could gain or lose for selecting each of the cards that appeared on screen in the given condition (notation adapted from Suzuki, 1997). For example, if a participant was asked to select between a single card worth +10 points (forced-choice task) and three cards worth +10 points (free-choice task), the condition was named (10)/(10|10|10). If a participant was asked to select between a single card worth negative 10 (-10) points (forced-choice task) and three cards worth -10 points (free-choice task), the condition was named (-10)/(-10|-10|-10).

In all conditions, the single card presented in the forced-choice task was fixed at +10 points or -10 points in the gain and loss contexts, respectively. In free-choice, at least one of the three cards was the same color (green) and worth the same number of points as the forced-choice card. Thus, participants could always obtain the same number of points in the free- and forced-choice tasks by selecting the green card. Table 1 lists the names of

each condition and the point values associated with each card color. Below, the conditions are described in corresponding gain/loss pairs.

Table 1

Summary of Choice Conditions in Gain and Loss

Context	Condition	Forced-choice	Free-choice
Gain +15	(10) / (10 | 25 | 25)	Green: 10	Green: 10 | Red: 25 | Red: 25
+5	(10) / (10 | 15 | 15)	Green: 10	Green: 10 | Purple: 15 | Purple: 15
equal	(10) / (10 | 10 | 10)	Green: 10	Green: 10 | Green: 10 | Green: 10
-5	(10) / (10 | 5 | 5)	Green: 10	Green: 10 | Orange: 5 | Orange: 5
-15	(10) / (10 | -5 | -5)	Green: 10	Green: 10 | Blue: -5 | Blue: -5
Loss +15	(-10) /(-10 | 5 | 5)	Green: -10	Green: -10 | Red: 5 | Red: 5
+5	(-10) / (-10 | -5 | -5)	Green: -10	Green: -10 | Purple: -5 | Purple: -5
equal	(-10) / (-10 | -10 | -10)	Green: -10	Green: -10 | Green: -10 | Green: -10
-5	(-10) / (-10 | -15 | -15)	Green: -10	Green: -10 | Orange: -15 | Orange: -15
-15	(-10) / (-10 | -25 | -25)	Green: -10	Green: -10 | Blue: -25 | Blue: -25

+15: **(10)/(10|25|25) and (-10)/(-10|5|5)**. The +15 conditions assessed preference when one of the three cards in free-choice was *equal to* the single card in forced-choice and the other two cards were *15 points greater* than forced-choice card. A single green card represented forced-choice and one green card and two red cards represented free-choice (see Figures 3 & 4). The (10)/(10|25|25) gain condition and (-10)/(-10|5|5) loss condition consisted of 72 trials each.

+5: **(10)/(10|15|15) and (-10)/(-10|-5|-5)**. The +5 conditions assessed preference when one of the three cards in free-choice was *equal to* the single card in forced-choice and the other two cards were *5 points greater* than the forced-choice card. A single green card represented forced-choice and one green card and two purple cards represented free-choice (see Figures 5 & 6). The (10)/(10|15|15) gain condition and (-10)/(-10|-5|-5) loss condition consisted of 72 trials each.

Equal: (10)/(10|10|10) and (-10)/(-10|-10|-10). The purpose of the equal conditions was to assess preference when the outcomes for selecting all cards in free- and forced-choice were equal. A single green card represented forced-choice and three green cards represented free-choice (see Figures 7 & 8). The (10)/(10|10|10) gain condition and (-10)/(-10|-10|-10) loss condition consisted of 72 trials each.

-5: **(10)/(10|5|5) and (-10)/(-10|-15|-15)**. The -5 conditions assessed preference when one of the three cards in free-choice was *equal to* the single card in forced-choice and the other two cards were *5 points fewer* than the single card in forced-choice. A single green card represented forced-choice and one green card and two orange cards represented free-choice (see Figures 9 & 10). The (10)/(10|5|5) gain condition and (-10)/(-10|-15|-15) loss condition consisted of 72 trials each.

-15: **(10)/(10|-5|-5) and (-10)/(-10|-25|-25)**. The -15 conditions assessed preference when one of the three cards in free-choice was *equal to* the single card in forced-choice and the other two cards were *15 points fewer* than the single card in forced-choice. A single green card represented forced-choice and one green card and two blue

cards represented free-choice (see Figures 11 & 12). The (10)/(10|-5|-5) gain condition and (-10)/(-10|-25|-25) loss condition consisted of 72 trials each.

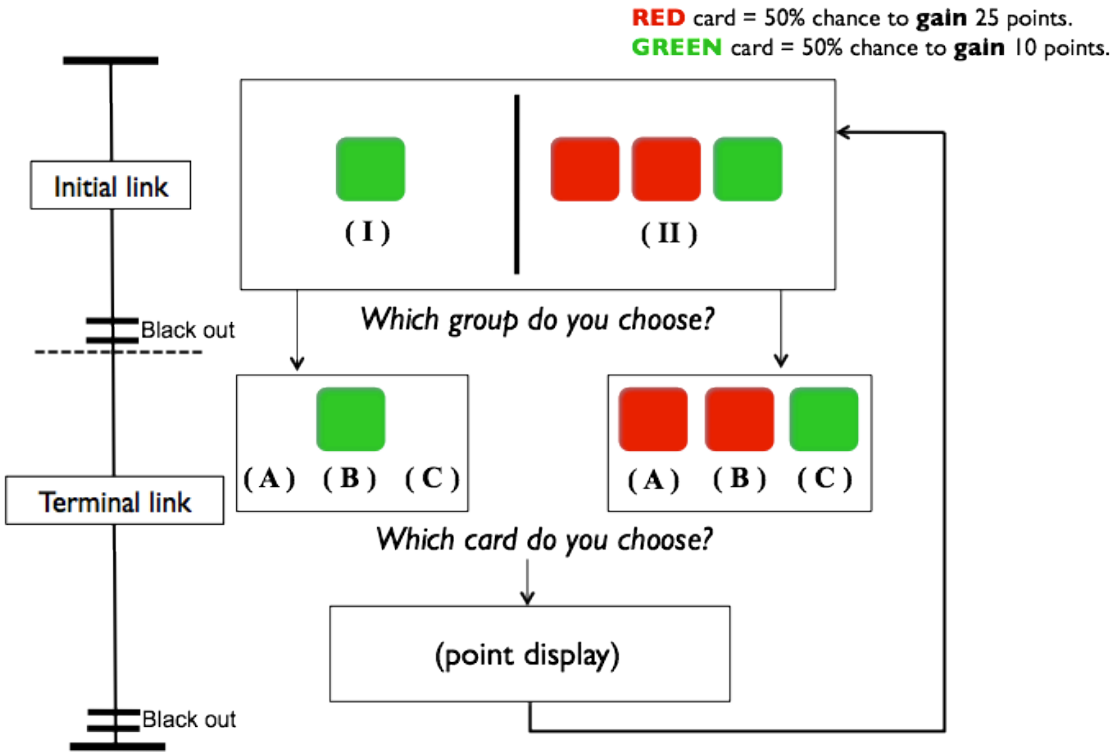

Figure 3. Concurrent-chains procedure used in the +15 gain condition (adapted from Hori & Shimazaki, 2010; Suzuki, 1997).

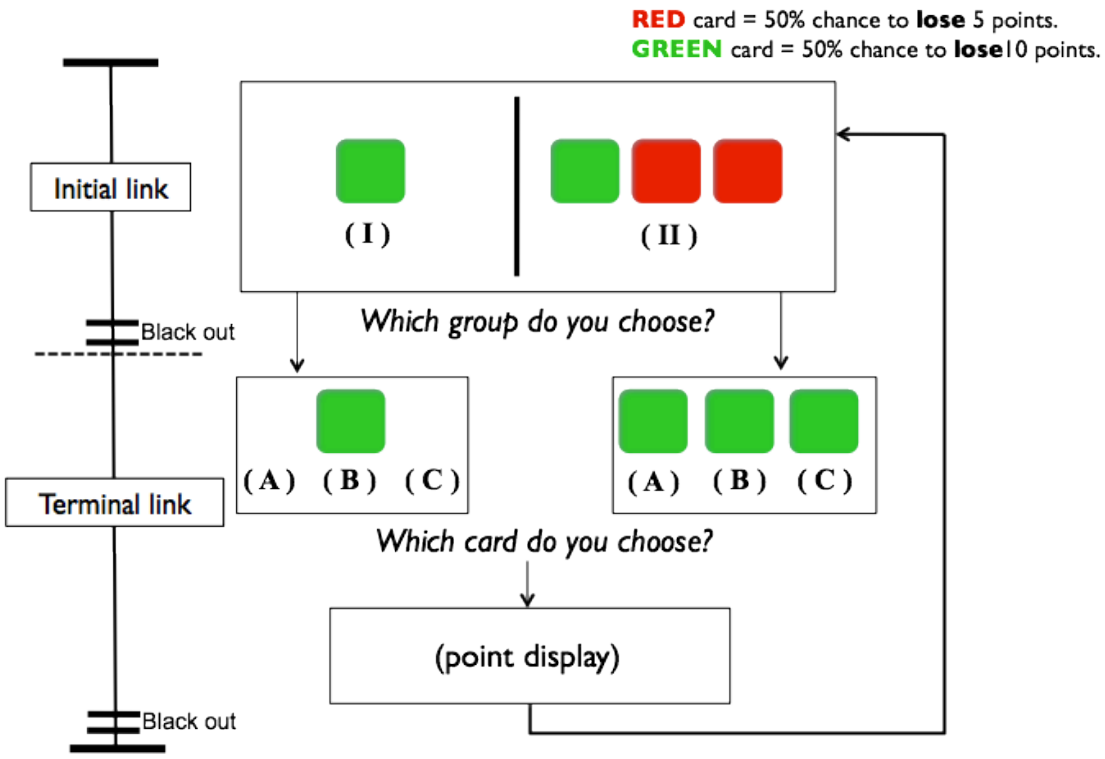

Figure 4. Concurrent-chains procedure used in the +15 loss condition (adapted from Hori & Shimazaki, 2010; Suzuki, 1997).

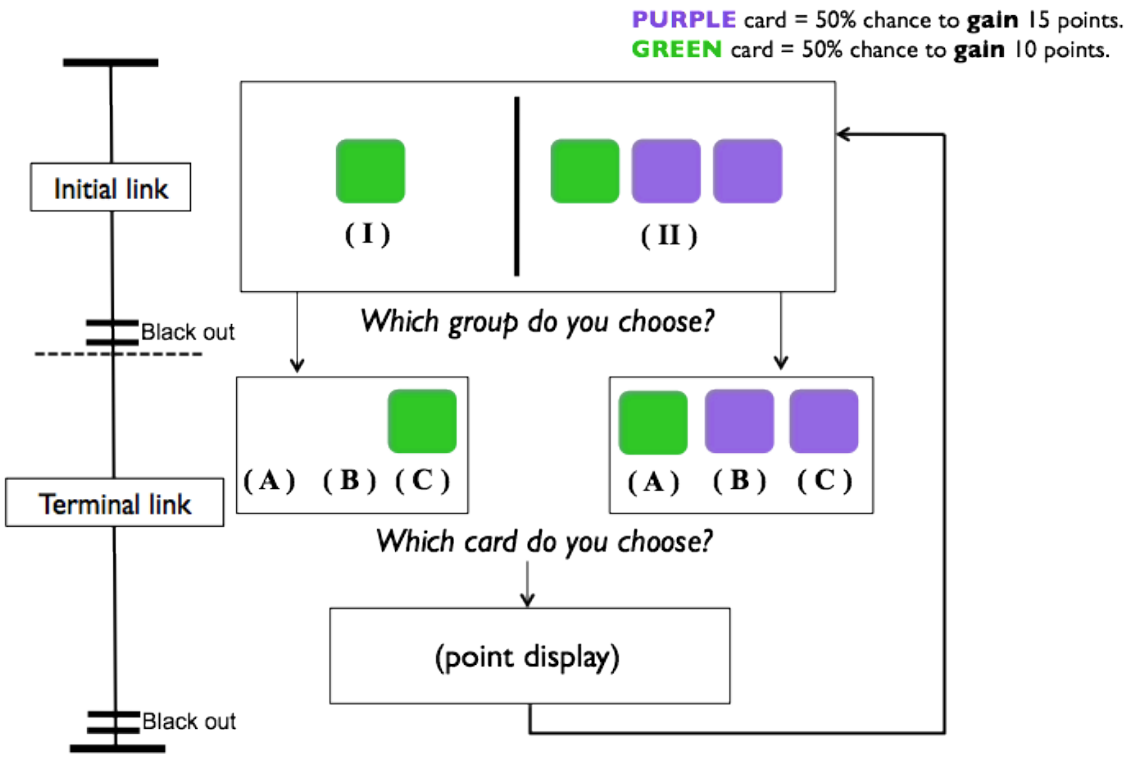

Figure 5. Concurrent-chains procedure used in the +5 gain condition (adapted from Hori & Shimazaki, 2010; Suzuki, 1997).

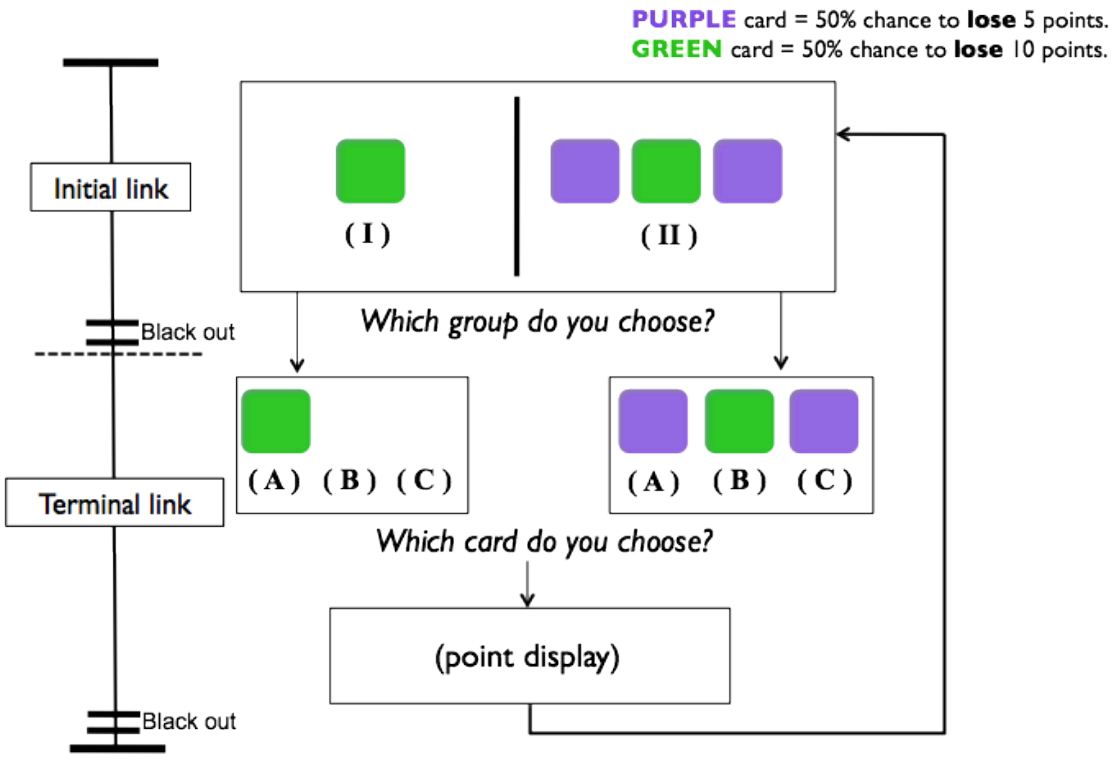

Figure 6. Concurrent-chains procedure used in the +5 loss condition (adapted from Hori & Shimazaki, 2010; Suzuki, 1997).

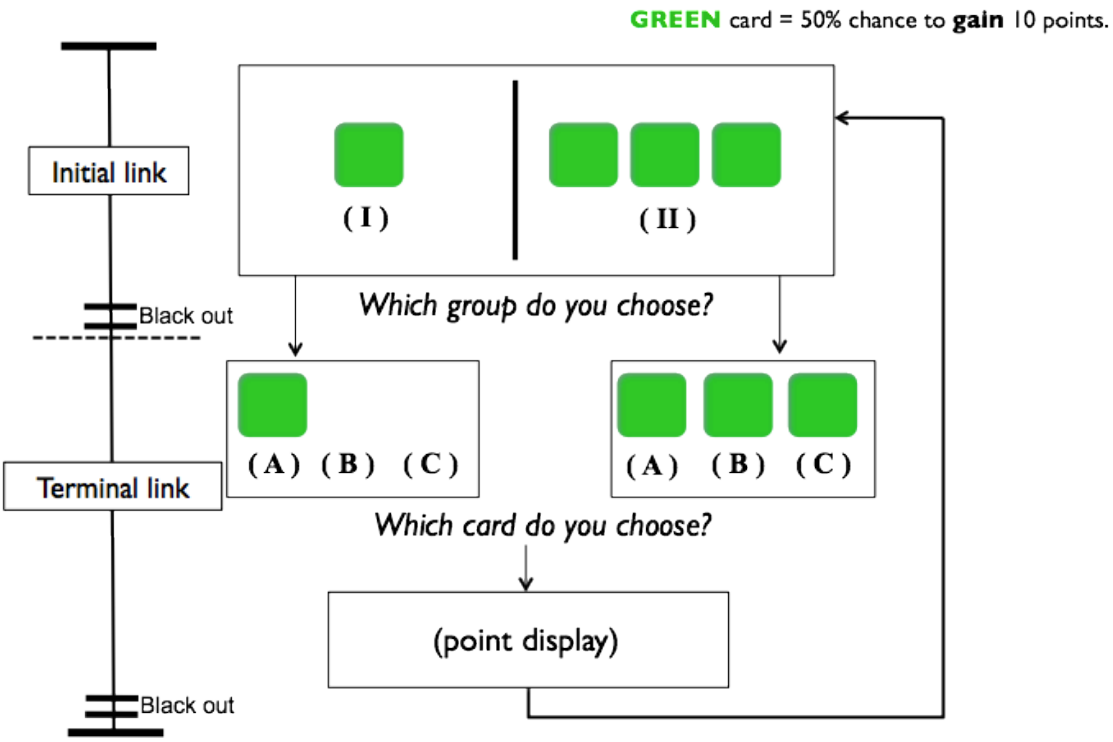

Figure 7. Concurrent-chains procedure used in the equal-gain condition (adapted from Hori & Shimazaki, 2010; Suzuki, 1997).

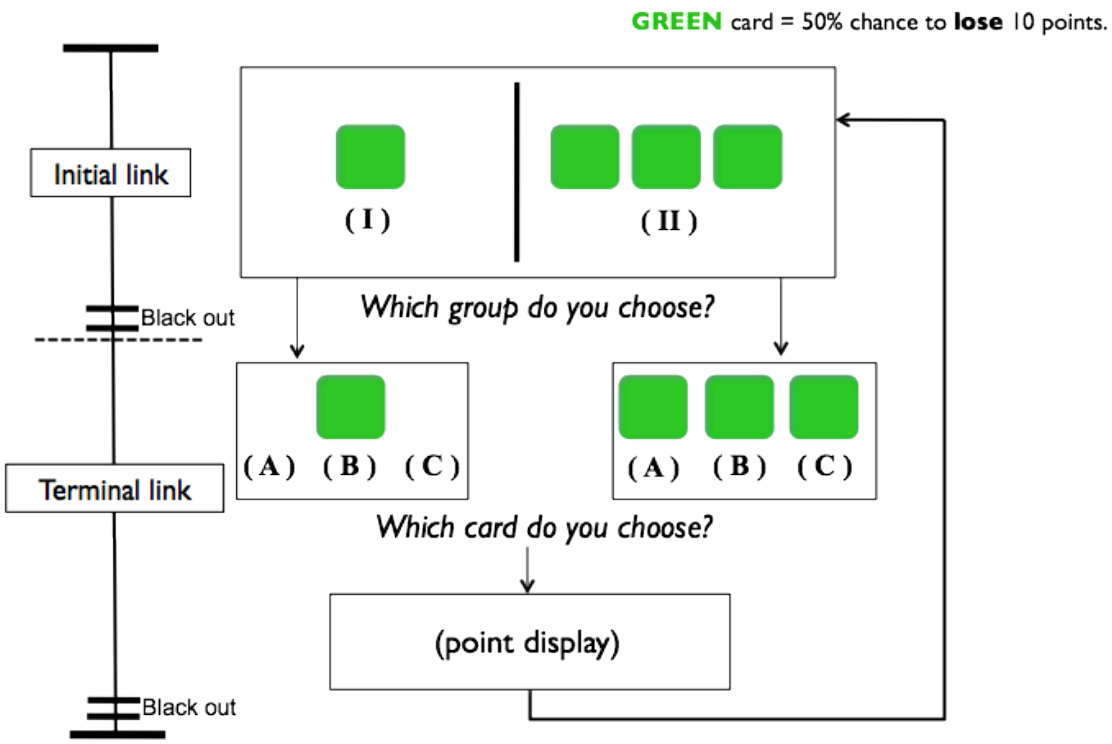

Figure 8. Concurrent-chains procedure used in the equal-loss condition (adapted from Hori & Shimazaki, 2010; Suzuki, 1997).

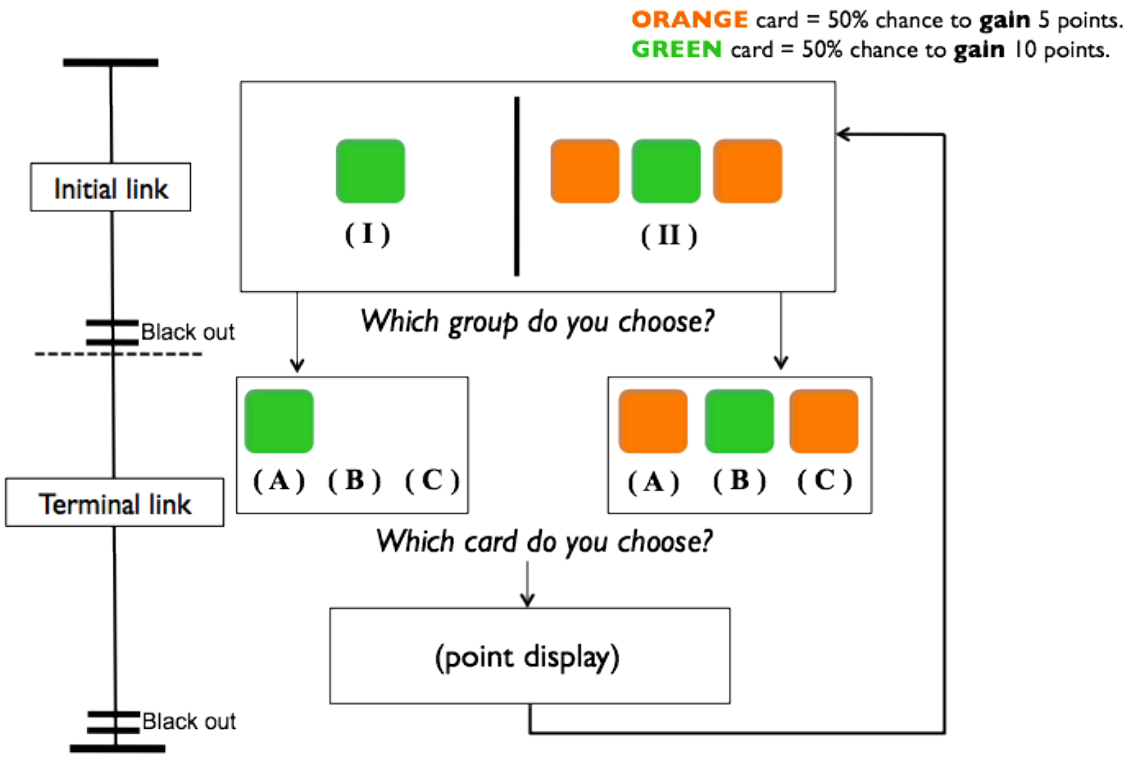

Figure 9. Concurrent-chains procedure used in the -5 gain condition (adapted from Hori & Shimazaki, 2010; Suzuki, 1997).

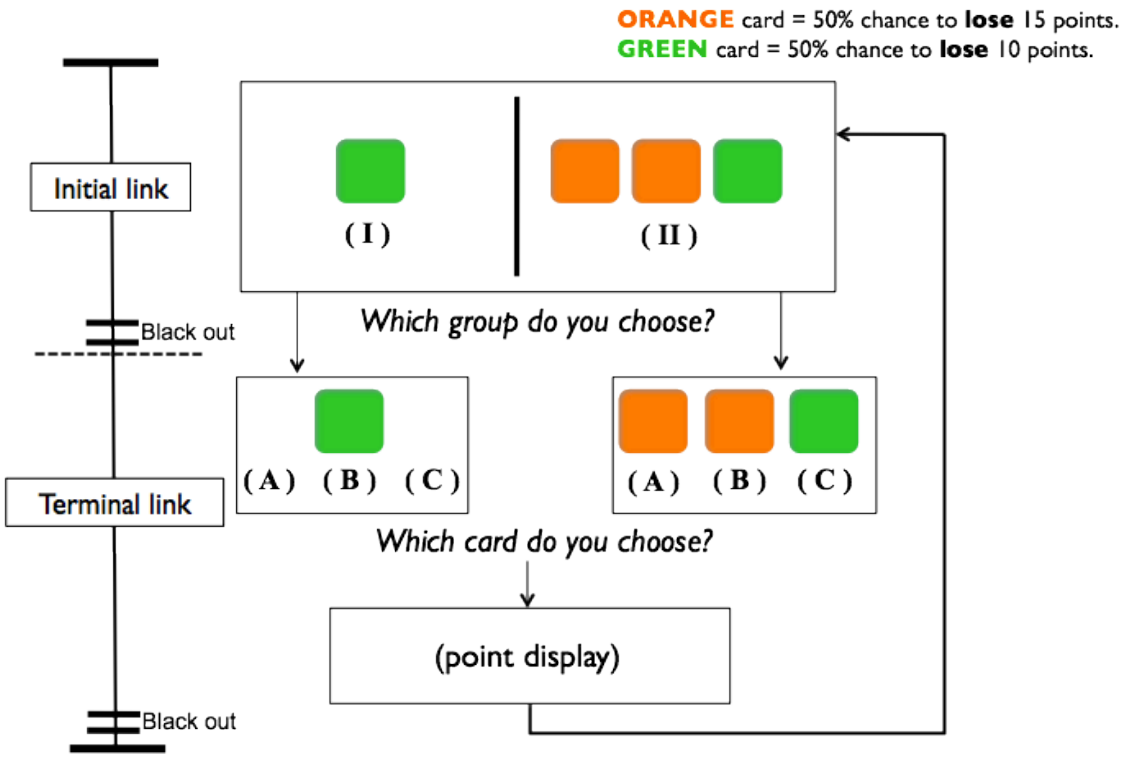

Figure 10. Concurrent-chains procedure used in the -5 loss condition (adapted from Hori & Shimazaki, 2010; Suzuki, 1997).

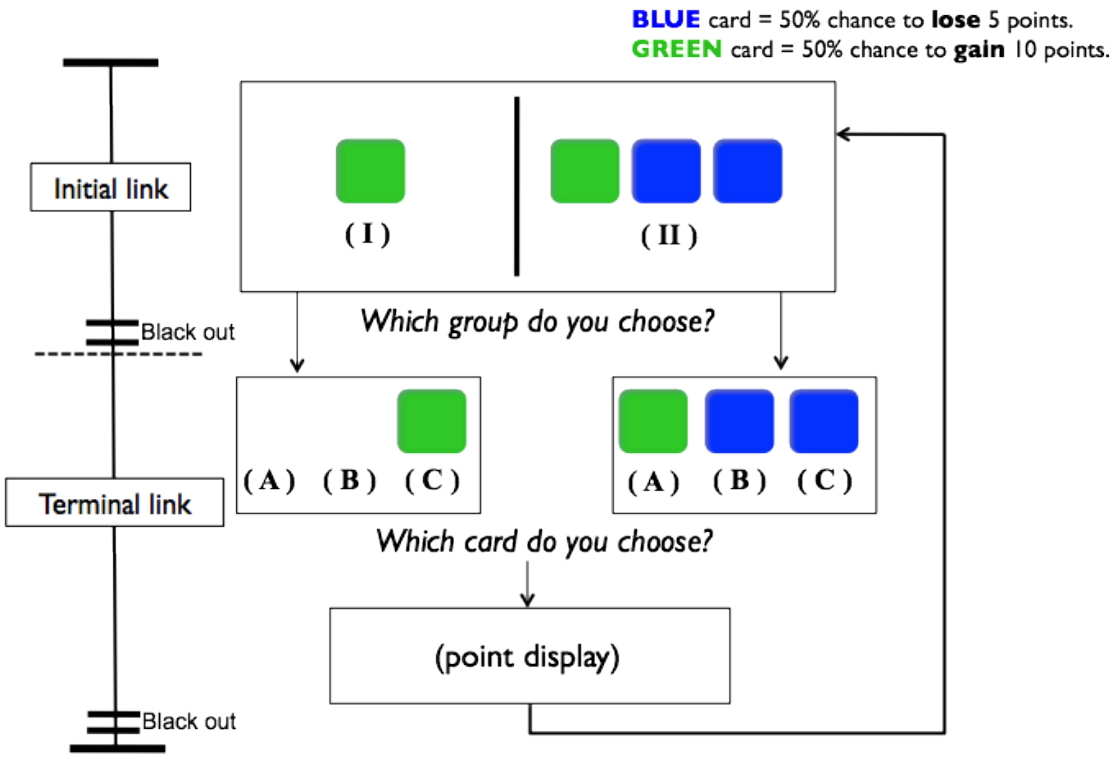

Figure 11. Concurrent-chains procedure used in the -15 gain condition (adapted from Hori & Shimazaki, 2010; Suzuki, 1997).

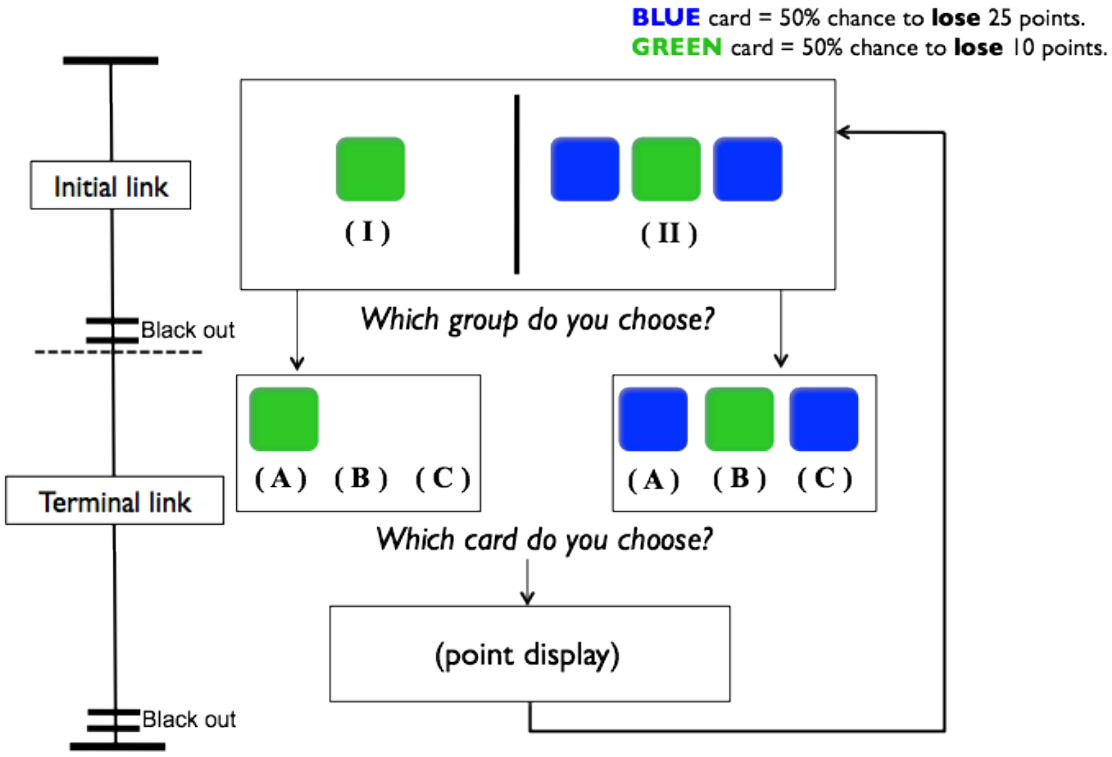

Figure 12. Concurrent-chains procedure used in the -15 loss condition (adapted from Hori & Shimazaki, 2010; Suzuki, 1997).

Concurrent-Chains Procedure

Initial link. The task used in this study was adapted from Suzuki's (1997, 2000) and Hori & Shimazaki's (2010) concurrent-chains procedures. The initial link in the concurrent-chain began with the simultaneous appearance of two sets of cards on the computer screen, which represented the free-choice and forced-choice tasks available in the terminal links of the chain. The forced-choice task was represented by an image of one green card and the free-choice task was represented by an image of three cards. One of the three cards in free-choice was always green and the other two cards were purple,

red, orange, blue, or green depending on the choice condition (described above). The positions and colors of the free-choice card set in the initial link depicted the positions and colors of the cards available in the terminal link. For example, if the free-choice card set showed a green card in between two red cards, the positions and colors of the cards would match this in the terminal link. The forced- and free-choice card sets were labeled "Group I" and "Group II" respectively, on the computer screen.

The question, "Which group do you choose?" appeared below the card sets and participants selected a set by clicking it once with the mouse. The screen positions (left or right) of the card sets in the initial link were randomly determined within trial blocks of 36. Participants' card set selection in the initial link produced a 0.5 s blackout during which the screen was blank, followed by the start of the terminal link.

Terminal link. The terminal link of the concurrent-chain began with the appearance of the choice task (free-choice or forced-choice) associated with the card set selected in the initial link. If the initial link selection was associated with free-choice, three cards appeared on screen along with the question, "Which card do you choose?" and participants selected a card by clicking it once with the mouse. The three cards were positioned on the left, middle, or right of the computer screen (labeled "A" "B" and "C" respectively, on screen) and these positions were randomly determined within trial blocks of 36. If the initial link selection was associated with forced-choice, a single card appeared on the screen along with the question "Which card do you choose?" and participants selected the card by clicking it once with the mouse. The single green card appeared in the left, middle, or right position (labeled "A" "B" and "C" respectively, on

screen) and the other two positions were blank. Card position in forced-choice terminal links was randomly determined within trial blocks of 36 as well. Mouse clicks on portions of the computer screen where cards or card sets did not appear resulted in no programmed consequences (i.e., the computer screen did not change, no points were delivered, and the trial did not terminate).

Point display. Participants' clicks on a card in the terminal links were followed by a 0.5 s blackout during which the screen was blank. After the blackout, a message was displayed on screen for 3 s. The message indicated the number of points gained or lost for the given trial. Participants were not presented with their cumulative point totals during the session. For gain/point trials, the message indicated the number of points gained (e.g., "You gained 5 points.") and for the gain/no-point trials the message always read "You gained 0 points." For loss/point trials, the message indicated the number of points lost (e.g., "You lost 5 points.") and for the loss/no-point trials the message always read "You lost 0 points."

The specific number of points that could potentially be gained or lost was dependent upon participants' card selections in the terminal link, but the probability of earning or losing those points was fixed at 0.5 throughout the session. The presentation of points or no-points after card selections in the terminal-link was randomly determined within trial blocks of 36. Thus, participants had an equal chance of gaining/losing the points associated with their card selection in the terminal link for every trial. Every 10 points gained or lost was equivalent to a gain or loss of $0.046.

In summary, it is presumed the selection of a card set in the initial link was maintained, or reinforced, by access to either the free-choice or forced-choice terminal link. It is also presumed that card selection in the terminal link was maintained by gaining points (gain context) or avoiding the loss of points (loss context). In the equal, -5, and -15 choice conditions, the maximum number of points participants were able to gain, or minimum points they could lose, was the same across the free- and forced-choice tasks. Thus, initial link selection provided a measure of preference for access to either free-choice or forced-choice in the terminal link. In the +5 and +15 conditions, however, free-choice included cards that, if selected, could result in a greater number of points gained or smaller number of points lost than in forced-choice. Thus, the +5 and +15 conditions were not intended to isolate preference for free-choice independent of the outcomes produced by card selection in the terminal link, but rather to readily produce free-choice preference.

Experimental Design

Participants' preferences were tested in gain (A) and loss (B) contexts and across the five choice conditions described above. Gain and loss choice contexts were compared using a crossover design (AB versus BA) and the choice conditions were manipulated within each gain and loss context. In blocks of two, half of the participants were randomly assigned to gain followed by loss (AB) and the other half were assigned to loss followed by gain (BA). Complete randomization was used to determine the order of the choice conditions within gain and loss for each subject (see Table 2 for the context and condition assignments for each subject).

The following trial characteristics were determined randomly within trial blocks of 36: (a) the delivery of points or no points, (b) screen positions (right or left) of the card sets in the initial links, and (c) screen positions (“A”, “B”, or “C”) of the card(s) in the terminal links.

Table 2

Order of Gain/Loss Contexts and Choice Conditions for All Subjects

	Context Order		Condition Order				
Subject Number	A	B	1	2	3	4	5
1	Loss	Gain	-15	-5	+15	Equal	+5
2	Gain	Loss	+15	-5	-15	Equal	+5
3	Gain	Loss	-5	Equal	+5	-15	+15
4	Loss	Gain	+15	-5	Equal	-15	+5
5	Gain	Loss	-15	+15	+5	-5	Equal
6	Loss	Gain	Equal	+5	+15	-5	-15
7	Loss	Gain	-5	-15	+5	Equal	+15
8	Gain	Loss	+15	Equal	-5	+5	-15
9	Gain	Loss	Equal	+5	+15	-15	-5
10	Loss	Gain	+5	-5	-15	Equal	+15
11	Gain	Loss	+5	-5	+15	-15	Equal
12	Loss	Gain	+15	-15	+5	-5	Equal
13	Gain	Loss	-5	+5	Equal	+15	-15
14	Loss	Gain	-15	-5	Equal	+15	+5

Data Analysis

Initial link. Participants' choice preferences were determined by their relative responding in the initial link of the concurrent-chain. Preferences were expressed by calculating selection proportions for free-choice. Selection proportions were calculated by dividing the number of times participants selected the card set associated with free-choice in the initial link divided by the total number of trials completed (Suzuki, 2002):

$$\frac{\text{\# of free-choice selections in initial link}}{\text{total \# of trials}}$$

A selection proportion of 1.0 indicated a perfect preference for free-choice and a proportion of 0 indicated a perfect preference for forced-choice. A selection proportion of 0.5 indicated that free-choice and forced-choice were chosen an equal number of times. Thus, selection proportions that ranged from 0.5 to 1.0 indicated preference for free-choice, proportions 0.49 to 0 indicated preference for forced-choice, and a proportion of 0.5 was the point of indifference, or no preference. For example, if a participant selected free-choice 54 out of 72 trials, the selection proportions would be 0.75 and 0.25 for free-choice and forced-choice, respectively. This would indicate a preference for free-choice.

A 2 (sequence group; gain/loss versus loss/gain) × 2 (choice context; gain versus loss) × 2 (cycle; first 36 versus last 36 trials) × 5 (choice condition; +15, +5, equal -5, and -15) mixed factorial analysis of variance (ANOVA) was used to examine the potential differential effects produced by the variables of primary interest: choice context and choice condition. The sequence group variable in the ANOVA refers to the order in which participants experienced the choice contexts (gain/loss versus loss/gain). Sequence group

was included in the analysis to confirm that the use of the crossover design effectively controlled for effects attributable to context sequence. The cycle variable in the ANOVA refers to the first half (Cycle 1) and second half (Cycle 2) of the trials in each condition ($N = 72$). Cycle was included in the analysis to test for possible differences in performance between the first 36 and last 36 trials of the choice conditions.

In addition to the ANOVA, single-sample *t*-tests were used to examine whether or not free-choice selection proportions in each condition varied significantly from indifference (0.5). Selection proportions significantly greater than 0.5 indicated free-choice preference, proportions significantly lower than 0.5 indicated free-choice avoidance, and proportions that did not differ significantly from 0.5 indicated indifference.

Terminal link. Participants' card selections in the terminal link of the concurrent-chain were also recorded. In the forced-choice terminal link participants had only one card from which to choose, so differential responding in the forced-choice link was not possible. Thus, the analysis of terminal-link responding was restricted to participants' selection among the three cards in the free-choice terminal link. Terminal-link responding was examined in the +15, +5, -5, and -15 conditions where participants selected from one green card and two non-green (purple, red, orange or blue) cards. Terminal-link responding in the equal condition was not analyzed because participants always selected among three green cards of equal value. In the +15 and +5 conditions, I expected participants to select the non-green cards (purple and red) more frequently than the green card in free-choice because the non-green cards were associated with more points. In the

-5 and -15 conditions, I expected participants to select the non-green cards (orange and blue) at a lower frequency than the green card in free-choice because the non-green cards were associated with fewer points.

A 2 (choice context; gain versus loss) × 4 (choice condition; +15, +5, -5, and -15) repeated measures ANOVA was used to examine the potential differential effects produced by choice context (gain versus loss) and the choice conditions of interest (+5, +15, -15, and -15) on non-green card selections in free-choice terminal links. The ANOVA allowed me to test for differences in terminal-link performance between contexts and among choice conditions.

Pearson's correlation coefficient (*r*) was then used to examine the relation between the frequency of non-green card selections and preference for free-choice within each condition. The purpose of examining the relation between non-green card selection and free-choice preference was to determine the extent to which selection frequency of the greater-valued cards, in the +15 and +5 conditions, and the lesser-valued cards, in the -5 and -15 conditions, correlated with preference for free-choice.

Points obtained. In addition participants' selection responses in the initial and terminal links, the total number of points obtained by each participant in all conditions during the experiment was tracked. The probability of obtaining points on any given trial was fixed at 0.5. Thus, participants were no more likely to obtain (gain or lose) points for selecting a card in the free-choice terminal link than in the forced-choice terminal link. Participants did, however, control the actual number of points obtained in the free- and forced-choice terminal links within each condition for two reasons: (a) participants

controlled the frequency with which they accessed free- versus forced-choice by way of their initial-link selections, and (b) participants controlled the number of points they could potentially obtain in free-choice in the +15, +5, -5, and -15 conditions by way of their terminal-link card selections. For these reasons, the number of points obtained was likely to vary across experimental conditions. My interest was in the relation between the number of points obtained within each condition and preference for free-choice. Pearson's correlation coefficient (*r*) was used to examine the relation between number of points obtained and preference for free-choice within each choice condition in the gain and loss contexts.

Results

Initial Link

ANOVA. The free-choice selection proportion data from the initial link were analyzed with a 2 (sequence group; gain/loss versus loss/gain) × 2 (choice context; gain versus loss) × 2 (cycle; first 36 versus last 36 trials) × 5 (choice condition; +15, +5, equal -5, and -15) mixed factorial ANOVA. The ANOVA yielded significant main effects of choice condition, $F(4, 48) = 27.61$, $p < .0001$, and cycle, $F(1, 12) = 10.02$, $p = .0081$, only. No significant main effects of sequence group or choice context were observed, and no significant interactions were found.

Figure 13 displays the free-choice selection proportions in the +15, +5, equal, -5, and -15 choice conditions collapsed across gain and loss; the corresponding means and standard deviations are presented in Table 3. On Figure 13, selection proportions displayed on the *y*-axis range from 0.0 to 1.0. A selection proportion of 0.5 is the point of indifference, or no preference. Proportions above 0.5 indicate that free-choice was selected more frequently than forced-choice, and proportions below 0.5 indicate forced-choice was selected more frequently than free-choice.

Condition effect. As preferences did not differ between the gain and loss choice contexts, data were collapsed across contexts in the post-hoc analysis of the condition effect. The condition effect was parsed with a one-way repeated measures ANOVA, restricted to condition, followed by Tukey's honestly significant difference (HSD) test. The ANOVA was significant, $F(4, 108) = 32.38$, $p < .0001$. All possible pairs of conditions differed significantly with respect to free-choice preferences, except for the

+15 versus +5 and -5 versus -15 conditions. The mean free-choice selection proportion in the +15 (M = 0.98, SD = 0.06) condition was significantly greater than the mean free-choice selection proportion in the equal (M = 0.76, SD = 0.25), -5 (M = 0.61, SD = 0.25), and -15 (M = 0.56, SD = 0.25) conditions. In addition, the +5 (M = 0.95, SD = 0.08) condition was significantly greater than the equal, -5, and -15 conditions, and the equal condition was significantly greater than the -5 and -15 conditions (see Table 4 for a summary of the post hoc test).

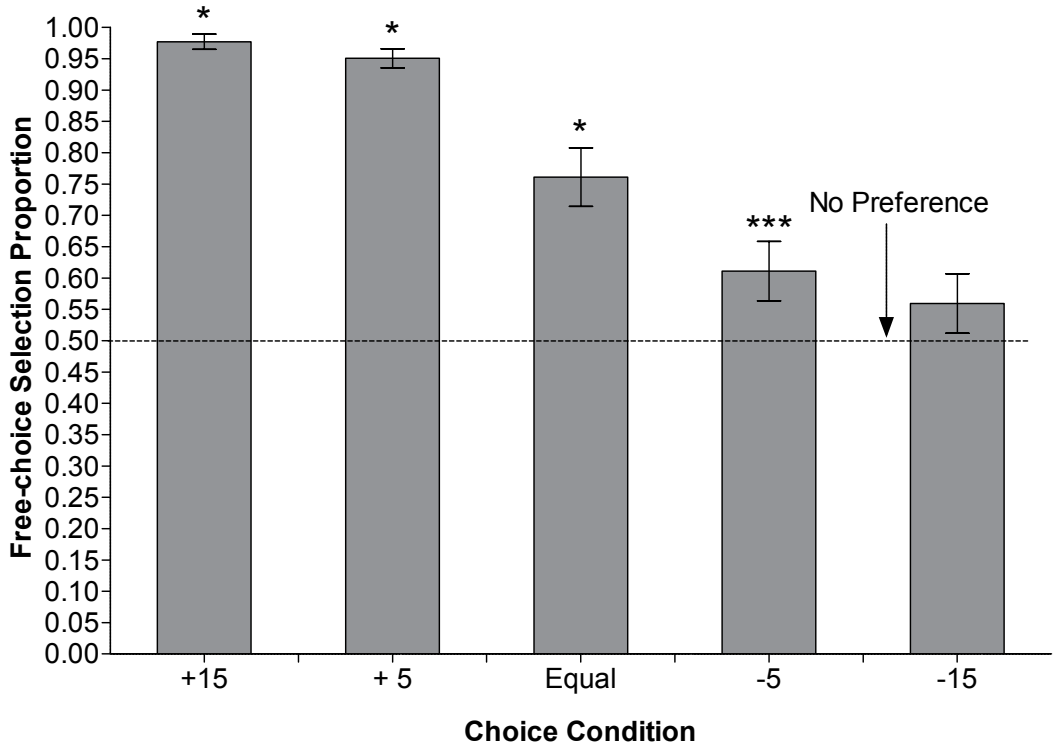

Figure 13. Mean free-choice selection proportions (N = 14) in the initial link across choice conditions, collapsed across gain and loss. Error bars represent standard errors and asterisks indicate the p-values (see below) associated with single-sample t-tests comparing the free-choice selection proportions in each condition to indifference (0.5)

*p < .001; ***p < .05

Table 3

Mean Free-choice Selection Proportions per Choice Condition in Gain and Loss (*Standard Deviations in Parentheses*)

Context		Condition	Free-choice selection proportion
Gain & loss combined		+15	0.98 (0.06)
		+5	0.95 (0.08)
		Equal	0.76 (0.25)
		-5	0.61 (0.25)
		-15	0.56 (0.25)
Gain	+15	(10) / (10 | 25 | 25)	0.96 (0.09)
	+5	(10) / (10 | 15 | 15)	0.94 (0.09)
	Equal	(10) / (10 | 10 | 10)	0.76 (0.26)
	-5	(10) / (10 | 5 | 5)	0.63 (0.20)
	-15	(10) / (10 | -5 | -5)	0.55 (0.23)
Loss	+15	(-10) /(-10 | 5 | 5)	0.99 (0.01)
	+5	(-10) / (-10 | -5 | -5)	0.96 (0.07)
	Equal	(-10) / (-10 | -10 | -10)	0.76 (0.24)
	-5	(-10) / (-10 | -15 | -15)	0.59 (0.30)
	-15	(-10) / (-10 | -25 | -25)	0.57 (0.28)

Note. $N = 14$

Table 4

Summary of p-values of Post Hoc Comparisons of Free-choice Preferences Between Choice Conditions, Collapsed Across Gain and Loss

	Condition				
Condition	+15	+5	equal	-5	-15
+15	-	-	-	-	-
+5	ns	-	-	-	-
equal	< .001	< .01	-	-	-
-5	< .001	< .001	< .05	-	-
-15	< .001	< .001	< .001	ns	-

Note. ns = not significant.

Cycle effect. The main effect of cycle indicated that free-choice preferences differed from the first 36 trials in each condition to last 36 trials in each condition. Table 5 displays the means and standard deviations for each cycle across the five choice conditions. When collapsed across conditions and contexts, free-choice preferences were significantly greater in Cycle 2 (M = 78.65, SD = 26.24) than in Cycle 1 (M = 75.69, SD = 26.65), $t(139) = 3.52$, $p = .0006$.

I also conducted a planned comparison of the effect of condition (+15, +5, equal, -5, and -15) on selection proportions in Cycles 1 and 2 separately. Two, one-way repeated measures ANOVAs, restricted to cycle, were used. For Cycle 1, the ANOVA was significant, $F(4, 108) = 31.00$, $p < .0001$, and all possible pairs of choice conditions differed significantly ($p < .05$) except for +15 versus +5, -5 versus, -15, and equal versus -5. For Cycle 2, the ANOVA was significant, $F(4, 108) = 29.58$, $p < .0001$, and all

possible pairs of choice conditions differed significantly ($p < .05$) except for +15 versus +5 and -5 versus, -15. Thus, the effect of choice condition on free-choice preferences in the first 36 trials (Cycle 1) and the last 36 trials (Cycle 2) was similar except that participants' preferences did not differ between the equal and -5 conditions in Cycle 1 but did differ in Cycle 2.

Table 5

Mean Free-choice Selection Proportions in Cycles 1 and 2 Across Choice Conditions (Standard Deviations in Parentheses)

Condition	Free-choice selection proportion	
	Cycle 1	Cycle 2
+15	97.02 (8.00)	98.31 (5.03)
+5	94.64 (9.29)	95.44 (7.83)
equal	72.91 (25.89)	79.37 (25.47)
-5	59.13 (25.61)	63.1 (26.23)
-15	54.76 (24.27)	57.04 (26.30)

Single-sample *t*-tests. When the gain and loss data were combined, free-choice preferences were significantly higher than chance level (0.5) in conditions where it was possible for participants to select cards in free-choice that resulted in a greater gain or smaller loss of points than in forced-choice. That is, participants preferred free-choice in the +15 ($M = 0.98$, $SD = 0.06$), $t(27) = 39.07$, $p < .0001$, and +5 ($M = 0.95$, $SD = 0.08$), $t(27) = 29.56$, $p < .0001$, conditions. Free-choice selection proportions were also significantly greater than 0.5 in the equal ($M = 0.76$, $SD = 0.25$), $t(27) = 5.57$, $p < .0001$

condition, where all card selections in free- and forced-choice produced the same number of points. Finally, participants preferred free-choice in the -5 (M = 0.61, SD = 0.25), $t(27) = 2.35$, p = .0265, condition, but no significant effects were observed in the -15 (M = 0.56, SD = 0.25), $t(27) = 1.25$, p = .2220, condition. These findings are displayed in Figure 13 and summarized in Table 6.

Table 6

Summary of Preferences in All Choice Conditions in Gain and Loss in Relation to Indifference (0.5)

Context		Condition	Result
Gain & loss combined		+15	Free-choice preference
		+5	Free-choice preference
		Equal	Free-choice preference
		-5	Free-choice preference
		-15	Indifference
Gain	+15	(10) / (10 | 25 | 25)	Free-choice preference
	+5	(10) / (10 | 15 | 15)	Free-choice preference
	Equal	(10) / (10 | 10 | 10)	Free-choice preference
	-5	(10) / (10 | 5 | 5)	Free-choice preference
	-15	(10) / (10 | -5 | -5)	Indifference
Loss	+15	(-10) /(-10 | 5 | 5)	Free-choice preference
	+5	(-10) / (-10 | -5 | -5)	Free-choice preference
	Equal	(-10) / (-10 | -10 | -10)	Free-preference preference
	-5	(-10) / (-10 | -15 | -15)	Indifference
	-15	(-10) / (-10 | -25 | -25)	Indifference

Note. Results are expressed as free-choice preference (selection proportion is significantly greater than 0.5), avoidance (selection proportion is significantly lower than 0.5), and indifference (selection proportion does not differ significantly from 0.5).

I also analyzed free-choice preferences in each choice condition for gain and loss separately. Figure 14 displays the mean free-choice selection proportions per choice condition, separated by gain and loss, and the corresponding means and standard deviations are presented in Table 3. When single-sample *t*-tests were applied to the gain data alone the results matched those of the combined data. Participants preferred free-choice in the gain +15 ($M = 0.96$, $SD = 0.09$), $t(13) = 19.32$, $p < .0001$, gain +5 ($M = 0.94$, $SD = 0.09$), $t(13) = 18.92$, $p < .0001$, equal gain ($M = 0.76$, $SD = 0.26$), $t(13) = 3.69$, $p = 0.0027$, and -5 gain ($M = 0.63$, $SD = 0.20$), $t(13) = 2.55$, $p = .0244$, conditions. No significant effects were observed in the -15 gain ($M = 0.55$, $SD = 0.23$) condition. When single-sample *t*-tests were applied to the loss data alone, participants preferred free-choice in the loss +15 ($M = 0.99$, $SD = 0.01$), $t(13) = 216.66$, $p < .0001$, loss +5 ($M = 0.96$, $SD = 0.07$), $t(13) = 22.91$, $p < .0001$, and equal loss ($M = 0.76$, $SD = 0.24$), $t(13) = 4.01$, $p = .0013$. No significant effects were observed in -5 loss ($M = 0.59$, $SD = 0.30$) or -15 loss ($M = 0.57$, $SD = 0.28$) conditions (see Table 6 for a summary of these results).

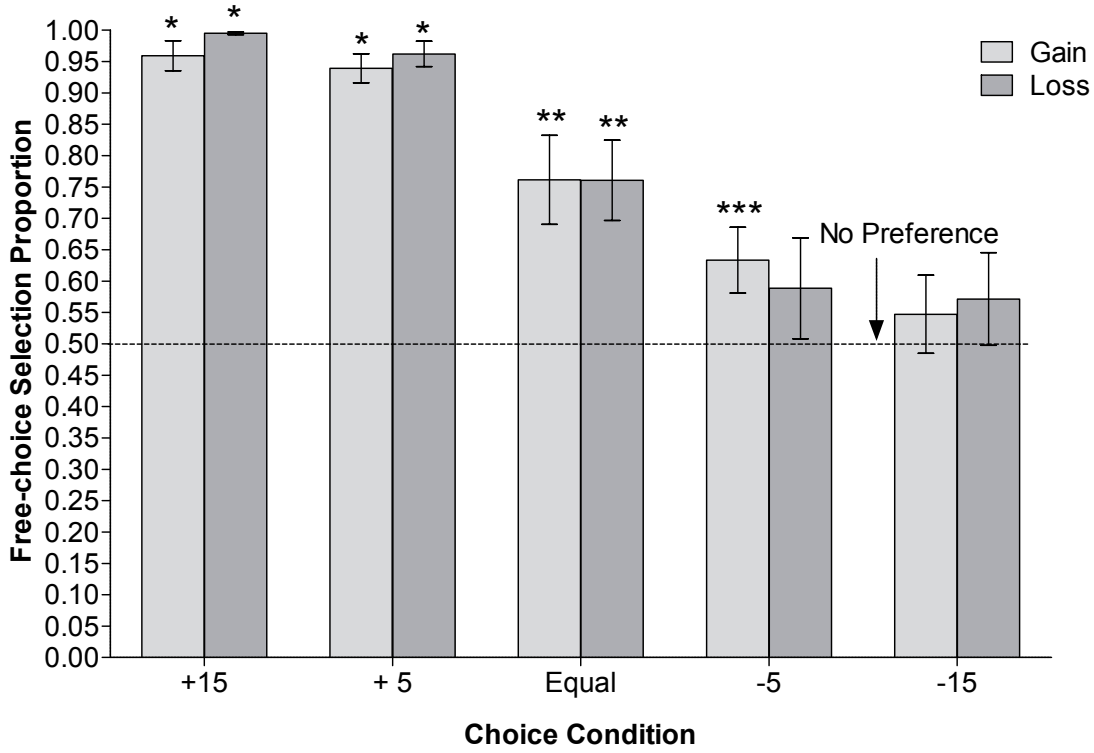

Figure 14. Mean free-choice selection proportions ($N = 14$) in the initial link across choice conditions in gain and loss. Error bars represent standard errors and asterisks indicate the *p*-values (see below) associated with single-sample *t*-tests comparing the free-choice selection proportions in each condition to indifference (0.5).

*$p < .001$; **$p < .01$; ***$p < .05$

Terminal Link

Figure 15 displays performance in the terminal links, expressed as the mean number of non-green card selections in free-choice, for the +15, +5, -5, and -15 conditions across gain and loss. Figure 15 clearly shows that participants selected the non-green cards in free-choice most frequently when those cards produced a greater gain or smaller loss of points than the green card (i.e., in the +15 gain, +5 gain, +15 loss, and +5 loss conditions). Table 7 summarizes the mean number of trials in which participants accessed free-choice, the number of non-green card selections in free-choice, and the percentage of trials non-green cards were selected in free-choice terminal links per condition.

ANOVA. The 2 (choice context; gain versus loss) × 4 (choice condition; +15, +5, -5, and -15) repeated measures ANOVA applied to the non-green card selection data yielded a significant main effect of condition, $F(3, 39) = 115.67$, $p < .0001$, and a significant context (gain/loss) × condition (+15, +5, -5, -15) interaction, $F(3, 39) = 3.00$, $p = .04$.

Condition effect. The condition effect was parsed with a one-way repeated measures ANOVA, restricted to condition, followed by Tukey's HSD test. The ANOVA was significant, $F(3, 81) = 187.77$, $p < .0001$, and the pairwise test showed that participants' selection of the non-green cards in the +15 ($M = 68.29$, $SD = 7.21$) condition was significantly greater than in the -5 ($M = 12.43$, $SD = 16.84$) and -15 ($M = 4.64$, $SD = 8.92$) conditions. In addition, Participants' selection of the non-green cards in the +5 ($M = 62.46$, $SD = 13.01$) condition was significantly greater than in the -5 and -15 conditions.

No significant differences were found between the +15 and +5 conditions or between the -5 and -15 conditions. These findings are summarized in Table 8.

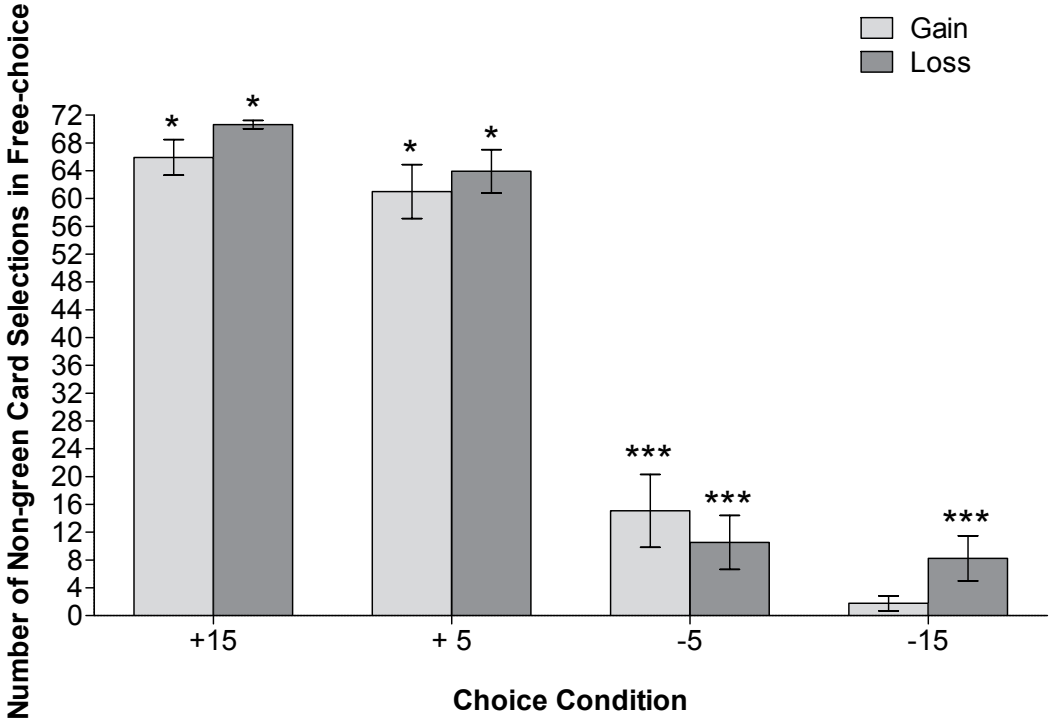

Figure 15. Non-green card selections ($N = 14$) in free-choice terminal links per choice condition in gain and loss. Error bars represent standard errors and asterisks indicate the *p*-values (see below) associated with single-sample *t*-tests comparing the non-green card selection frequency in each condition to zero.

*$p < .001$; ***$p < .05$

Table 7

Summary of the Mean Number of Trials Participants Accessed Free-choice, the Number of Non-green Card Selections in Free-choice, and the Percentage of Trials Non-green Cards Were Selected in Free-choice Per Condition (Standard Deviations in Parentheses)

Context	Condition	Total free-choice terminal links	Total non-green card selections	Percentage of non-green card selections
Gain	+15	69.07 (6.39)	65.93 (9.55)	95.12% (7.47%)
	+5	67.57 (6.32)	61.00 (14.52)	89.12% (15.40%)
	-5	45.57 (14.15)	15.07 (19.64)	28.52% (35.17%)
	-15	39.43 (16.77)	1.64 (3.77)	3.42% (6.82%)
Loss	+15	71.57 (0.65)	70.64 (2.21)	98.69% (2.56%)
	+5	69.29 (5.36)	63.93 (11.66)	91.57% (11.84%)
	-5	42.43 (21.60)	9.79 (13.73)	19.17% (24.60%)
	-15	41.07 (19.80)	7.64 (11.48)	15.31% (21.93%)

Table 8

Summary of p-values of Post Hoc Comparisons of Non-green Card Selections in Free-choice Between Choice Conditions, Collapsed Across Gain and Loss

	Condition			
Condition	+15	+5	-5	-15
+15	-	-	-	-
+5	ns	-	-	-
-5	< .001	< .001	-	-
-15	< .001	< .001	ns	-

Note. ns = not significant.

Context × condition interaction. Figure 16 displays the context (gain/loss) × condition (+15, +5, -5, -15) interaction for non-green card selections in free-choice. The context × condition interaction indicates that the effect of context on non-green card selection frequency was dependent upon choice condition. The interaction was parsed with four paired *t*-tests to determine which condition pairs (e.g., +5 gain versus +5 loss) differed across gain and loss with respect to non-green card selection. The analysis showed that non-green card selection differed significantly across gain and loss in the +15 and -15 conditions, but not in the +5 and -5 conditions. Participants selected the non-green cards more frequently in the +15 loss ($M = 70.64$, $SD = 2.21$) condition than in the +15 gain ($M = 65.93$, $SD = 9.55$) condition, $t(13) = 2.25$, $p = .0424$. Participants also selected the non-green cards more frequently in the -15 loss ($M = 7.64$, $SD = 11.48$) condition than in the -15 gain ($M = 1.64$, $SD = 3.77$) condition, $t(13) = 2.48$, $p = .0274$. No significant differences were found between the +5 gain ($M = 61.00$, $SD = 14.52$) versus +5 loss ($M = 63.93$, $SD = 11.66$), $t(13) = 1.00$, $p = .3344$, and the -5 gain ($M = 15.07$, $SD = 19.64$) versus -5 loss ($M = 9.79$, $SD = 13.73$) conditions, $t(13) = 1.21$, $p = .2826$. See Table 9 for a summary of these results.

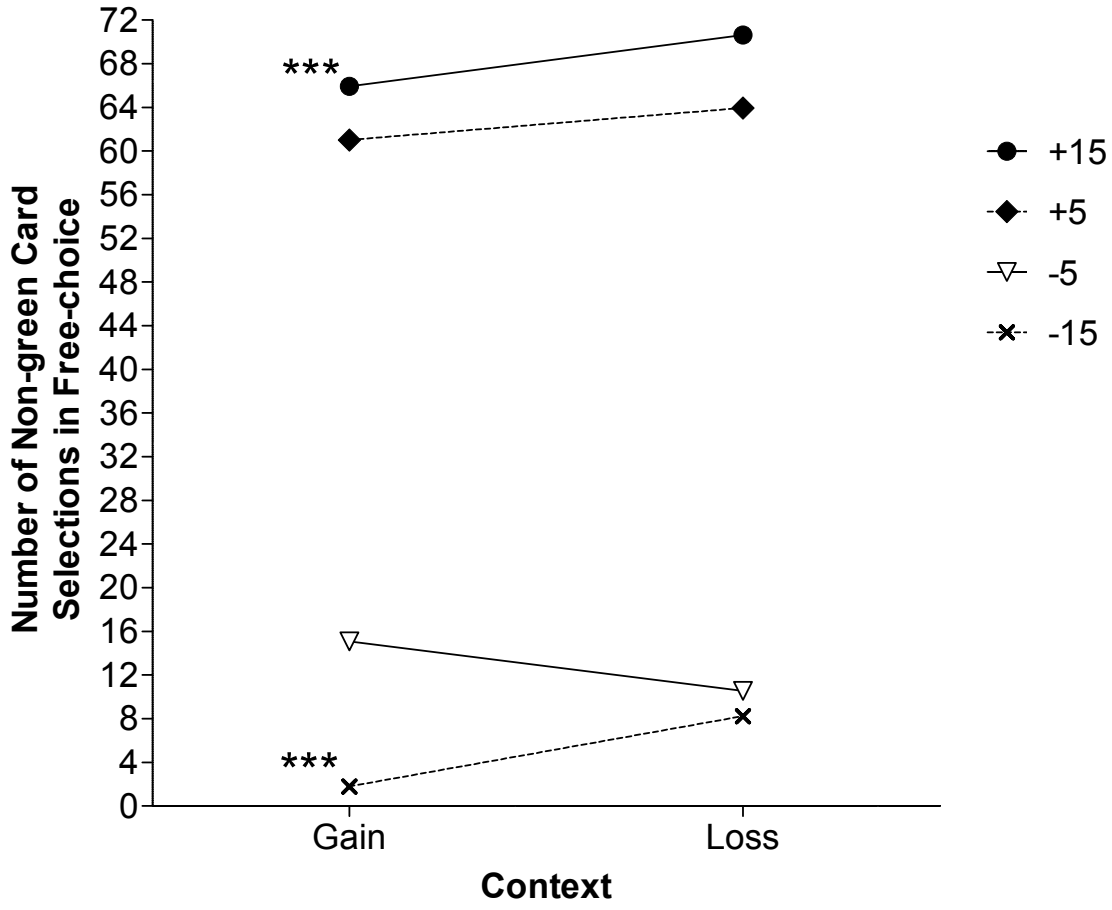

Figure 16. Context × condition interaction ($N = 14$) for the number of non-green card selections in free-choice terminal links. Asterisks indicate the *p*-values (see below) associated with the *t*-tests comparing non-green card selections in gain versus loss for each condition.

***$p < .05$

Table 9

Summary of p-values of Post Hoc Paired t-tests of Non-green Card Selections in Free-choice Between Choice Condition Pairs, Across Gain and Loss

	Gain			
Loss	+15	+5	-5	-15
+15	0.0424	-	-	-
+5	-	ns	-	-
-5	-	-	ns	-
-15	-	-	-	0.0274

Note. ns = not significant.

Pearson's correlation coefficient (*r*). I expected participants who selected the non-green card more often than the green card in the +15 and +5 conditions to have higher preferences for free-choice, and participants who selected the non-green card more often than the green card in the -5 and -15 conditions to have lower preferences for free-choice.

Gain context. Figure 17 displays a combined scatterplot of the relations between free-choice preference and non-green card selections in free-choice in the +15, +5, -5, and -15 gain conditions. The number of non-green card selections in the free-choice terminal links was positively correlated with preferences for free-choice in the +15 and +5 gain conditions (see Figure 18). These results indicate that participants' frequency of selecting the cards that produced the largest point gains in free-choice corresponded with their level of preference for free-choice. No significant correlations between non-green

card selection and free-choice preference were found for the -5 gain and -15 gain conditions (see Figure 18).

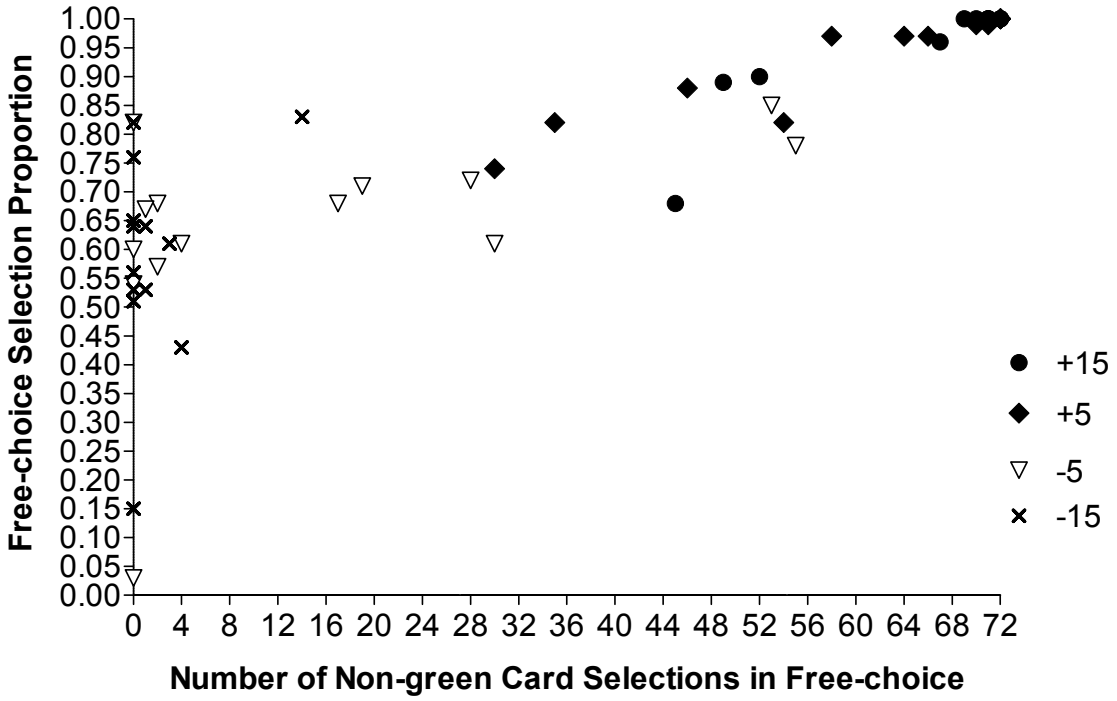

Figure 17. Superimposed scatterplots ($N = 14$) of the relation between the number of non-green card selections in free-choice and free-choice preference in the +15 gain ($r = 0.89$, $p < .0001$), +5 gain ($r = 0.94$, $p < .0001$), -5 gain ($r = 0.47$, $p = .0927$), and -15 gain conditions ($r = 0.33$, $p = .2511$) conditions.

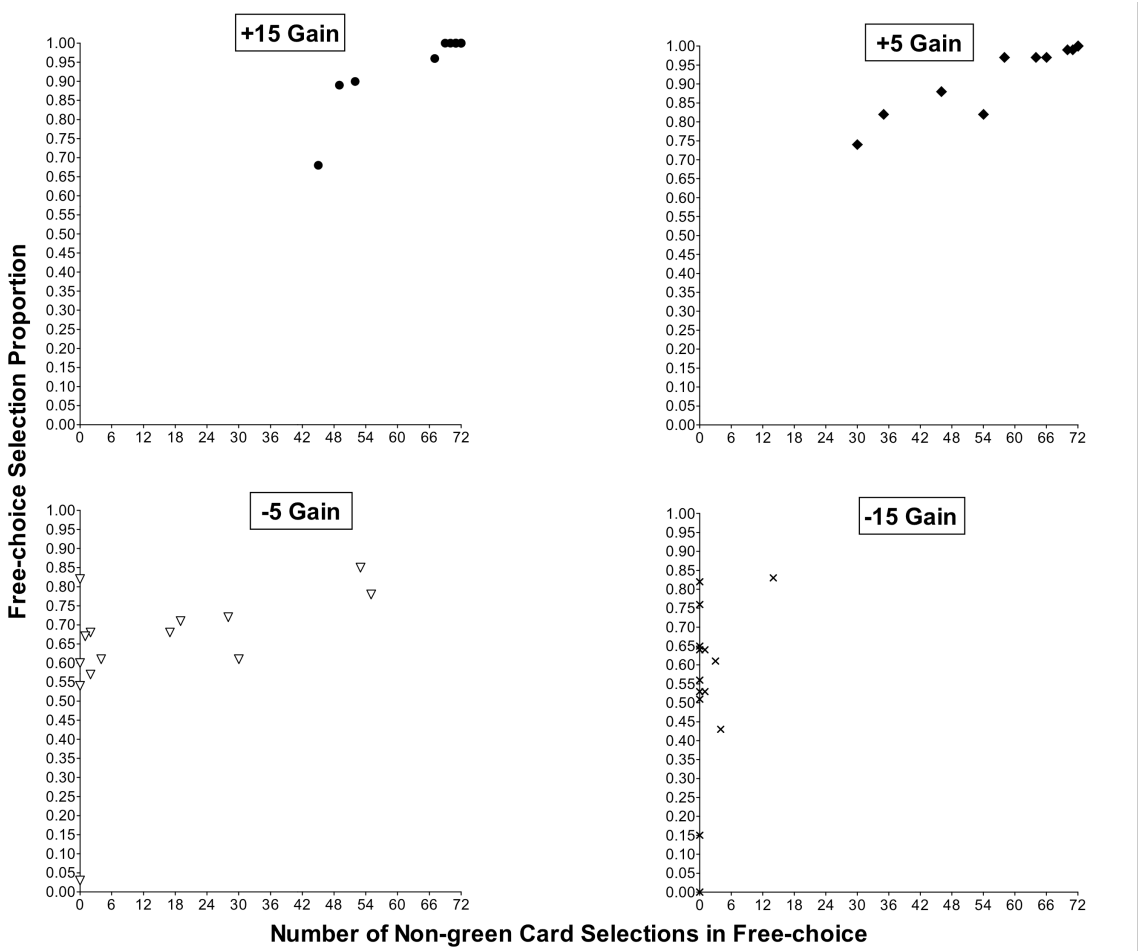

Figure 18. Individual scatterplots ($N = 14$) of the relation between the number of non-green card selections in free-choice and free-choice preference in +15 gain ($r = 0.89$, $p < .0001$), +5 gain ($r = 0.94$, $p < .0001$), -5 gain ($r = 0.47$, $p = .0927$), and -15 gain conditions ($r = 0.33$, $p = .2511$).

Loss context. Figure 19 displays a combined scatterplot of the relations between free-choice preference and non-green card selections in free-choice in the +15, +5, -5, and -15 loss conditions. In the +15 and +5 loss conditions, the number of non-green card selections in the free-choice terminal link was positively correlated with preferences for free-choice (see Figure 20). These results indicate that participants' frequency of

selecting the cards that produced the smallest point losses in free-choice corresponded with their level of preference for free-choice. No significant correlations between non-green card selection and free-choice preference were found for the -5 and -15 loss conditions (see Figure 20).

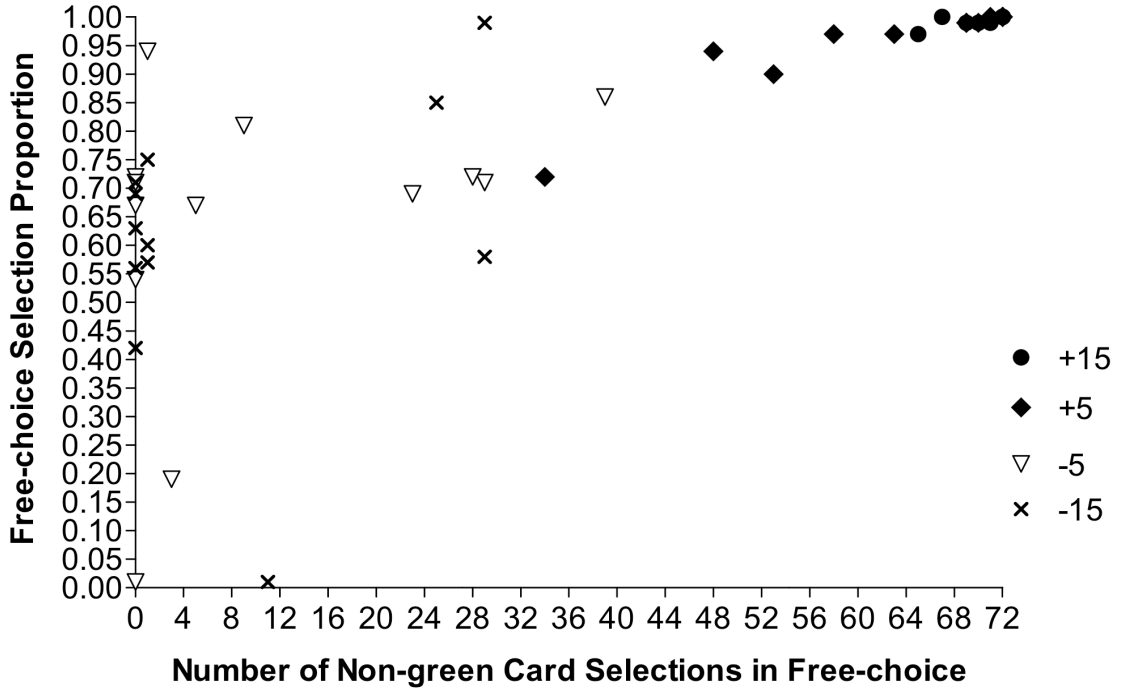

Figure 19. Superimposed scatterplots ($N = 14$) of the relation between the number of non-green card selections in free-choice and free-choice preference in the +15 loss ($r = 0.75$, $p = .0018$), +5 loss ($r = 0.92$, $p < .0001$), -5 loss ($r = 0.40$, $p = .1522$), and -15 loss conditions ($r = 0.39$, $p = .1724$) conditions.

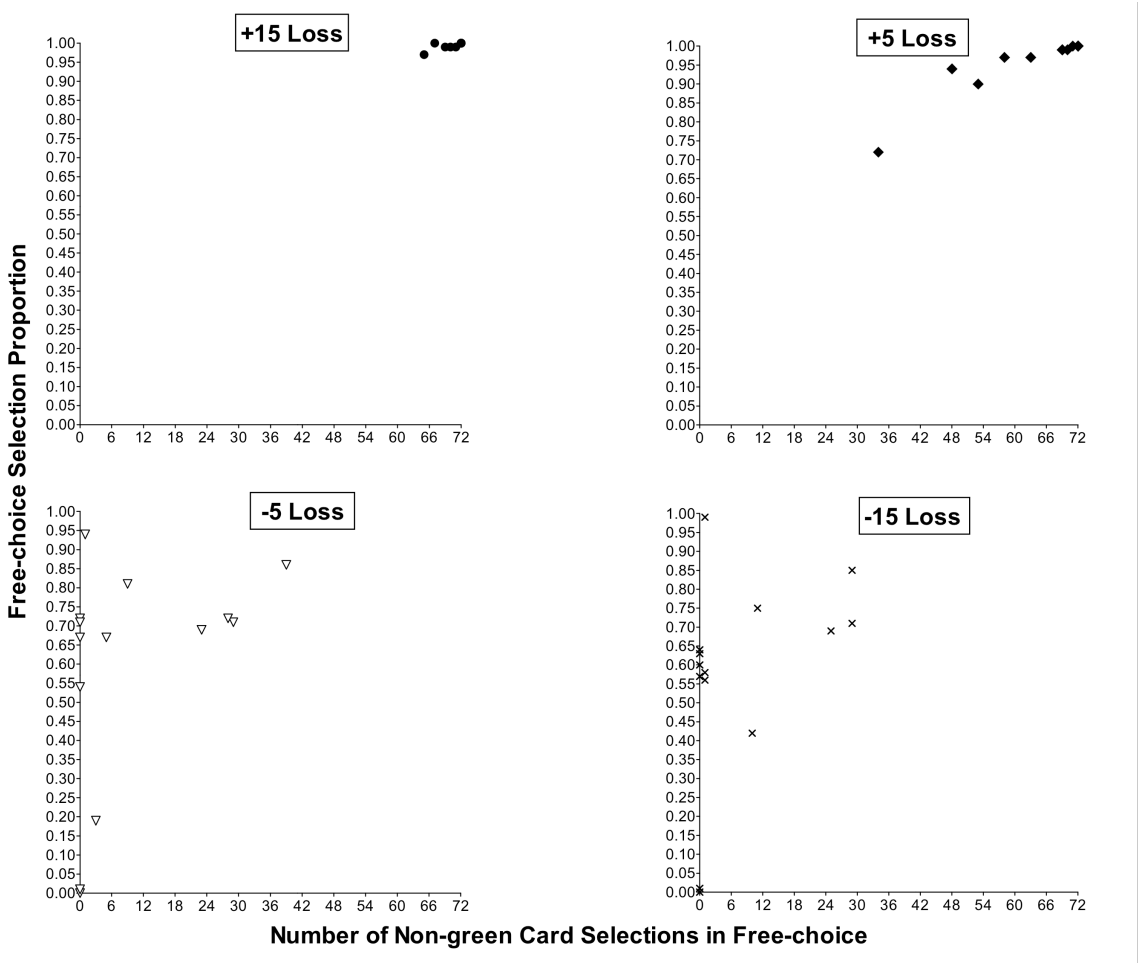

Figure 20. Individual scatterplots ($N = 14$) of the relation between the number of non-green card selections in free-choice and free-choice preference in +15 loss ($r = 0.75$, $p = .0018$), +5 loss ($r = 0.92$, $p < .0001$), -5 loss ($r = 0.40$, $p = .1522$), and -15 loss conditions ($r = 0.39$, $p = .1724$).

Points-obtained

Pearson's correlation coefficient (*r*). Participants' free-choice preferences and the total number of points they obtained were positively correlated in the +15 gain, +5 gain, +15 loss, and +5 loss conditions (see Figures 21 & 22). No significant correlations were found between free-choice preference and total points obtained in the -5 gain, -15

gain, -5 loss, and -15 loss conditions (see Figures 21 & 22). Overall, the relations between total points obtained and free-choice preference followed the same pattern as the relations between non-green card selection and free-choice preference.

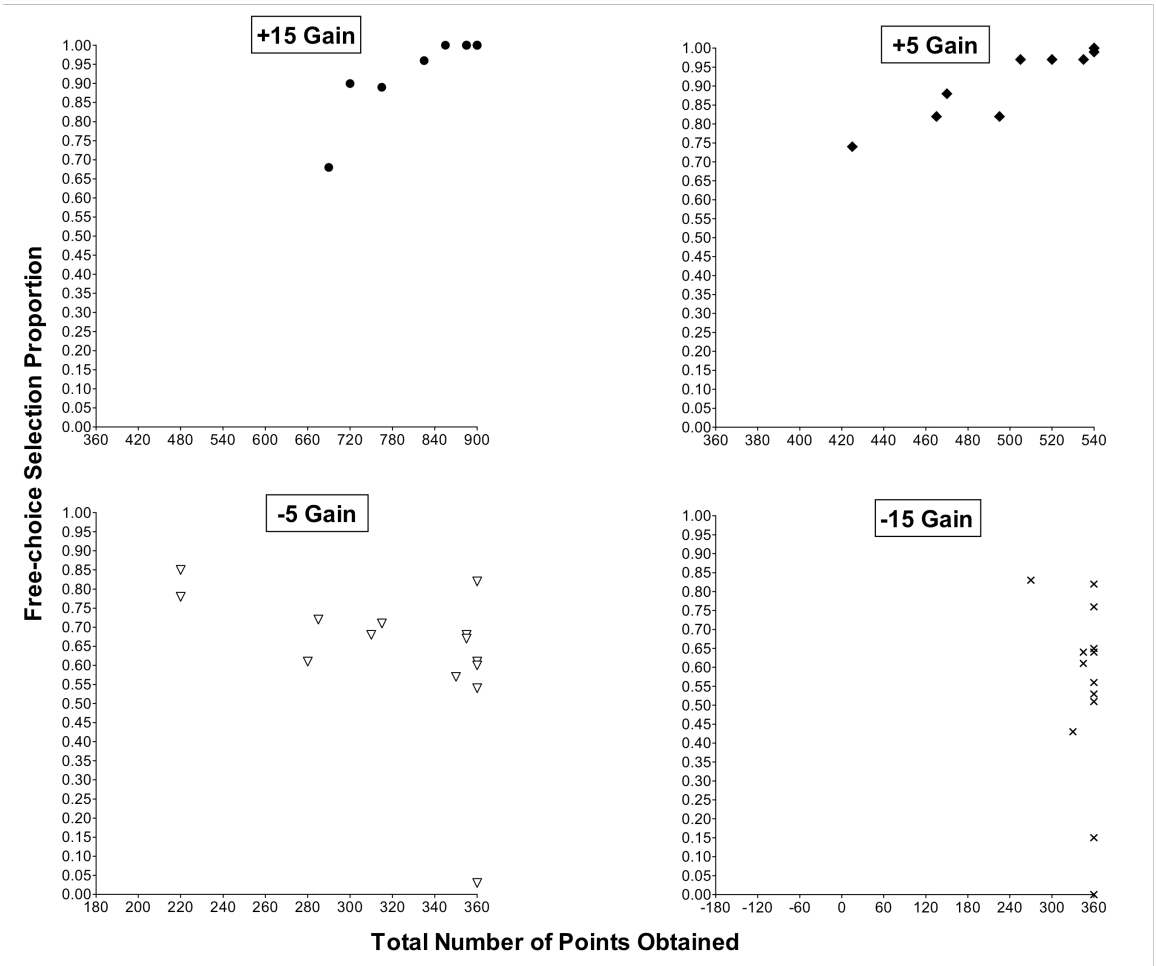

Figure 21. Individual scatterplots ($N = 14$) of the relation between the number points obtained and free-choice preference in +15 gain ($r = 0.89$, $p < 0.0001$), +5 gain ($r = 0.94$, $p < .0001$), -5 gain ($r = -0.46$, $p = .0941$), and -15 gain ($r = -0.33$, $p = .2544$) conditions. The minimum and maximum points that could be obtained varied according to condition as follows: +15 gain (minimum = 360, maximum = 900), +5 gain (minimum = 360, maximum = 540), -5 gain (minimum = 180, maximum = 360), and -15 gain (minimum = -180, maximum = 360).

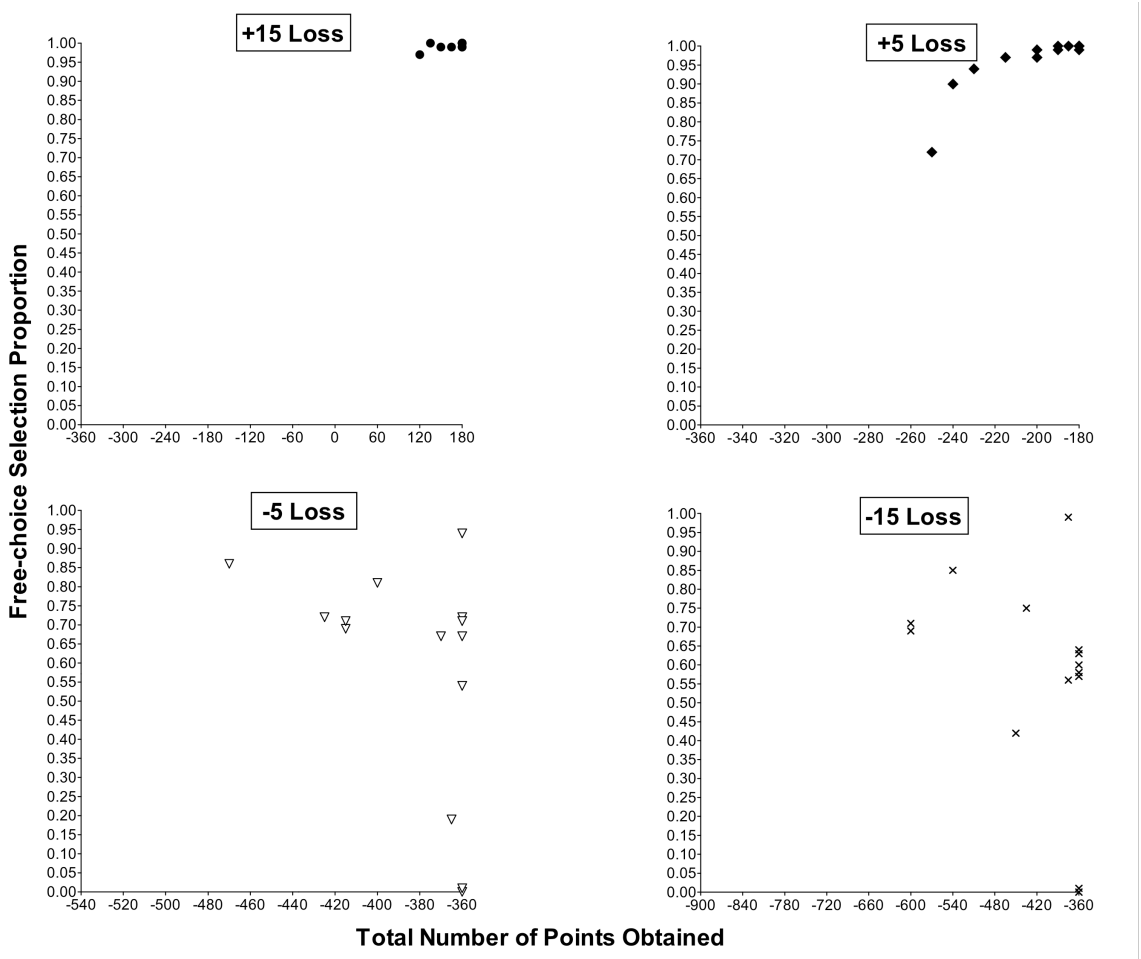

Figure 22. Individual scatterplots (N = 14) of the relation between the number points obtained and free-choice preference in +15 loss (r = 0.68, p = .0076), +5 loss (r = 0.84, p = .0002), -5 loss (r = -0.43, p = .1275), and -15 loss (r = -0.36, p = .2100) conditions. The minimum and maximum points that could be obtained varied according to condition as follows: +15 loss (minimum = -360, maximum = 180), +5 loss (minimum = -360, maximum = -180), -5 loss (minimum = -540, maximum = -360), and -15 loss (minimum = -900, maximum = -360).

Discussion

Initial Link

Participants' free-choice selection proportions were significantly higher than chance level (0.5) when more points could be gained, or fewer points lost, in free-choice relative to forced-choice (i.e., +15 gain/loss and +5 gain/loss). In addition, participants preferred free-choice when an equal number of points could be gained or lost in free- and forced-choice (i.e., equal gain/loss), and in the -5 gain condition in which free-choice included points both equal to and fewer than the forced-choice situation. Participants did not avoid free-choice in the -15 gain, -5 loss, and -15 loss conditions, however. In the present research, avoidance was defined as a free-choice selection proportion significantly lower than chance level (0.5). None of the choice conditions met this criterion and none yielded mean selection proportions lower than 0.5. Yet, while the mean selection proportions in the -15 gain, -5 loss, and -15 loss conditions were all greater than 0.5, none differed significantly from 0.5. Taken together, these observations suggest that the point manipulation readily produced free-choice preferences when free-choice included cards that were equal to and greater than forced-choice, but the inclusion of lesser-valued cards in free-choice was not sufficient to produce free-choice avoidance relative to chance level. These findings corroborate previous choice research with human subjects (Suzuki, 1997).

Participants' preferences were not differentially affected by the gain and loss manipulation, but participants' choice preferences did vary as a function of the five choice conditions (+15, +5, equal, -5, and -15). The differences observed between the

equal and +5 and the equal and -5 conditions corroborate the results of some earlier research (i.e., Suzuki, 1997). However, the significant decreases in free-choice preference observed from the equal to the -5 conditions do not align with the findings of Hori and Shimazaki (2010) who did not find analogous differences. A major distinction between the free-choice terminal links in the present study and Hori and Shimazaki's is that three cards were included in free-choice and Hori and Shimazaki included two cards. Hori and Shimazaki found that participants' preferences for free-choice did not decrease significantly from equal to -5 when the -5 condition included *one* card that produced fewer points than forced-choice, while the present research found that participants preferences did reduce when the -5 condition included *two* cards that produced fewer points than forced-choice. Collectively, these results suggest that the inclusion of more than one undesirable option in free-choice may lead to substantial drops in free-choice preference relative to a condition where all available choices are identical.

The addition of the +15 and -15 conditions yielded some interesting results that build upon previous findings. The pattern of differences observed among all five conditions suggests that the effects produced by the point manipulation were not linear. That is, free-choice selection proportions increased from equal to +5 and from equal to +15, and decreased from equal to -5 and from equal to -15. But, no significant differences were observed between +15 and +5 or -5 and -15 conditions. The absence of an increase in free-choice preference from +5 to +15 may simply be due to a ceiling effect. Free-choice selection proportions in the +5 condition were very high ($M = 0.95$) and close to 1.0, so there was little room for preferences to increase in the +15 condition. In the -5

condition, however, the mean free-choice selection proportion was above chance level (*M* = 0.61), so there was sufficient room to observe decreases in preference in the -15 condition, but no significant drop in preference was found.

Terminal Link

The primary purpose for analyzing terminal-link responding was to determine the extent to which participants' selections among alternatives in the free-choice terminal link related to their preferences for accessing free-choice. This was measured by tracking the frequency with which participants chose the non-green cards in free-choice terminal links. The green cards in free-choice terminal links were held constant at +10 points in gain and -10 points in loss. Thus, the non-green cards available in free-choice represented point outcomes that were considered more (+15 and +5) or less (-5 and -15) desirable than the green cards.

First, the terminal link analysis showed that participants selected the non-green card more frequently in the +15 and +5 conditions than in the -5 and -15 conditions in both the gain and loss choice contexts (see Figure 15). These observations are not surprising in that participants could gain more, or lose fewer, points for selecting the non-green card in the +15 and +5 conditions, and could gain fewer, or lose more, points for selecting the non-green card in the -5 and -15 conditions. Second, it was found that non-green card selection varied systematically with choice condition. The +5, -5, and -15 conditions and the +15, -5, and -15 conditions differed significantly from one another, but no differences were found between the +5 and +15 or -5 and -15 conditions (see Table 7). This pattern of differences in non-green card selection across conditions corresponds to

the pattern of differences observed for participants' free-choice preferences. The analysis also showed that differences in non-green card selection frequency across gain and loss depended upon choice condition. That is, the +15 gain and +15 loss and the -15 gain and -15 loss conditions differed with respect to non-green card selection, but the +5 gain and +5 loss and -5 gain and -5 loss conditions did not (see Table 8).

Hayes et al. (1981) suggested that free-choice preferences are likely to correlate with the responses emitted in the free-choice terminal link. Hayes et al. found that when subjects displayed a low probability of selecting an undesirable option in a free-choice situation, free-choice was largely avoided. Hayes et al. also observed higher preferences for free-choice when subjects frequently selected a second desirable option in free-choice. In the present study, participants' free-choice preferences were positively correlated with their number of non-green card selections in the +15 and +5 conditions, in both the gain and loss contexts (see Figures 16 & 18). These correlations align with Hayes et al.'s predictions. Participants' non-green card selections and free-choice preferences did not correlate in the -5 and -15 conditions (see Figures 16 & 18), however, which suggests that free-choice preferences in these conditions may have fluctuated independently of terminal-link responding in these conditions.

To further explore the relation between non-green card selection and free-choice preference, an additional analysis was conducted. The goal was to gather more information about differences in terminal-link card selection across the choice conditions. The correlations between choice preferences and non-green card selections (described above) do provide some information, but these correlations necessarily exclude the equal

condition from the analysis, as no non-green cards were present for participants to select in the equal condition. Thus, a measure of non-green card selection that took the equal condition into account was needed. To do this, single-sample *t*-tests were used to compare the frequencies of non-green card selections in the +15, +5, -5 and -15 to zero. This measured how participants' non-green card selections in each condition compared to a hypothetical choice scenario where no non-green cards were available from which to choose. Thus, I essentially compared non-green card selection in each condition to a hypothetical equal condition. This comparison is important in the analysis of the relation between terminal-link selection and free-choice preference because I found that free-choice preferences in all conditions differed significantly from the equal condition, and I sought to make an analogous comparison between non-green card selection and the equal condition. This way, I could determine if conditions differed significantly from equal on one or both measures. For example, if participants' free-choice preferences and non-green card selections both differed from equal in the -5 gain condition, one could argue that it is impossible to attribute the decrease in preference from the equal to the -5 condition to condition effects alone because participants' selection of non-green cards also differed from equal as well. Conversely, if free-choice preferences in a given condition differed from equal, and non-green card selections did not, I am in a better position to argue that free-choice preferences were produced by access to multiple alternatives alone, and not exposure to the outcomes produced by selecting those alternatives.

The analysis showed that only the -15 gain condition differed from equal with respect to free-choice preference, and *not* non-green card selection ($M = 1.64$, $SD = 3.78$),

$t(13) = 1.63$, $p = .1274$ (see Figure 15). Thus, the free-choice preferences observed in the -15 gain condition do not seem to be due to a tendency to select the undesirable option. This allows me to make a strong argument that some factor *other than exposure to the undesirable outcome* was responsible for the decrease in free-choice preferences in the -15 gain condition. These findings align with Hayes et al.'s (1981) predictions that subjects will avoid free-choice or express indifference if there is a low probability that they will sample an undesirable option made available in the choice situation.

In the other conditions (+15 gain/loss, +5 gain/loss, -5 gain/loss, and -15 loss), the data suggest that I cannot separate the effects of condition on preference from the tendency for participants to select the more desirable or less desirable options in free-choice. That is, the single-sample *t*-tests showed that participants' choice preferences in all conditions, except for -15 gain, were accompanied by a significant tendency to sample the variety of options in the free-choice terminal link. With respect to the -5 and -15 conditions, these observations are contrary to Hayes et al.'s (1981) predictions. That is, I observed significant decreases in free-choice preferences from the equal condition to conditions where an undesirable option was included (i.e., -5 and -15 conditions). At the same time, however, participants were likely to select the undesirable option.

Based on the analyses described above, it is not entirely clear why participants' preferences for free-choice decreased in the -5 and -15 conditions relative to the equal condition. Some researchers have suggested that participants may be averse to choice scenarios that include a mix of desirable and undesirable outcomes because it is possible for them to make a "mistake" or make the "wrong choice" under such conditions (Hayes

et al., 1981; Lockhart, 1979). My findings do not provide firm support for this notion or conclusive contradictory evidence. My correlational analysis showed that participants who were more likely to make the "wrong choice" by selecting the non-green card in the -5 and -15 conditions did not tend to have lower free-choice preferences than participants who made the "wrong choice" at a lower frequency. At the same time, however, the effect of choice condition on free-choice preference could not be fully separated from the tendency to select the more or less desirable options in free-choice. The -15 gain condition was the only condition that yielded a free-choice selection proportion that differed significantly from the equal condition and a non-green card selection frequency that did *not* differ from equal (i.e., zero in the single-sample *t*-test). Based on these observations, the reduction in preference from equal to -15 gain was not accompanied by the frequent selection of, and subsequent exposure to, the undesirable option. Rather, participants' may have been averse to making choices in the presence of undesirable outcomes, even though they were not likely to "make the wrong choice" by selecting those outcomes (Hayes et al., 1981).

Overall, the inconsistencies in the terminal-link analysis results do not allow me to firmly conclude that the participants in the present experiment selected free-choice at a lower frequency in the -5 and -15 conditions as a result of making choices that exposed them to undesirable outcomes.

Points Obtained

By tracking the actual points that participants obtained (gained or lost) within each choice condition, I was able to evaluate the extent to which the number of obtained

points was related to free-choice preference. The number of points obtained was positively correlated with free-choice preference in the +15 and +5 choice conditions, but no relation was found between points obtained and preference in the -5 and -15 conditions. These observations suggest that obtained points only corresponded to free-choice preferences when more points could be gained, or fewer points lost, in the free-choice situation.

Strengths, Limitations, and Future Research

The present research systematically replicates and extends the work of a small number of researchers who have investigated the choice preferences of adult humans under concurrent-chains schedules of reinforcement (i.e., Hori & Shimazaki, 2010; Suzuki, 1997, 2000, 2002). The experiment includes strengths, which yielded some important contributions to the literature, and several limitations that should be taken into account in future studies of this type.

Some earlier findings with non-human subjects (i.e., Hayes et al., 1981) indicated that terminal link performance is likely to look very different in situations where free-choice is preferred to situations where free-choice is avoided. Previous studies with human participants have reported only minimal (Hori & Shimazaki, 2010) or no (Suzuki, 1997) information about responding in the terminal link of the concurrent-chain. Thus, little has been documented about the relation between human participants' terminal link performance and choice preference. A unique strength of the present experiment is the careful consideration and analysis of the terminal link response data. As discussed previously, this analysis provides some preliminary information about *why* (i.e., a

tendency to select the undesirable option) and under *what conditions* (i.e., when more than one undesirable option is present in free-choice) participants' choice preferences are influenced by the presence of undesirable stimuli in the free-choice terminal link. These findings provide impetus for further examination of the relation between performance in the initial and terminal links of the concurrent-chain, and the analysis presented here may be a useful model for interested researchers in this paradigm.

One issue with the terminal-link analysis in the present study was that the number of free-choice terminal links that contributed to the mean in each condition varied (range: 39.43-71.57) because participants controlled their exposure to free-choice by way of their initial link selections. Future research could improve the terminal-link analysis by adding a condition similar to Hayes et al. (1981) in which subjects were required to access the free-choice terminal link and make selections among the available alternatives. This would provide a more even measure of participants' terminal-link performance as the experimenter could control the number of free-choice trials that contribute the analysis.

Indeed, the most complex findings of the present study concern the apparent interrelatedness of free-choice preference and response allocation in the free-choice terminal link. Although my extensive analysis of terminal-link responding provided important information, several points remain unclear. For example, part of the analysis suggests that in all but one condition (-15 gain) the effects of condition on choice preferences cannot be separated from the tendency for participants to select the more desirable or less desirable options in free-choice. If this is the case, the drops in preference for free-choice from the equal to the -5 loss and -15 gain/loss conditions may

be a result of a tendency for the participants to expose themselves to the undesirable outcome. On the other hand, the reduction in free-choice preferences observed in the -15 gain condition might be the result of an aversion to making a choice in the presence of an undesirable option, even though the undesirable option was rarely selected (Hayes et al., 1981). Either way, much like the pigeons in Hayes et al., participants in the present experiment were averse to conditions that provided the opportunity to select undesirable options and seemed unwilling to regularly "put themselves at risk" of choosing those options (Hutchinson, 2005).

Another possible limitation of this research is that participants' choice preferences were tested under a *probabilistic* reinforcement contingency. That is, participants were rewarded for selecting cards in the terminal link 50% of the time and reward delivery was randomly determined across trials. Previous researchers who have studied human subjects' choice preferences in the context of concurrent-chains procedures have also used reinforcement probabilities lower than 1.0 (Hori & Shimazaki, 2010; Suzuki, 1997, 2000, 2002). One practical reason for this is to sustain participants' active engagement in the experimental task, which may be reduced if points are delivered at the end of every trial in an experiment. Certainly, some of my pilot research suggests that participants will likely exhibit strong side preferences only when points are delivered at the end of 100% of the trials in an experimental session (Rost, 2011).

While the delivery of points in the present experiment was no more likely in the free-choice than the forced-choice terminal links, and participants were given instructions that they always had an even 50% chance of gaining or losing points (see Figures 3-12),

some participants seemed to develop alternate views of the contingencies. In an exit survey (see Appendix 3), participants were asked, “If you had a preference for either Group 1 (one-card group) or Group 2 (three-card group), what was the reason for your preference?” Three out of 14 participants provided responses that suggested they perceived a greater probability of earning points in the three-card group (free-choice) than the one-card group (forced-choice). For example, Participant 7 wrote, “I selected Group 2 more than Group 1 because Group 2 had three cards which gave me a 2/3 chance of earning/gaining points as opposed to having just 1/4 chance with Group 1.” Similarly, Participant 12 reported a preference for the three-card group and wrote, “Because if there are more cards there’s more of a chance that I’ll get points.” Participant 13 also preferred the three-card group and stated, “There seems to be more possibility because of the number of cards it contained.” Thus, for these participants it seems that the unpredictability of the probabilistic reward contingency may have influenced their levels of preference for free-choice. One possible solution would be to provide participants with a more extensive description of the contingencies within the concurrent-chain, and confirm they clearly understand the arrangement by way of a short questionnaire.

As the exit survey responses noted above suggest, some participants incorrectly attributed the larger number of stimuli in free-choice with a greater probability of obtaining points. Schmidt et al. (2009) proposed that some research participants may do this because they have reinforcement histories in which the chance of obtaining a reward or reward magnitude is positively correlated with the number of alternatives available in a choice situation. As a result, the multiple stimuli presented in a free-choice condition

may act as an *illusory discriminative stimulus*, which signals that the chance of obtaining a reward or reward magnitude is greater in the free-choice condition. In turn, response allocation to free-choice may be the function of this illusory contingency and not a preference for the opportunity to choose (Schmidt et al., 2009). In the present study, the probabilistic reinforcement contingency may have allowed the free-choice stimulus display to function as an illusory discriminative stimulus for some participants. For example, Participant 12 reportedly preferred free-choice, "Because if there are more cards there's more of a chance that I'll get points." Thus, it seems that Participant 12 reasoned that a larger number of cards signaled a better chance of point gains (or avoidance of point losses) at the end of the terminal link. Participant 12's reasoning likely resulted because the delivery of points was unpredictable (i.e., points were delivered on a random schedule, 50% of the time). If point delivery was non-probabilistic or certain at the end of every free- and forced-choice terminal link, it is seems logical that both the free- and forced-choice stimulus displays would function to signal identical reinforcement contingencies. For this reason, predictable and certain outcomes at the end of the terminal-link may preclude response allocation to free-choice in the initial link *if* that allocation is due to a illusory discriminative function of the free-choice stimulus display. Conversely, if response allocation to free-choice is not due to this illusory contingency, but rather to a preference for the opportunity to select among multiple stimuli, free-choice preference may persist under certain reinforcement conditions. To unpack these possibilities, it would be informative to conduct choice research with

human subjects that directly manipulates reinforcement probability in the terminal link to examine how different probabilities effect preferences for free- versus forced-choice.

Some research has been conducted wherein subjects' preferences for free- versus forced-choice were compared under probabilistic and non-probabilistic terminal-link reinforcement contingencies. In a study with pigeons, Ono (2000) examined preferences for free-choice in a multiple concurrent-chains procedure when terminal-link reinforcement was probabilistic (uncertain) and non-probabilistic (certain). Three birds were exposed to uncertain (0.5 probability) followed by certain (1.0 probability) access to grain, and showed preferences for free-choice in the uncertain condition only. Three other birds were first exposed to the certain contingency, in which small and inconsistent preferences for free-choice were observed, and did not prefer free-choice in a subsequent uncertain condition. Ono concluded that only naive pigeons (i.e., birds who were *not* first exposed to certain reinforcement in the terminal link) preferred free- over forced-choice under uncertain conditions. Ono's findings provide some impetus for research with human subjects that examines choice preferences under certain and uncertain reinforcement contingencies, and the possible interactive effects of these conditions.

An additional limitation of the present study relates to the number of points participants obtained in the free- and forced-choice terminal links. As mentioned earlier in this paper, the probability of gaining or losing points on any given trial was fixed at 0.5. Thus, participants were no more likely to gain or lose points for selecting a card in the free-choice terminal link than in the forced-choice terminal link. While the probability of point delivery was held constant, participants did control the number of free- and

forced-choice trials they were exposed to by way of their initial-link selections. In turn, participants determined the *number* of free- and forced-choice trials that were associated with point delivery overall. Thus, if a participant gained more, or lost fewer, points in free-choice overall, it is possible that an expressed preference for free-choice simply matched the higher density of points associated with the free-choice terminal link.

A post hoc examination of the relation between obtained points and free-choice preferences within each condition revealed that the number of points obtained in free-choice was positively correlated with free-choice preference in the +5 and +15 conditions, but not in the -5 and -15 conditions. These observations do suggest that participants' preferences for free-choice were not solely attributable to point density, but future researchers should attempt to more adequately control for this potential confound. Previous researchers have used experimental controls, like yoking procedures, to guarantee that reinforcer density is equated between free- and forced-choice terminal links (see Hayes et al., 1981 and Schmidt et al., 2009 for examples of yoked concurrent-chains schedules of reinforcement).

In future studies of this type, researchers should investigate the effects of larger point losses on free-choice preferences. As discussed earlier, selection proportions in the -5 ($M = 0.61$) and -15 ($M = 0.56$) conditions were above chance level, so there was ample room for preferences to decrease in these conditions. This leaves open the possibility that a larger point loss (e.g., -20, -30, etc.) could produce free-choice preferences significantly lower than chance level (i.e., free-choice avoidance). It is possible that the "undesirable outcomes" made available in the -5 and -15 free-choice terminal links were not

sufficiently aversive to produce the active avoidance of free-choice as was seen by Hayes et al. (1981). If future studies found that the inclusion of larger magnitude losses significantly lowered preference for free-choice, this would lend support to this possibility.

Applied Significance

Catania (1975) defined freedom in terms of action (i.e., the act of making choices for oneself). Following Catania's conception of freedom, the fundamental aim of the present study was to estimate the value of freedom from an empirical perspective by measuring participants' preferences between conditions that allowed choice among alternatives to conditions that did not. Clearly, the generality of the present findings is limited by the very nature of the experimental setting and procedures (i.e. laboratory setting, concurrent-chains procedure). Still, these results are potentially important for understanding the extent to which individuals value the opportunity to choose and isolating variables that may influence that value. Most notably, the results of the present experiment suggest that free-choice situations that offer the opportunity to select undesirable outcomes will likely result in a marked reduction in a previously expressed preference for choice.

Overall, it seems the main point of applied significance that should be derived from these results is that preference for freedom of choice does not seem to be fixed or absolute. Rather, an individual's preference for choice is more likely to be dynamic and amenable to the specific properties of the choice situation. Thus, when considering the complexities of human behavior outside of the laboratory, it should not be assumed that

an individual will always value or prefer the opportunity to exercise choice. This point seems quite relevant for employers, marketers, caretakers, teachers, parents, and others who have some degree of control in constructing the extent and variety of choices in peoples' lives.

Summary and Conclusions

The results of the present research demonstrate that, in the context of a concurrent-chains procedure, participants preferred gaining access to free-choice to forced-choice when presented with an array of identical choices. Not surprisingly, participants also preferred free-choice when the free-choice situation included a more desirable outcome than forced-choice. Most interestingly, participants' free-choice preferences decreased substantially when two undesirable outcomes were made available in free-choice. Altogether, the pattern of differences I observed between the +15, +5, equal, -5, and -15 choice conditions can be summarized as follows:

1. If free-choice in condition *a* included cards that produced a *greater* number of points (+15 and +5 conditions) than forced-choice, and free-choice in condition *b* included cards that produced *fewer* points (-5 and -15 conditions) than forced-choice, conditions *a* and *b* differed significantly.
2. If free-choice in condition *a* included cards that produced a *greater* number of points (+15 and +5 conditions) than forced-choice, and free-choice in condition *b* included cards that produced the *same* number of points (equal condition) as forced-choice, conditions *a* and *b* differed significantly.

3. If free-choice in condition *a* included cards that produced *fewer* points (-5 and -15 conditions) than forced-choice, and free-choice in condition *b* included cards that produced the *same* number of points (equal conditions) as forced-choice, conditions *a* and *b* differed significantly.
4. If free-choice in conditions *a* and *b* both included cards that produced a *greater* number of points (+15 and +5 conditions) than forced-choice, conditions *a* and *b* did not differ significantly.
5. If free-choice in conditions *a* and *b* both included cards that produced *fewer* points (-5 and -15 conditions) than forced-choice, conditions *a* and *b* did not differ significantly.

In conclusion, only a small number of studies have investigated human subjects' preferences for free-choice when the variety of outcomes available in free-choice are both desirable and undesirable. The findings of the present study demonstrate that preference for the opportunity to choose among alternatives is not persistent in all circumstances. Participants' choice preferences in this study were clearly sensitive to changes to the composition of options available in free-choice. Specifically, my results lend support to the findings of Suzuki (1997), who found that participants' preferences for free-choice reduced substantially when undesirable outcomes were part of the choice situation. On balance, my findings are in conflict with other researchers who did not observe decreases under similar experimental conditions (i.e., Hori & Shimazaki, 2010). Thus, more research is needed to settle the inconsistencies that remain in the minimal collection of studies that have addressed this topic.

Appendix A

Gain Condition Instructions

Welcome to the Choice Experiment!

Your purposes during the first part of the experiment are to:

1. Make choices.
2. Gain as many points as you can.

You can gain a maximum of 2,520 points.

First, you will choose between two groups of cards. Then, you will choose a single card from the group you have selected. After choosing a single card from the group you can gain some points. After you choose a card, the number of points you gained for choosing that card will be displayed on screen. Most of the time the card values will be positive and you can gain points. But, some of the time card values might be negative, in which case you can lose points. To select a group or a single card, just click it once with the computer mouse.

The cards will have different colors depending on the number of points that can be gained *or* lost. This information will be displayed at the top of the screen for you.

For **every 10 points** you gain you will gain **$0.046 (a little more than 4 cents gained)**. At the very end of the experiment today the dollar amount you will receive will be displayed on screen.

When "It's time for a short break!" appears on screen, you will take a 1-minute break. After 1 minute has passed you will be asked to double click the screen to continue with the experiment. You will also take a 5-minute break after the first part of the experiment. A message will appear on screen when it is time for your 5-minute break. Before you begin the first part of the experiment, you will practice the task by completing a brief training.

DOUBLE CLICK HERE TO BEGIN TRAINING

Appendix B

Loss Condition Instructions

Welcome to the Choice Experiment!

Your purposes during the first part of the experiment are to:

1. Make choices.
2. Avoid losing as many points as you can.

You will start with 2,520 points.

First, you will choose between two groups of cards. Then, you will choose a single card from the group you have selected. After choosing a single card from the group you can lose some points. After you choose a card, the number of points you lost for choosing that card will be displayed on screen. Most of the time the card values will be negative and you can lose points. But, some of the time card values might be positive, in which case you can gain points. To select a group or a single card, just click it once with the computer mouse.

The cards will have different colors depending on the number of points that can be gained *or* lost. This information will be displayed at the top of the screen for you.

For **every 10 points** you lose you will lose **$0.046 (a little more than 4 cents lost)**. At the very end of the experiment today the dollar amount you will receive will be displayed on screen.

When "It's time for a short break!" appears on screen, you will take a 1-minute break. After 1 minute has passed you will be asked to double click the screen to continue with the experiment. You will also take a 5-minute break after the first part of the experiment. A message will appear on screen when it is time for your 5-minute break. Before you begin the first part of the experiment, you will practice the task by completing a brief training.

DOUBLE CLICK HERE TO BEGIN TRAINING

Appendix C

Exit Survey

Choice Study - Exit Survey

Please answer the following questions about your experience participating today. Please use the back of the sheet if you need more space to write.

1. In your opinion—what was this study about?

2. Did **Group I** contain one card or more than one card? Circle below.

   ONE CARD MORE THAN ONE CARD NEITHER

3. Did **Group II** contain one card or more than one card? Circle below.

   ONE CARD MORE THAN ONE CARD NEITHER

4. When you had a **choice** between Group I and Group II, which did you select more? Circle below.

   GROUP 1 GROUP2 NEITHER

5. If you had a **preference** for either Group I or Group II, what was the reason for your preference? In other words, *why* did you like selecting one group over the other?

6. Did anything in the task **affect your preference** for Group I vs. Group II?

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