CHOICE BRACKETING: DETERMINANTS AND MECHANISMS

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Abstract

Choice bracketing refers to whether an individual considers choices separately (narrow choice bracketing) or together (broad choice bracketing). This manuscript investigates two key questions that have been under investigated in the choice bracketing literature. The first is “what prompts people to bracket choices broadly?”. The second question is “by what mechanism does choice bracketing affect risk taking?”. The results of two experiments are used to demonstrate that association between choices can prompt people to bracket broadly, and that non-computational mechanisms likely underly choice bracketing effects on risk-taking. These results are used to advocate for a view of choice bracketing that positions it as a key decision making process that helps people structure decision problems in a way that addresses situational needs.

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Choice Bracketing: Determinants and Mechanisms

Scholars have long been fascinated by the issue of repeated choice. Early entrants in this field expressed concern over the standard practice of drawing sweeping conclusions about cognition on the basis of research using static, isolated choices (Busemeyer, 1982; Edwards, 1962; Gray & Tallman, 1984; Rachlin et al., 1986; Rapoport & Wallsten, 1972; Toda, 1962). These concerns were supported by speculation that people may behave differently under individual and repeated choice scenarios. For example, consider the following now-famous anecdote from Paul Samuelson (1963):

> …I offered some lunch colleagues to bet each $200 to $100 that the side of a coin *they* specified would not appear at the first toss. One distinguished scholar – who lays no claim to advanced mathematical skills – gave the following answer: 'I won't bet because I would feel the $100 loss more than the $200 gain. But I'll take you on if you promise to let me make 100 such bets.' (p. 50-51)

Investigations into this phenomenon quickly left the lunchroom and entered the lab, ultimately yielding a long list of differences in decision making across isolated and repeated-choice scenarios (Coombs & Bowen, 1971; Gneezy & Potters, 1997; Langer & Weber, 2001; Leopard, 1978; Lopes, 1981; Keren, 1991; Keren & Wagenaar, 1987; Montgomery & Adelbratt, 1982; Redelmeier & Tversky, 1992; Tversky & Bar-Hillel, 1983; Wedell & Böckenhold, 1990; Wedell & Böckenhold, 1994).

One of the more compelling examples was provided by Redelmeier and Tversky (1992). They presented participants with the following problem: "Imagine that you have the opportunity to play a gamble that offers a 50% chance to win $2,000 and a 50% chance to lose $500." (p. 191). They found that most participants preferred to play this gamble five times over just once, and furthermore preferred to play it six times over five. However, when participants were instructed to imagine that they had played the gamble five times and were offered the opportunity to play it an additional time (a sixth time), most rejected this opportunity.

What is compelling about this example is that differences in decision making are not a product of simply being exposed to a single decision or multiple. Instead, it is how those choices are perceived. When framed as a single gamble, the sixth gamble was rejected. When framed as one of many, it was accepted. Therefore, the perception of whether or not a choice belongs to a group of decisions is an important aspect of decision making.

Choice Bracketing

Definition

Ensuing scholarly activity attempted to define and understand this phenomenon, now known as "choice bracketing". This term was first used by Read, Loewenstein, and Rabin (1999) in their seminal paper by the same name. However, as they note, a wide variety of terms for the same basic phenomenon have been used, such as sequential and simultaneous choice (Read et al., 2001; Simonson, 1990), isolated and distributed choice (Herrnstein & Prelec, 1991), narrow and broad decision frames (Barberis et al., 2006; Kahneman & Lovallo, 1993), acts and patterns (Rachlin, 1995), and local and overall value functions (Heyman, 1996). Related concepts have also been identified, such as the diversification heuristic (Read & Loewenstein, 1995; Read, Loewenstein, & Kalyanaraman, 1999), partition dependence (Fox et al., 2005), and temporal reframing (Gourville, 1998).

Read, Loewenstein, and Rabin (1999) define choice bracketing as "the grouping of individual choices together into sets…When the sets are small, containing one or very few choices, we say that bracketing is *narrow*, while when the sets are large, we say that it is *broad*." (p. 172).

A unique aspect of choice bracketing research is that it is not about how people respond to particular choice features, such as losses (Kahneman & Tversky, 1979), uncertainty (Kahneman & Tversky, 1979), ownership (Knetsch & Sinden, 1984), or labels (Thaler, 1990). Rather, Read, Loewenstein, and Rabin (1999) describe it as serving an "interactive or enabling role" (p. 193) in shifting attention "from the macro level to the micro level" (p. 193) and vice versa. Similarly, Ding (2012) describes choice bracketing as a "mental procedure" (p. 1) that governs how people solve decision problems. Webb and Shu (2013) describe it as "mental representation" (p. 6). This paper is aligned with such perspectives, and views choice bracketing as a cognitive process that modifies the perceived structure of decision problems.

It is important to note some boundary conditions on the concept of choice bracketing. First, choice bracketing applies well to decision problems involving individual, invariant choices. That is, the concept of considering choices apart vs. together requires that we be able to treat choices independently enough to permit segregate decision making, and it also requires decisions that share enough contextual factors so that they could presumably be considered together. Choice bracketing also applies well to situations where choices are made in a relatively short period of time, otherwise biases such as temporal discounting (Green et al., 1994) and cognitive functions such as memory are likely to exert significant influence.

Overlap with Similar Constructs

Choice bracketing co-exists with a number of related cognitive constructs, such as intertemporal choice (Berns et al., 2007), attention, dynamic decision making (Edwards, 1962), pseudo-set framing (Barasz et al., 2017), set-fit effects (Evers et al., 2014), entitativity (Smith et al., 2013), and joint vs. separate evaluation (Hsee, 1998; Hsee et al., 2005). One conceptually similar construct that is particularly noteworthy is construal level theory (CLT; Trope & Liberman, 2011). Construal level theory contends that people form mental representations of distant psychological objects (psychological distance is the subjective experience of distance from the here-and-now) such as predictions, memories, speculations, and other people's perspectives. The authors of this theory levy arguments about the adaptive function of CLT that are similar to the view of choice bracketing I present in this manuscript. For example, they write, "The use of high-level, abstract construals to represent psychologically distal objects is thus indispensable for effective functioning in many domains: for developing object constancy, orienting in space, planning the future, learning from the past, relating to and understanding other people, and for considering alternative outcomes and courses of action." (Trope & Liberman, 2011, p. 4).

CLT has been shown to be relevant to a wide assortment of judgment and decision making phenomena such as risk taking (Lermer et al., 2015; Trautmann & van de Kuilen, 2012), probability estimation (Wakslak & Trope, 2009), temporal discounting (Liberman & Trope, 2003; Kim et al., 2013), and self-control (Fujita, 2008; Fujita & Carnevale, 2012). Furthermore, some have investigated the relationship between CLT and choice bracketing specifically. Webb and Shu (2013) conclude that temporal distance (i.e., CLT) and choice bracketing have distinct effects on risk-taking, and further explain that temporal distance alters mental construal whereas choice bracketing is more of a framing effect that alters risk preference. Of note, however, Webb and Shu (2013) use an outcome aggregation manipulation to induce choice bracketing; as will be discussed later, this is more accurately considered an outcome bracketing manipulation rather than a choice bracketing one, so questions about the overlap between CLT and choice bracketing remain.

CLT and choice bracketing share overlap but are distinct concepts. CLT is a broad theory that purports to explain a vast compendium of psychological phenomena and judgment and decision making concepts, to such a degree that some have suggested that it represents an integrative framework for various preference reversals (Fiedler, 2007). Choice bracketing, however, is only concerned with the grouping together of decisions. It may be that in time choice bracketing will be recognized as a manifestation, example, or sub-set of CLT. However, even if this does happen, it will not take away from the value of investigating the ideas explored in the present manuscript.

Function

Initial forays into understanding choice bracketing suggested that narrow bracketing is a sub-optimal decision making tendency, borne out of miserly processing and intuitive, experiential reasoning. For example, in their 1993 paper, Kahneman and Lovallo state, "We have suggested that people tend to make decisions one at a time, and in particular that they are prone to neglect the relevance of future decision opportunities" (p. 23), and Tversky and Kahneman (1981) write, "…people generally evaluate acts in terms of a minimal account…because this mode of framing (i) simplifies evaluation and reduces cognitive strain, (ii) reflects the intuition that consequences should be causally linked to acts, and (iii) matches the properties of hedonic experience, which is more sensitive to desirable and undesirable changes than to steady states" (p. 456-457).

To a large extent, this early conceptualization has endured. Experimental research has continued to observe people's proclivity for narrow bracketing (Camerer, 2000; Ellis & Freeman, 2020; Hilgers & Wibral, 2014; Wulff et al., 2015). It has also supported the link between narrow bracketing and cognitive load (Abeler & Marklein, 2007; Kalayci & Serra-Garcia, 2012; Rabin & Weizsäcker, 2010; Stracke et al., 2015), though not unanimously (Koch & Nafziger, 2019). Furthermore, examples of the downsides of narrow bracketing (e.g., Barberis et al., 2006; Chen & Corter, 2006; Rabin & Weizsäcker, 2009) and advantages of broad bracketing (e.g., Savani et al., 2011) continue to abound.

It is necessary to give the caveat "to a large extent" because a growing body of literature has documented situations where narrow bracketing can have value and broad bracketing can be detrimental. For example, several researchers have noted that while narrow bracketing may be sub-optimal from a utility maximization perspective (Camerer et al., 1997), it has important motivational advantages. Ariely and Wertenbroch (2002) showed that people will voluntarily commit to earlier deadlines (which decreases utility), because it increases self-control and motivation. Conversely, researchers such as Koch and Nafziger (2016, 2020) and Hsiaw (2018) have demonstrated that broad bracketing can impair goal pursuit because it reduces the perceived cost of deviating from the goal (e.g., "cheat days" when dieting). Similarly, Soman and Cheema (2004) noted that broad goals can make it more challenging to recover from failures, because the demotivation and negative emotion arising from these failures affects subsequent behaviour. Findings in other fields, such as research on the "fresh start effect", habit discontinuity, and goal proximity are consistent with these theories (Cochran & Tesser, 1996; Dai et al., 2015; Verplanken et al., 2008; Wood et al., 2005; Zemack-Rugar et al., 2012).

Drawbacks associated with broad bracketing have also been observed around consumption. Most notably, research on the diversification bias has identified a sub-optimal tendency to diversify consumption under broad bracketing (Fox et al., 2005; Read &

Loewenstein, 1995; Read, Loewenstein, & Kalyanaraman, 1999). For example, consider people's tendency to order a new meal at a restaurant they attend frequently, even when they have already identified a dish they enjoy.

Considering these findings together, I argue for a view of choice bracketing where both narrow and broad bracketing are considered valuable modes of decision making. Narrow bracketing is not conducive to computationally optimal solutions. However, it has modest cognitive requirements, and can have important benefits when present-based factors are a concern, such as willpower or utility derived from consumption. Thus, it may be ideally suited as a default mode of decision making that keeps organisms engaged in the here-and-now and keeps cognitive resources on hand should they be needed. Conversely, broad bracketing plays a key role in guiding decision making through complex environments, though this requires additional cognitive resources and can lead to motivational/emotional errors. It may be ideally suited as a secondary mode of decision making, to be employed after the organism has identified a need for more expansive thinking.

This view of choice bracketing positions it as a crucial decision making process. While it may be easy in the lab to limit the number of choices a person faces, life is not so considerate. Life is a constant stream of decisions, many of which are connected at varying degrees of abstraction. In such an environment, a higher-order decision making process that assists us in expanding and narrowing our field of consideration is adaptive.

Advancing Our Understanding of Choice Bracketing

If it is true that choice bracketing is a cognitive process that helps people structure decision problems, then there are two important questions that require additional investigation. The first is, "What prompts people to bracket choices broadly?" The second is "By what mechanism does choice bracketing affect decision making?" Together, these questions will enhance our understanding of the adaptive role that choice bracketing plays in decision making by revealing more about the signals it responds to, and the manner in which it subsequently alters decision making.

What Prompts People to Bracket Choices Broadly?

If it is true that people bracket choices narrowly by default, and switch to broad bracketing when they perceive a need for more expansive thinking, then we would expect this switch to be triggered by certain pieces of information. What are those pieces of information?

Despite Read, Loewenstein, and Rabin (1999) describing this question as a "crucial direction for future research" (p. 187), it has received relatively little scholarly attention. They speculate that "many bracketing choices result from a wide range of subtle and unconscious factors that influence the way we categorize the world." (Read, Loewenstein, & Rabin, 1999, p. 187), and identify cognitive capacity, cognitive inertia (adopting the frame provided), pre-existing heuristics (e.g., grouping "weekdays" and "weekends" together), and motivated bracketing (e.g., bracketing narrowly to increase self-control) as examples of factors that may play an important role in determining whether somebody brackets a choice narrowly or broadly. Some have suggested that choice similarity may determine how a choice is bracketed (Redelmeier & Tversky, 1992), such that dissimilar choices are more likely to be bracketed narrowly. Empirical evidence for this theory can be found in work by Moher and Koehler (2010) and Webb and Shu (2018). Additionally, several papers have documented the tendency for people to bracket choices narrowly when they are complex (Kalayci & Serra-Garcia, 2012; Koch & Nafziger, 2019; Stracke et al., 2015).

The various choice bracketing manipulations that have been used in experimental research also offer clues as to the determinants of choice bracketing. An overwhelmingly popular approach has been to present participants with aggregate outcome information (e.g., Gourville, 1998; Hilgers & Wibral, 2014; Larson et al., 2016; Webb & Shu, 2017), thereby integrating individual choices into a larger composite choice. However, this may be more accurately termed an outcome bracketing manipulation (described later) rather than a choice bracketing one. Other studies (e.g., Keren & Wagenaar, 1987; Redelmeier & Tversky, 1992; Wedell & Böckenhold, 1994) induce broad bracketing by explicitly describing choices as belonging to a set. Moher and Koehler (2010) similarly used visual contiguity (presenting gambles on-screen at the same time) as a broad choice bracketing manipulation.

To summarize, cognitive capacity, similarity, complexity, heuristics, verbal descriptions, visual contiguity, and motivational needs have been offered as potential determinants of choice bracketing. Research on cognitive capacity, similarity, and complexity tell us that cognitive load cues people to bracket narrowly. Research on heuristics, verbal descriptions, and visual contiguity tells us that people tend to accept decision problems as formulated; when choices are partitioned people tend to bracket narrowly and when they are grouped together they tend to bracket broadly. Research on motivational needs suggests that people have some awareness of the motivational consequences of choice bracketing, and intentionally employ narrow bracketing to increase self-control.

These findings, however, do not answer the question “what prompts people to bracket choices broadly?” This is for two reasons. First, the majority of the above-cited research is concerned with narrow bracketing. These findings do not necessarily tell us about broad bracketing; for instance, it is unlikely that presenting people with very simple choices would by itself prompt broad bracketing. Second, work that does speak to broad bracketing specifically, such as research that has used visual contiguity and explicit descriptions of group membership, likely say more about the power of framing than about the situational determinants of choice bracketing specifically.

Clarity on this issue is deeply important if it is true that people tend to bracket choices narrowly by default and switch to broad choice bracketing when there is a need for more expansive thinking. What triggers this switch? One possibility that I explore in this manuscript is that association between choices is an important decision feature that prompts broad bracketing. Choices are associated if the outcome of one choice is related to the options of another. For example, physically moving through an environment requires making a sequence of associated choices—moving from one place to another enables subsequent movement from a particular point in space that would not have been possible if the previous movement had not been made. As another example, the decision to procrastinate in the moment changes the amount of work associated with future procrastinate vs. work decisions.

The claim that an association between choices can prompt broad bracketing is based on three observations. The first is a common-sense observation that if the choice bracketing system triggers broad bracketing when more expansive thinking is required, one of the most obvious situations where expansive thinking is required is when present choices alter the form of future choices. The second observation is that the ability to consider a set of choices (broad choice bracketing) by virtue of the associations between them is an important part of executive functions such as planning and the formation of attentional sets (Banich, 2009). To illustrate, the association between disks on the Tower of London task (Shallice, 1982) is order—the correct placement of one disk depends on the placement of the others. On the Wisconsin Card Sorting

Test (Berg, 1948), the association between choices is the implicit rule that governs how cards should be sorted—when participants detect a switch in rules, they are able to do so because differences in reinforcement signal a change in the association between prospective choices.

The third observation is that empirical research has extensively documented the instrumental role that association plays in cognition generally. For example, Tverksy and Kahneman (1977) claimed that probabilistic thinking is often driven by inferences about underlying causal mechanisms. As an example, the hot hand fallacy (Gilovich et al., 1985) is the product of causal inferences about unusual sequences of random events (e.g., the reason why a basketball player has made an impressive number of shots in a row is because they are "on their game"). Hassin, Bargh, and Uleman (2002) showed that people spontaneously infer causal relations when presented with semantic information. Morewedge and Kahneman (2010) have outlined the importance of associative coherence (congruence between associations prompted by a stimulus) as a key factor in several decision making errors, including framing effects (choice bracketing is commonly portrayed as a framing effect). Additionally, association is a critical component of other longitudinal cognitive processes, such as learning (Shanks, 2007).

Research on probability matching has also shown that decision making can be guided by the perception that choices are associated (Fantino & Esfandiari, 2002; Gal & Baron, 1996; Gao & Corter, 2015; McCracken et al., 1962; Newell et al., 29013; Peterson & Ulehla, 1965; Shanks et al., 2002; Tversky & Edwards, 1966; West & Stanovich, 2003). A classic example of a probability matching problem is as follows (see Anderson & Grant, 1957 and Tversky & Edwards, 1966). Imagine that you have two lights placed before you (one red and one blue) and are tasked with predicting which light will flash next. Over time you notice the red one flashes more often, but the blue one also flashes on several trials. Is it better to always predict red, or to split your predictions between red and blue to some extent? Probability matching research has shown that people tend to sub optimally split their predictions. One theory about why people behave this way is that they believe the light flashes are associated, such that past sequences affect the likelihood of future ones. For example, Peterson and Ulehla (1965) found that permitting participants to produce the random events in their study (in their case, by getting participants to roll the dice that they then made predictions on) reduced probability matching, presumably because participants no longer expected prearranged sequences in the dice rolls. As another example, McCracken, Osterhout, and Voss (1962) found that participants engaged in less probability matching when instructions emphasized the independent nature of the events and reassured them that there was no pattern to discover. Gal and Baron (1996) found that individuals who were less susceptible to probability matching, and instead simply predicted the highest probability event in their experiment, justified their choices after the fact by mentioning the independence of events. Tversky and Edwards (1966) found that instructing participants that the probabilities associated with events would change throughout the experiment decreased probability matching, and speculated that this is consistent with "the hypothesis that the asymptotic probability of predicting the outcome depends on S's opinion concerning the process generating the observed sequence" (p. 683).

Although the claim that an association between choices can prompt broad bracketing has not yet been tested, one study on choice bracketing has yielded findings that hint at this possibility. Stracke, Kerschbamer, and Sunde (2015) had participants play a pairwise elimination game, with two rounds. In the first round, four participants were paired off and played against each other. In the second round, the winners from the first round played against each other. In each round, participants purchased lottery balls using in-game money and the player whose ball was drawn won. Participants were randomly assigned to two conditions—in the "separate reward" frame winners received a reward at the end of each round. In the "integrated reward" frame winners only receive their reward at the end of both rounds. It was found that participants in the "integrated reward" frame purchased more lottery balls in round 1 than those in the "separate reward" frame. The authors conclude that participants in the "separate reward" condition viewed the two rounds as separate games, whereas those in the "integrated reward" condition viewed the first round as a qualifying round for the second. They also included a separate set of conditions using the same manipulation, but where the second round was a pure-chance lottery (i.e., participants could not pay for lottery balls). Here they found that participants in the "integrated reward" frame purchased fewer lottery balls than those in the "separate reward" frame. The authors present this finding as additional support for their conclusion that participants in the "integrated reward" frame viewed the two rounds as connected, because those participants valued qualifying less when they could not influence the likelihood of winning the second round.

Here, as with much other choice bracketing research, the bracketing manipulation is based on the aggregation of outcomes. In the "separate reward" frame, outcomes are presented on a choice-by-choice basis. In the "integrated reward" frame, they are presented in an aggregate form, across choices. The authors argue that this manipulation "induce[d] participants to view the stage-1 interaction as a qualification stage" (Stracke et al., 2015, p. 2) and conclude that, "different frames affect behavior of decision makers by influencing their perception of the consequences associated with their decisions." (Stracke et al., 2015, p. 31). I take the idea of "qualification" as inspiration for the investigation of association as a potential determinant of broad bracketing, separate from outcome aggregation manipulations.

By What Mechanism Does Choice Bracketing Affect Decision Making?

Most early research on choice bracketing used a risky choice paradigm. In these articles, a prominent explanation for how choice bracketing affects decision making is that it alters the arithmetic that individuals perform when considering their choices, such that they fail to aggregate outcomes or integrate probabilities under narrow bracketing (Gneezy & Potters, 1997; Li, 2003; Redelmeier & Tversky, 1992; Tversky & Kahneman, 1981; Wedell & Böckenhold, 1990). For example, Tversky and Kahneman (1981) describe "minimal accounts" as excluding all assets or outcomes that are not connected to the choice under immediate consideration. Redelmeier and Tversky (1992) describe participants' decision to reject an additional sixth gamble after hypothetically playing five gambles as a failure to "combin[e] it with the distribution of outcomes induced by the fivefold play" (p. 192). Other researchers have suggested that under repeated choice scenarios individuals might be more sensitive to computational factors such as variance (Coombs, 1975; Coombs & Bowen, 1971), outcome magnitude (Wedell & Böckenholt, 1990), and probability (Wedell & Böckenholt, 1994).

There is more to choice bracketing than mental math, however. Work on riskless choice has shown several noncomputational mechanisms that explain bracketing effects. For example, Soman and Cheema (2004) suggest a wide range of possible mechanisms by which broad bracketing can impair goal pursuit following a failure, such as demotivation, frustration, negative affect, decreased self-efficacy, negative self-monitoring, and rebound effects. Hsiaw (2018) claims that broadly bracketed goals can lead people to respond to information that is not relevant to goal pursuit, resulting in behaviours such as the sunk cost fallacy and "coasting" (reducing effort following greater than expected progress). In their hallmark paper on choice bracketing, Read, Loewenstein, and Rabin (1999) speculate that narrow bracketing might increase self-control by making self-control goals (e.g., abstinence) feel more achievable (e.g., "I only have to be sober today, rather than sober forever"). Camerer, Babcock, and Loewenstein (1997) suggested that narrow bracketing can increase self-control by setting more frequent reference points against which performance is evaluated.

There is also circumstantial evidence of noncomputational mechanisms in the domain of risky choice. For example, Montgomery and Adelbratt (1982) randomly assigned participants to consider either individual or repeated gambles. They also randomly assigned participants in both conditions to either receive expected value information, or not. They found that the expected value information manipulation only affected risk-taking in the multiple gamble condition, suggesting that decision making under narrow bracketing is not limited by one's ability to compute expected value. Instead, it seems that under narrow bracketing people may not make use of such information. As another example, Li (2003) argued for a traditional computational explanation, writing, "multiple instantiations of gambles induce subjects to integrate probabilities with outcomes using a long-run perspective" (p. 118). However, in their study participants were provided with expected value information (a metric that integrates probabilities and outcomes) in both their isolated and repeated-choice conditions, suggesting that the observed difference across conditions must have been the result of other factors. Chen and Corter (2006) similarly found that some differences across isolated and multiple play conditions remained, even when all participants were shown a graph of the multiple-trial outcome distribution. They conclude, "it is not due purely to a failure to aggregate correctly over the multiple trials" (Chen & Corter, 2006, p. 1), and suggest that this lingering non-computational effect could be explained by people's tendency to compromise across mixed options (Simonson, 1989; Simonson & Tversky, 1992).

To summarize, there is evidence that choice bracketing works at least partially through noncomputational mechanisms, but specific hypotheses about these mechanisms have been under-investigated in risky choice paradigms.

Addressing this gap in the literature is important for two reasons. First, risky choice is an overwhelmingly popular paradigm both in the choice bracketing literature and judgment and decision making research in general. A comprehensive theoretical model of choice bracketing should be able to explain how choice bracketing affects risk-taking. The second reason is that uncertainty is a key feature of many real life decision making problems (e.g., investment, diagnosis, innovation). Given the consequences associated with choice bracketing, greater clarity on the mechanisms that drive these outcomes could help inform educational and choice architecture initiatives designed to empower informed decision making and improve well-being.

One noncomputational mechanism that has been hypothesized to drive choice bracketing effects on risky choice is risk perception. That is, the subjective felt experience of riskiness, separate from quantitative evaluations of risk (Loewenstein et al., 2001; Slovic et al., 2004). Coombs and Meyer (1969) could be considered early proponents of this theory, in that they specified and tested a model of risk-taking under isolated and repeated play that revolved around "the subjective variable of riskiness" (p. 514).

Research on the relationship between bracketing and risk perception is scarce. To date, only two studies involving bracketing and risk perception have been conducted. The first was conducted by Webb and Shu (2017). They present the results of two studies. In the first study, participants assigned to the narrow bracketing condition were presented with a description of a single gamble and were offered the choice between a sure thing and the gamble, which would be repeated some number of times (i.e., either choose the sure thing 90 times or play the gamble 90 times). Positive expected value, negative expected value, and pure-loss gambles were used. Participants assigned to the broad bracketing were provided with a probability distribution for the same gamble and were offered the same choice between repeatedly obtaining the sure thing or playing the gamble. Webb and Shu (2017) found that under narrow bracketing participants took fewer risks when presented with positive expected value gambles, and greater risks when presented with negative expected value and pure loss gambles. They also found that under narrow bracketing risk perception was higher for positive expected value gambles and lower for negative expected value and pure loss gambles. They conclude that "…bracketing effects work, at least in part, by changing the perceived risk associated with the gamble." (Webb & Shu, 2017, p. 389-390). Their findings are consistent with prior research on the relationship between bracketing and risk taking for similar types of gambles (Benartzi & Thaler, 1995; Keren & Wagenaar, 1987; Montgomery & Adelbratt, 1982). In their second study, participants were presented with either the single gamble information (narrow bracketing), the outcome distribution for that gamble (broad bracketing), or a visual representation of the number of expected wins and losses for the prescribed number of plays ("broad trial" bracketing). Here they observed reduced risk seeking in the narrow and broad-trial conditions compared to the broad bracketing condition for positive expected value gambles, and increased risk seeking in the narrow and broad-trial conditions compared to the broad bracketing condition for negative expected value and pure loss gambles. They do not report risk perception data for this study.

The second study was conducted by Chaudhry et al. (2020). In their study, individuals played either single or multiple plays of gambles with rare severe adverse consequences (e.g., choose between a sure loss of $0.45 or a 1% chance of losing $45). They additionally randomly assigned participants to either receive information on the probability of the rare event occurring on a single play (narrow bracketing), or the probability of it occurring at least once across multiple plays (broad bracketing). They found that individuals in the broad bracketing condition were less risk-seeking than those in the narrow bracketing condition, which is consistent with prior research cumulative risk for gambles with severe adverse consequences (Bar-Hillel, 1973; Doyle, 1997). The authors additionally measured risk perception but do not report their findings.

There are several opportunities to build on the foundation set by these papers. The first involves differentiating between choice and outcome bracketing. Authors such as Moher and Koehler (2010) and Hadar et al. (2020) have shown that the consideration of choices either individually or in groups (choice bracketing) is conceptually and empirically distinct from the isolated/simultaneous consideration of the outcomes associated with those choices (outcome bracketing), and that broad choice bracketing can occur in the presence of narrow outcome bracketing (and vice versa). This distinction has been largely overlooked in the choice bracketing literature. For example, research that is commonly cited when discussing choice bracketing and risk taking includes work by Benartzi and Thaler (1995), Gneezy and Potters (1997), Keren & Wagenaar (1987), and Payne (1973). However, in these studies broad bracketing manipulations involve presenting participants with aggregate outcome information (e.g., displaying cumulative probability distributions, restricting the frequency with which individuals can view their investment portfolio). Outcome manipulations have continued to be used in more recent research demonstrating the impact of bracketing on risky choice (Haigh & List, 2005; Larson, List, and Metcalfe, 2016).

In both Webb and Shu (2017) and Chaudhry et al.'s (2020) paper, outcome bracketing manipulations were used. In Webb and Shu's (2017) second study, they do use a choice bracketing manipulation (which they call a "broad-trial" bracketing manipulation) by presenting some participants with a visual representation of expected wins and losses, which the authors state "makes salient the number of repeated trials without directly aggregating the outcomes across trials" (p. 390). However, they do not report risk perception data for that study.

This leads to the second opportunity to contribute to this developing research area. Although both Webb and Shu (2017) and Chaudhry et al. (2020) gathered data on risk perception, Webb and Shu only report it for their study involving an outcome bracketing manipulation, and Chaudhry et al. do not report it at all. Therefore, measuring the relationship between choice bracketing (separate from outcome bracketing), risk perception, and risk taking remains an important gap in the literature.

In investigating mechanisms underlying the relationship between choice bracketing and risky decision making, I restrict the scope of my inquiry to gambles involving rare severe adverse consequences (like Chaudhry et al., 2020). Research on this topic is crucial because these types of gambles generalize to several important real life decision making problems where choice bracketing effects may be relevant. For instance, speeding, smoking, unprotected sex, and residence in common disaster areas are all behaviours that involve decisions about events with a low segregate probability of adverse consequences, and where choices are often bracketed narrowly. Greater clarity on the mechanisms underlying the relationship between choice bracketing and risk perception could contribute to attempts to help people make better choices about these important issues.

The hypothesis that is tested in this manuscript is that when outcome considerations are controlled for, narrow choice bracketing reduces risk perception, and thus increases subsequent risk taking for gambles involving rare serious outcomes. For instance, consider a common risk that people take—speeding. It is likely that people have some recognition that speeding is associated with an increased risk of being pulled over or getting in an accident. Those with licenses have received training to this effect. Signs consistently inform them of this rule and its enforcement. But we only speed one trip at a time, and the chance of adverse consequences occurring on a given trip is very low. It is possible that individuals bracketing their driving choices narrowly are more likely to speed because, although they know it is associated with adverse outcomes in the long term, it doesn't feel very risky in the moment. As another example, consider Read, Loewenstein, and Rabin's (1999) discussion of smoking. Smoking is a repetitive behaviour where most smokers know where their choices will lead them eventually (Oncken et al., 2005), and yet they continue to behave sub-optimally. Of course, other factors are highly relevant here, such as physiological addiction, but it is worth exploring whether the partitions built into this decision making problem (i.e., we smoke one cigarette at a time) might affect people's "here and now" subjective sense of risk.

Study 1: Determinants of Broad Bracketing

Overview

The purpose of the present study is to test the hypothesis that association between choices can prompt people to bracket choices broadly. This claim is based on common-sense observations (e.g., that people readily engage in systematic decision making across choices in daily life), research that demonstrates the powerful impact of perceived association or contingency on decision making (e.g., causal inference, probability matching), and choice bracketing research that is suggestive of a link between associated choices and broad bracketing (e.g., Stracke et al., 2015).

A repeated-choice decision making task was used to test this hypothesis. During the task, individuals are presented with multiple ways of accumulating points. Some of these ways of navigating the task involve associated choices, and others do not. Inferences about whether participants are bracketing narrowly or broadly are made by comparing participants' pattern of decision making across the task to pre-specified theory-based patterns that reflect narrow or broad bracketing. Of note, the goal of this study is to identify feature-based determinants of choice bracketing—that is, qualities of a decision that prompt people to independently or autonomously bracket choices broadly. As such, this study does not involve an experimental choice bracketing manipulation. Instead, participants are placed in a decision making environment, and the coincidence of associated choices and patterns of decision making that reflect broad bracketing is observed.

If there is evidence that people bracket their choices broadly when presented with associated choices, it will advance our understanding of choice bracketing by identifying one of the pieces of information that triggers the choice bracketing system to switch from narrow to broad choice bracketing. This will shed light on the adaptive function that choice bracketing serves (i.e., what situations or signals does it respond to?) and point towards potential interventions that can be used to encourage or dissuade the switch from narrow to broad choice bracketing.

Methods

Participants

290 participants were recruited from York University's Undergraduate Research Participant Pool, where undergraduate students taking the course "Introduction to Psychology" participate in research studies as part of their course requirements. This sample size was selected to allow for adequate power; data analysis will involve sub-setting this data (e.g., comparing the

number of participants grouped into different clusters, within one of four experimental conditions).

Participants were directed to a website that hosted the study materials. 10 participants disconnected from the task website during administration, and later restarted the task. Because of potential practice effects, these participants were removed from the data analysis. A further 23 participants disconnected from the task website and did not connect again. Because disconnection from the task may represent a withdrawal of consent, these participants were also removed from the data analysis. The final sample size was 257.

Participants were aged 18 to 52 with a mean age of M = 19.91. 78% of participants identified as female, 20% identified as male, and 2% identified with another gender identity (e.g., non-binary, genderqueer).

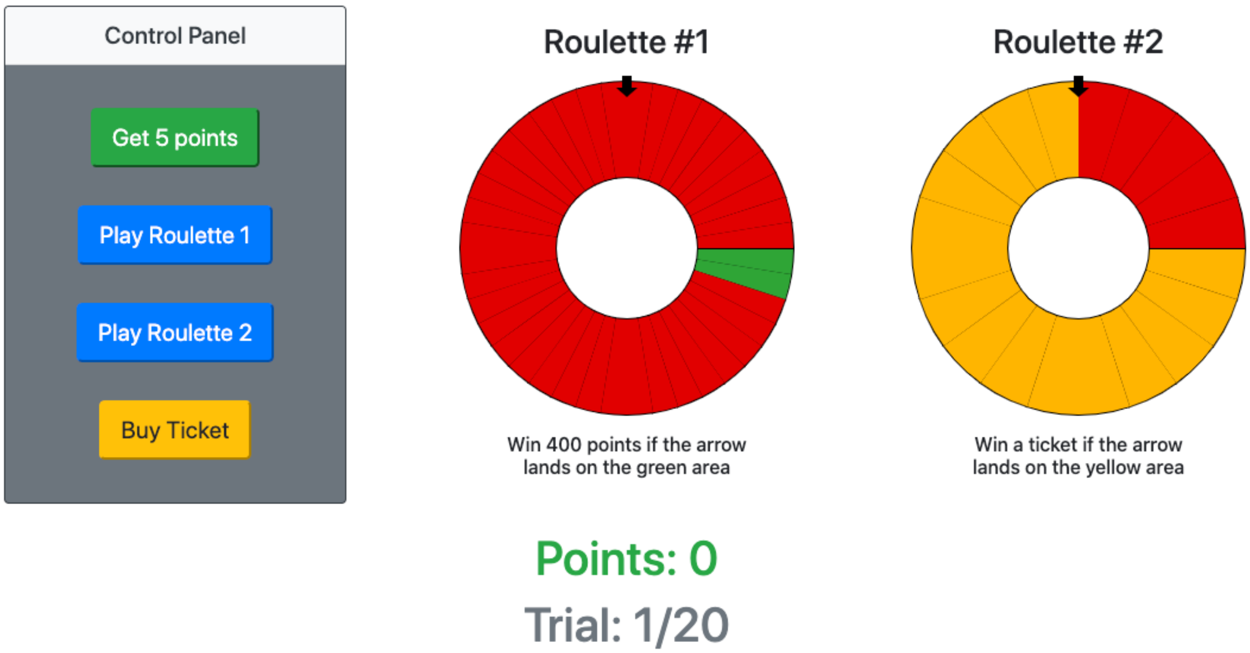
Materials

Task Layout. A digital repeated-choice decision making task was created for use in this study. The task is designed to elicit patterned decision making and allows inferences to be made on the basis of these patterns of decisions about whether participants are bracketing their choices narrowly or broadly.

Participants were informed that they would be playing a decision making game. Upon starting the task, participants were instructed that the goal of the game is to make as many points as possible. They subsequently completed an interactive, guided tutorial (described later). During the task, participants were presented with a control panel, which contains a number of buttons. Participants may press one button per trial, and the task contains 20 trials. Thus, all participants performed exactly 20 button presses throughout administration. Figure 1 displays a configuration of the task with all possible buttons included (different configurations will be discussed later), and Figures 2-5 draw attention to each button and its specific functionality. In Figures 2-5, only those parts of the task that are relevant to the button being discussed are displayed in colour.

Figure 1

Study 1 Experimental Task



Pressing the “Get 5 Points” button (Figure 2) immediately awards the participant 5 points. Prior research on choice bracketing has shown that people prefer guaranteed gains to positive expected-value gambles under narrow bracketing (Redelmeier & Tversky, 1992). Thus, it is expected that participants who are bracketing their choices on the task narrowly will press the “Get 5 Points” button repeatedly.

Pressing the “Play Roulette #1” button (Figure 3) will make the roulette wheel titled “Roulette #1” spin. If the black arrow lands on the green area, the participant wins 400 points. If the black arrow lands on the red area, they do not win any points. Past research has suggested that people find low probability, high reward prospects appealing in groups but unappealing individually (e.g., Keren & Wagenaar, 1987). Thus, participants are expected to press the "Play Roulette #1" button only if they are bracketing broadly.

Figure 2

Get 5 Points Button

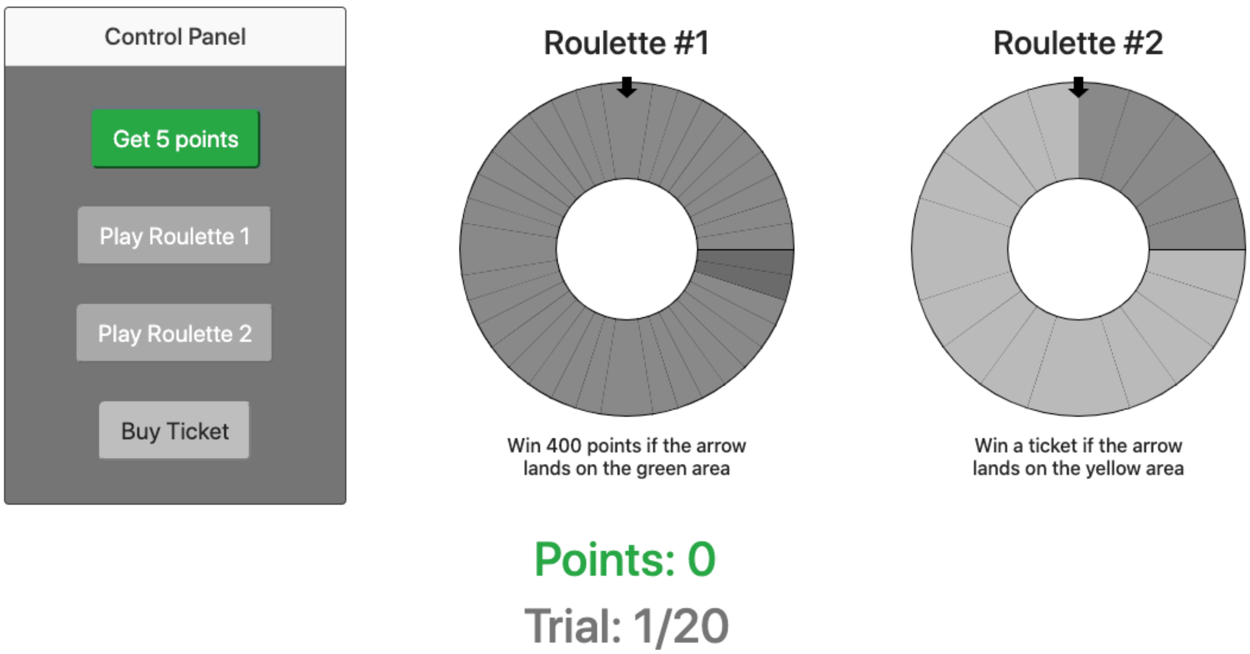
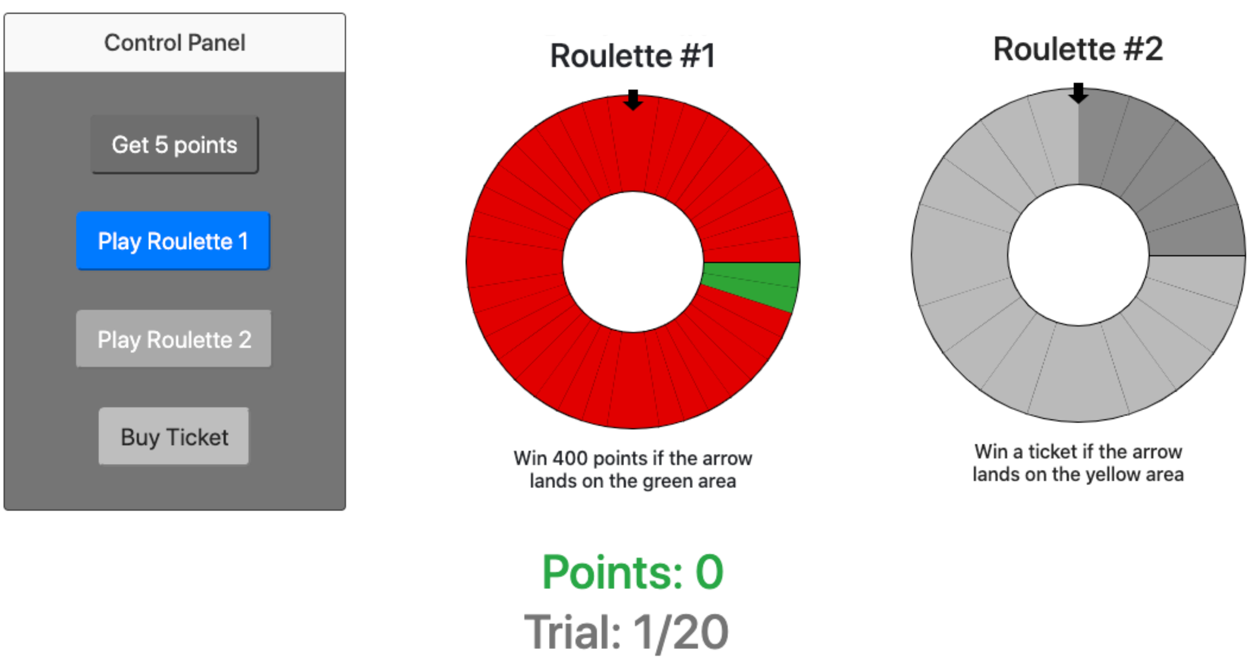


Figure 3

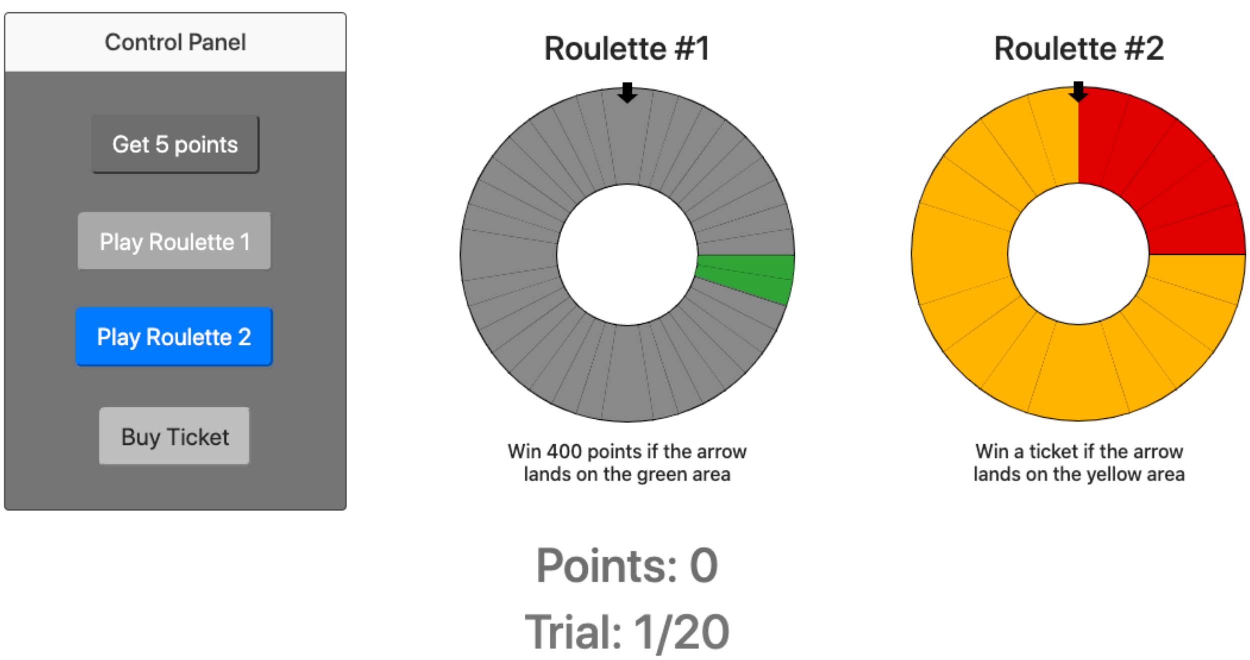
Play Roulette 1 Button



Pressing the “Play Roulette #2” button (Figure 4) will make the roulette wheel titled “Roulette #2” spin. If the black arrow lands on the yellow area, participants receive a ticket. Tickets increase the green area (the chance of winning) on roulette #1 by 2.5%. When participants play roulette #1, they automatically use all of the tickets they have acquired. Thus, tickets only increase the likelihood of winning roulette #1 on a *single* subsequent trial—they do not permanently change the odds associated with playing roulette #1 across multiple trials. Therefore, the “Play Roulette #2” button offers participants a chance to increase their likelihood of winning roulette #1 the next time it is played. Because the “Play Roulette #2” button’s only function is to affect the likelihood of winning points on a future trial, it is expected that only participants who are bracketing broadly will press this button.

Figure 4

Play Roulette 2 Button

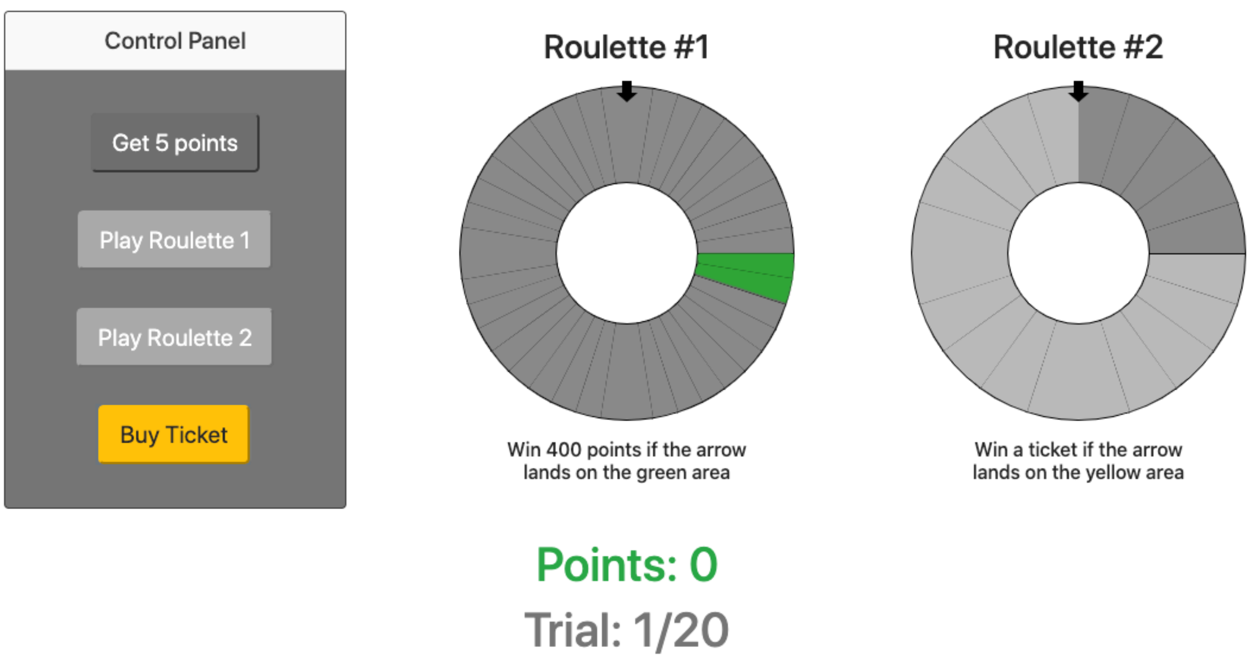


Pressing the "Buy Ticket" button (Figure 5) provides participants with a ticket. As stated, this increases the green area on roulette #1 by 2.5%. Using the "Buy Ticket" button costs 2 points. When a participant presses the "Buy Ticket" button they are paying 2 points to increase the likelihood of winning roulette #1 the next time it is played. Participants can have negative points.

Pressing the "Buy Ticket" button incurs immediate costs and alters the likelihood of future outcomes. Therefore, it is expected that only participants who are bracketing broadly will press this button.

Figure 5

Buy Ticket Button



Teaching Participants a Complex Task. Participants learned how to use this task through an interactive, guided tutorial. Each page of the tutorial is displayed in the Appendix, Figures A1-7. For tutorial pages that describe how buttons work, participants were only able to proceed to the next page when they had demonstrated an ability to press the relevant button. Until they did so, the “next” button was disabled. For some tutorial pages, such as the tutorial page describing the “Play Roulette #2” button, participants had to perform multiple button presses in a specified order (e.g., pressing the “Play Roulette #2” button multiple times and then the “Play Roulette #1”, thereby demonstrating how these buttons work together). Participants were permitted to repeat the tutorial as many times as they wished. At the end of the tutorial, participants were reminded of several important details—that they could only take one action (click one button) per trial; that their goal was to make as many points as possible; that they did not have to use all of the available buttons, only those they thought would help them make as many points as possible; and that they could have negative points. After completing the tutorial, participants played 20 practice trials of the task. Following these practice trials, the main 20 trials were administered.

Task Strategies and Their Meaning. This task offers participants four coherent strategies to obtain points: A) acquire points by pressing the “Get 5 Points” button; B) accumulate tickets across trials by pressing the “Play Roulette 2” button repeatedly, then redeem those tickets by pressing the “Play Roulette 1” button; C) accumulate tickets across trials by repeatedly pressing the “Buy Ticket” button, then redeem those tickets by pressing the “Play Roulette 1” button; and D) press the “Play Roulette 1” button repeatedly in the hopes of winning the 400 points one or more times across the 20 trials. Table 1 summarizes these strategies.

As Table 1 shows, each strategy also indicates the use of either narrow or broad choice bracketing. As stated previously, given that there is no experimental manipulation of choice bracketing, the presence of narrow or broad choice bracketing is believed to be determined by the features of the choices participants are presented with. Of note, while individual differences (e.g., cognitive capacity) likely play a role as well, random assignment should distribute them relatively evenly across experimental conditions (described later), allowing us to remain focused on feature-based determinants of choice bracketing. There are three potential features on this task that could prompt broad bracketing. The first is a probabilistic association between choices. The "Play Roulette #2" button and "Play Roulette #1" button share a probabilistic association—when pressed, the "Play Roulette #2" button may alter the likelihood of winning points when the "Play Roulette #1" button is pressed next. This association is probabilistic because pressing the "Play Roulette #2" button only carries a 75% chance of winning a ticket (which increases the odds of winning roulette #1 the next time it is played). By forming an association between choices, participants are invited to consider those choices together—to bracket their choices broadly. This pattern of behaviour corresponds to Strategy B.

Table 1

Task Strategies and Their Expected Value

Strategy	Button Presses	Choice Bracket Required	Expected Value
A	"Get 5 Points" x 20 presses	Narrow	100
B	"Play Roulette 2" x 19 presses "Play Roulette 1" x 1 press	Broad	162.5
C	"Buy Ticket" x 19 presses "Play Roulette 1" x 1 press	Broad	172
D	"Play Roulette 1" x 20 presses	Broad	400

The second task feature that could prompt broad bracketing is a deterministic association between choices. The "Buy Ticket" button guarantees an increased likelihood of winning roulette #1 on a future trial (unlike roulette #2, every time you press the "Buy Ticket" button you receive a ticket). This pattern of behaviour corresponds to Strategy C. This strategy was included in the design to provide a stronger test of the hypothesis that an association between choices can prompt broad bracketing. In addition to offering a guaranteed increased likelihood of winning roulette #1 the next time it is played, the "Buy Ticket" button also incurs an immediate loss of 2 points. Past research has shown that under broad bracketing, people are less loss averse (Keren & Wagenaar, 1987; Larson et al., 2016; Webb & Shu, 2017). They are more willing to risk intermediary losses if they believe it will lead to better outcomes in the long run. In this way, compared to the "Play Roulette #2" button, the "Buy Ticket" button combines a stronger incentive for people who are bracketing broadly, as well as a stronger disincentive for people who are bracketing narrowly. Thus, if Strategy C is preferred to Strategy B, it offers additional support for the hypothesis that an association between choices can prompt broad bracketing.

The third task feature that could prompt broad bracketing is expected value. Scholars have argued that people do not make decisions on the basis of expected value under repeated-choice conditions (Montgomery & Adelbratt, 1982) and do not autonomously integrate the mathematical properties of multiple choices (Kahneman & Lovallo, 1993). Thus, it is expected that participants will not bracket choices broadly purely on the basis of expected value. Strategy D offers an opportunity to formally test this hypothesis, as it corresponds to a pattern of behaviour that would only be appealing to an individual who has realized that the mathematical properties of Roulette #1 are desirable across trials, even if the chance of winning on any given trial is low. Of note, it is unlikely that individuals would follow Strategy D under narrow bracketing because prior research has demonstrated that, under narrow bracketing, people tend to prefer a small, sure gains over more profitable risky prospects (Keren & Wagenaar, 1987; Webb & Shu, 2017; Wedell & Böckenhold, 1990).

Strategies and Their Expected Value. These strategies correspond to different expected values (reported in Table 1). Strategy D was given the highest expected value to incentivize individuals bracketing broadly on the basis of expected value to follow this strategy. Its expected value is more than twice as large as the next most profitable strategy (Strategy C), thus providing participants who might be bracketing broadly based on expected value a strong signal to attend to. As previously discussed, given people's preference for sure gains over larger magnitude uncertain gains under narrow bracketing, it is unlikely that individuals who are bracketing narrowly would follow this strategy. Strategy A was given the lowest expected value to reinforce the inference that only an individual who is bracketing narrowly (and thus paying exclusive attention to their change in points on the present trial) would find this strategy appealing. It is the least advantageous strategy, and so the decision to select it is much more likely to result from a failure to recognize other options (i.e., those only visible under broad bracketing). Of note, Strategy A is also the only approach that involves certain outcomes. As discussed previously, risk-taking for positive expected value gambles (which involves tolerating uncertainty) increases under broad bracketing. Therefore, the certainty offered by Strategy A is likely more appealing to individuals bracketing narrowly than broadly, providing yet another reason to believe that individuals who follow this strategy are bracketing narrowly.

Strategies B and C have very similar expected values. Making their expected values greater than that of Strategy A is a necessary byproduct of designing the perceived magnitude of possible returns so that they large enough to incentivize those bracketing broadly to select this strategy over Strategy A. These strategies have a much lower expected value than Strategy D to reinforce the inference that individuals who follow these strategies are bracketing broadly on the basis of some factor other than expected value (specifically, association between choices).

It is not expected that the difference in expected value between Strategies B and C will affect decision making. Making them precisely equal would have required either increasing the likelihood of winning Roulette #2 from 75% to 80% or increasing the price of a ticket from 2 points to 2.5 points. Increasing the likelihood associated with roulette #2 runs the risk of undermining the difference between Strategy B and C—buying a ticket seems less worthwhile if Roulette #2 *nearly* guarantees a ticket. In addition to wanting to avoid the confusion of half points, increasing the price of the ticket beyond 2 points runs the risk of making the "pain of paying" (Zellermayer, 1996) for tickets so high that the strategy is abandoned, even if participants think it is optimal. After all, there is evidence that broad bracketing attenuates loss aversion, not that broad bracketing eliminates loss aversion. Requiring participants to pay more than 2 points for a ticket may have interfered with their ability to stick with Strategy C, even if they believed it to be optimal. Variations on this task where the expected values associated with Strategy B and C are exactly equal may be a subject for future research. For the present study, however, it is not anticipated that expected value will be a factor guiding decision making between Strategy B and Strategy C. If participants are attending to expected value, it is much more likely that they will simply choose Strategy D.

Experimental Conditions. The hypothesis that an association between choices can prompt broad bracketing corresponds to a preference ranking for the strategies described earlier. This preference ranking, and the logic underlying it, will now be explained.

If it is true that participants will bracket choices broadly when they are associated, the counterfactual to this statement should also be true—they will bracket choices narrowly when presented with choices that are not associated. In other words, when only strategy A and strategy D are viable, participants should prefer strategy A. This hypothesis is aligned with previously cited research suggesting that people bracket choices narrowly by default.

When only strategy A, B, and D are viable, participants should prefer strategy B—Strategy A only looks appealing to participants who are bracketing narrowly, and people are not expected to bracket broadly on the basis of expected value (strategy D). When only strategy A, C, and D are viable, participants should prefer strategy C, for the same reasons.

Finally, when all strategies are viable, participants should prefer strategy C. Even though strategy C involves intermediate losses, this should not dissuade participants because they will be bracketing broadly, will be therefore less loss averse, and will pick the choice that most decidedly advances their goal of boosting the probability of winning roulette #1.

In order to test this hypothesized strategy preference ranking, participants were randomly assigned to one of four experimental conditions. Within these conditions, only some strategies are available because only some of the possible buttons are included. The conditions, the buttons included, the possible strategies, the strategies participants are expected to follow, and the preferences that strategy use implies, are summarized in Table 2. Figures A8-A11 in the Appendix show what the four conditions look like.

Procedure

After signing up to participate in the study through the URPP, participants were provided with a URL link that directed them to a website hosting the study materials. Participants were presented with an informed consent form. Those who did not wish to participate received a debrief form. Participants who consented to participate in the study were then asked to enter their URPP ID (to aide in granting them credits), their age, and their gender identity. Participants were then randomly assigned to one of the four conditions described above.

Table 2

Experimental Conditions and Their Purpose

Condition	Available Buttons	Possible Strategies	Expected Strategy	Strategy Preference	Strategy Preference Ranking
1	5 Points Roulette #1	A, D	A	A > D	
2	5 Points Roulette #1 Roulette #2	A, B, D	B	B > A > D	
3	5 Points Roulette #1 Buy Ticket	A, C, D	C	C > A > D	C > B > A > D
4	5 Points Roulette #1 Roulette #2 Buy Ticket	A, B, C, D	C	C > B > A > D	

Immediately after random assignment, participants completed the interactive guided tutorial described earlier. Participants only received instructions for the buttons present in their condition (e.g., participants in condition 1 did not receive tutorial instructions on how to press the “Play Roulette #2” and “Buy Ticket” buttons because those were not present in their condition). After completing the tutorial, participants played 20 practice trials. Following this they completed the main 20 trials of the task. Participants were subsequently directed to a debrief form. Finally, participants were informed that the study was over and that they could close their web browser.

Hypotheses

Given the strategy preference ranking described earlier (and summarized in Table 2), it is hypothesized that the dominant strategy in condition 1 will be Strategy A, in condition 2 it will be Strategy B, in condition 3 it will be Strategy C, and in condition 4 it will be Strategy C.

Data Analysis Plan

This task produces longitudinal categorical data; there are 20 time points (trials), and a single behaviour (button press) is performed at each time point. Sequence analysis (Abbott, 1995) is a collection of data visualization and analysis methods that use longitudinal categorical data to describe how similar patterns of responses are to one another. These patterns can be subsequently grouped based on similarity, using a clustering technique. Once patterns are grouped, a chi-square goodness of fit test can be used to determine whether one pattern is more common than the others (i.e., whether a given strategy is dominant in a condition).

Sequence Analysis. Sequence analysis is an umbrella term that covers a wide range of techniques. The specific technique used in this study is called optimal matching (Abbot & Forrest, 1986). To understand how optimal matching works, imagine we are comparing two participants' responses (two sequences of 20 button presses, ordered by trial). The optimal matching algorithm determines the minimum number of changes required to make the sequences identical. That number is then used to represent the "distance" or dissimilarity between those two sequences. This happens with all of the sequences in the dataset; every participant's sequence is compared to every other participant's sequence. These pairwise distances are recorded in a "distance matrix". This matrix quantifies how similar every pattern is to every other pattern.

Sequence analysis has been used to examine a wide variety of patterned phenomena, such as the career trajectories of women in finance (Blair-Loy, 1999) and musicians (Abbott &

Hrycak, 1990), placement instability in foster care (Havlicek, 2010), shifts in hostage negotiations (Holmes, 1997), progression of crimes (Keatley & Clarke, 2020), team-based interactions (Herndon & Lewis, 2015), and organizational routines (Salvato, 2009). Sequence analysis has been used previously in cognitive research. For example, Poole and Holmes (1995) used optimal matching to examine differences in the development of group decision making over time when some decision-makers used computer-assisted decision making technology and others did not. Zanesco (2020) used this approach to describe streams of thought during various cognitive tasks. As another example, Van Laer and Elen (2018) used optimal matching to describe longitudinal patterns in self-regulated learning.

Prototypical and Variant Sequences. Table 1 describes the button presses involved in the previously described strategies that participants can use to navigate the experimental task. However, the criteria for labeling a given sequence of button presses as representing one of these strategies is somewhat flexible. For example, it is hypothesized that participants who are broadly bracketing on the basis of a deterministic association between choices will press the "Buy Ticket" button 19 times and the "Play Roulette #1" button 1 time. If, however, a participant presses the "Buy Ticket" button 18 times, the "Play Roulette #1" button one time, and the "Get 5 Points" button once, this sequence would still be interpreted as indicating broad bracketing on the basis of a deterministic association between choices. Some flexibility in interpretation is important, because people are bound to navigate a 20-event task in somewhat different ways even if they are operating under similar guiding principles. There is precedence in the literature for this assertion. For example, it is common for individuals to identify desirable decks on the Iowa Gambling Task using the same overall strategy (sampling decks until eventually landing on one or two "good" decks) but in superficially different ways (Steingroever et al., 2013).

Flexibility of interpretation is also important for sequences that contain some important component of a given strategy, but also have features that distinguish them from the prototypical sequence for that strategy. For example, imagine an individual that presses the “Buy Ticket” button 9 times, presses the “Play Roulette #1” button once, and then presses the “Get 5 Points” button 10 times. It is possible that this individual broadly bracketed their choices, but after redeeming their tickets decided that this strategy was not worth it and resigned themselves to simply accruing points with the “Get 5 Points” button. This individual displays some of the thinking believed to underly Strategy C—they just do not follow it throughout the entirety of the task.

Such sequences can be considered “variants” on the expected strategies. Of course, labeling these sequences as such is a post-hoc exercise, and is thus deserving of additional scrutiny. However, this practice of distinguishing between prototypical and variant behaviour on decision making tasks has precedence in the literature. For example, some authors have theorized that logical processes underly certain sub-optimal sequences of card flips on the Selection Task (Evans, 1996).

Clustering. After the similarity between all sequences in a dataset is determined, those sequences can be grouped according to similarity. In this study, Ward’s method (Ward, 1963) was used to accomplish this. Ward’s method is an agglomerative, hierarchical clustering technique. It starts by placing every sequence in its own cluster. It then merges clusters such that the distances (calculated by the optimal matching algorithm) between members of a cluster are as small as possible. In the present study, it performs this operation as many times as necessary until it meets the pre-specified number of clusters. The number of desired clusters was based on the number of expected comprehensible strategies (see Table 2) in each condition, plus an additional cluster to catch unexpected responses.

In the results section, clusters are given labels that describe the strategy that is being displayed by the sequences in that cluster. However, these clusters are formed purely from the data. The only meaning they have is that which the author (and readers) ascribe to them.

Data Filtering. The data analysis procedure just described is comparative—it describes and groups sequences according to their similarity to one another. One of the consequences of this technique is that sequences that are less relevant to the primary research question can interfere with the analysis as a whole. Two such sequences are those with high variability (potentially reflecting random responding), and those with unusual or peculiar patterns of responding (potentially reflecting an incomplete grasp of how the task works). As such, data is considered in steps. The first steps involves examining only data with low variability and no unusual sequences. The second step involves examining this data, alongside data with high variability. The final step involves examining unusual sequences on a case-by-case basis.

High Variability. In the present study, sequences with a Shannon entropy (Shannon, 1948) score greater than or equal to 0.8 were deemed to be high variance (1 is the maximum score), and potentially indicative of random responding. Shannon entropy can be understood similar to variance. For example, in Condition 4 participants can press one of four possible buttons on every trial. There are 20 trials. If they press each button 5 times, the Shannon entropy of their sequence will be 1—in terms of the frequency of each response, it is indistinguishable from a perfectly random sequence. One important feature that the Shannon entropy formula does not take into account is the order of responses in a sequence. So, for example, the sequence 1-2-3-4-1-2-3-4 and 1-1-2-2-3-3-4-4 both have a Shannon entropy score of 1, even though they describe very different patterns. For this reason, there is still value in examining sequences with high entropy scores—there still may be systematicity to their patterns, even if the responses in those patterns appear with similar frequency. The cutoff of 0.8 was chosen in an attempt to retain a large amount of data for the main analysis. As with effect sizes (Funder & Ozer, 2019), decisions about ascribing meaning to quantitative metrics should be informed by the field of research within which it is embedded and the specifics of the research study. Given the novelty of both the experimental task and the infrequent use of this data analysis procedure in the field of judgment and decision making, the relatively liberal value of 0.8 was selected because it would separate out only the more severe cases of high variance responding.

Unusual Response Patterns. Unusual response patterns were defined based on theory. Two such sequences were defined. The first involves unredeemed tickets. In this situation, participants obtain a ticket (through winning roulette #2 or pressing the "Buy Ticket" button) but never attempt to redeem those tickets by pressing the "Play Roulette #1" button. Tickets serve no function other than to increase the odds of winning roulette #1. Thus, the reasoning behind such a sequence is hard to infer and could reflect uninformed responding.

The second sequence involves the delayed use of tickets. This occurs when a participant obtains a ticket but then presses the "Get 5 Points" button before later redeeming their tickets by pressing the "Play Roulette #1" button. Obtaining and redeeming tickets is a cohesive strategy, and accumulating points with the "Get 5 Points" button does nothing to further that strategy. As such, this sequence may also reflect uninformed responding.

Although these patterns are peculiar enough to warrant considering them separately from the primary analysis, they are still worth examining. For example, it is possible that participants with unredeemed tickets simply change their mind about the strategy they wish to follow and decide not to redeem their tickets because they believe it is no longer advantageous.

To account for the possibility that these behaviours may have been performed accidentally (e.g., by a mis-click), participants' sequences were only considered separately from the main analysis if they performed two or more such events (unredeemed or delayed tickets).

Software. Readers who are interested in conducting this analysis themselves are advised to consult the R package TraMineR (Gabadinho et al., 2011). The "seqdef" function creates the sequence object (the list of behaviours, ordered by time), the "seqdist" function uses the optimal matching algorithm to calculate the distance matrix, the "agnes" function allows for clustering of sequences, the "seqient" function calculates Shannon entropy values for sequences which can be used to filter data as desired, and the "seqIplot" function allows sequences to be plotted. Filtering for unusual or peculiar patterns was done using user-defined R functions.

Results

Reading Sequence Plots

Sequence plots display each participant's behaviour at each time point. Time (trial) is plotted on the horizontal axis. Each participant's data is displayed on a single horizontal line, arranged along the vertical axis. Sequences assigned to the same cluster are presented in the same panel. The width of sequences varies depending on the number of other sequences in the cluster, but this is not an important feature of the graph.

As explained above, there is value in looking at three different sequence plots. The first depicts the primary sequences; that is, patterns that do not have high entropy and do not contain any of the unusual sequences described earlier. These represent the most readily interpretable sequences. The second depicts both the primary sequences and high entropy sequences, because although high variance patterns may contain more variable responding, that responding may still be systematic and therefore interpretable. The final sequence plot contains only those patterns which involve unusual sequences (unredeemed and hanging tickets). The reason for looking at these plots is that they may capture individuals who switch strategies, or who make relatively small errors in responding in an otherwise interpretable sequence.

Reading Sunburst Charts

To further aid in evaluating which strategy is dominant in each condition, sunburst charts were generated for every condition. Figure 8 shows the sunburst chart for condition 1. Sunburst charts can be understood like hierarchical pie charts. The centre ring displays the proportion of responses for the primary sequences (i.e., how many were Strategy A, how many were Strategy D, etc.) The second ring displays responses for the primary and high variance sequences. The third ring (e.g., see Figure 13) displays all responses, including unusual sequences. In this way, patterns depicted close to the centre are more readily interpretable, and those on the fringes require some additional degree of inference.

Condition 1

It was hypothesized that Strategy A would be the dominant strategy in condition 1. Figure 6 presents the primary sequences for condition 1. Of note, there are no unusual sequences for condition 1 because both unusual sequences involve tickets, and there is no way of obtaining tickets on condition 1. The majority of participants (n = 21) responded in a manner consistent with Strategy A—consistently, and nearly exclusively, pressing the “Get 5 Points” button. A limited number of participants (n = 7) responded in a manner consistent with Strategy D. A chi-square goodness of fit test on this data, assuming that the two panels labelled “Strategy A” can indeed be considered to reflect the same strategy, is statistically significant, $X^2 = 7$, $p = .008$, indicating that Strategy A is the dominant strategy for the primary patterns in condition 1.

Figure 6

Condition 1 Primary Sequences

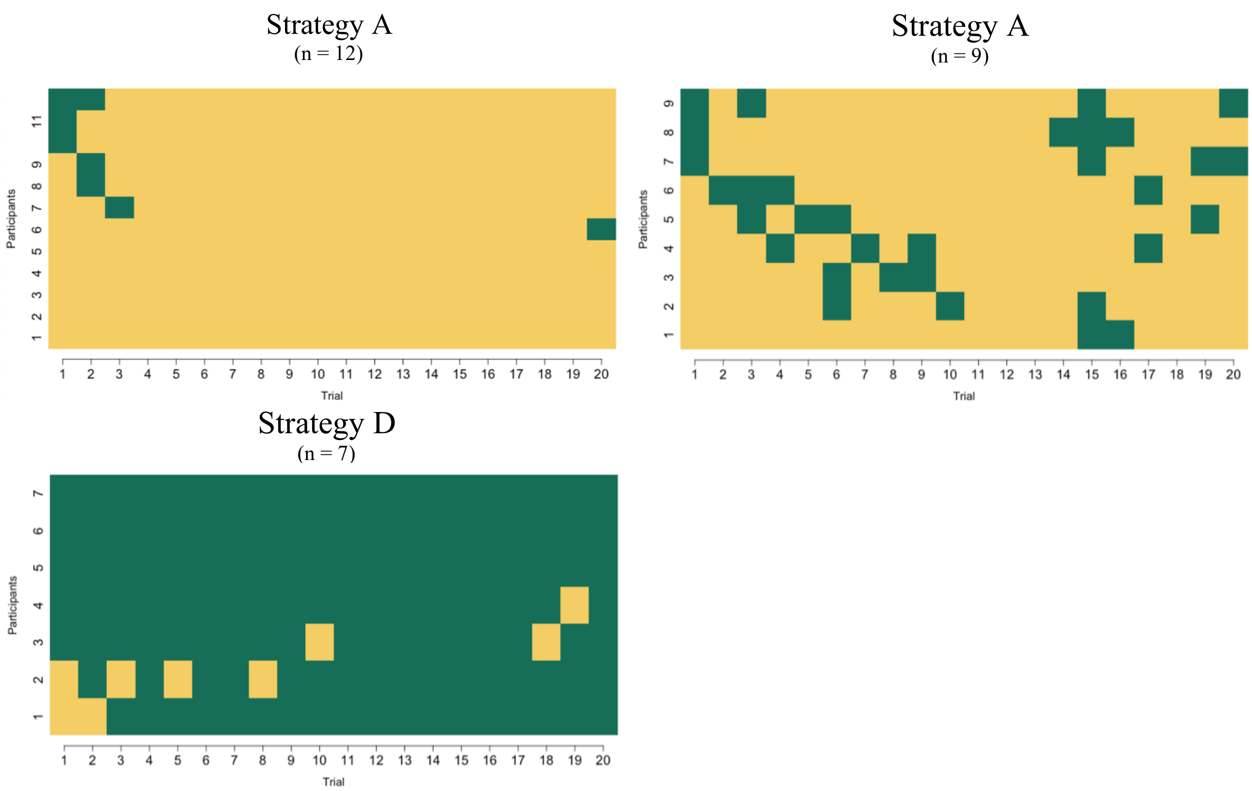


Figure 7 presents the primary and high variance sequences for condition 1. Substantially more participants (n = 30) responded in a manner consistent with Strategy A than with Strategy D (n = 9). A meaningful number of participants (n = 19) were grouped into a cluster that involved switching between the “Get 5 Points” and “Play Roulette #1” buttons. Some switch a limited number of times, while others switch very frequently. The reason for this switching behaviour is unknown, and likely differs depending on the frequency. Individuals who switch infrequently may be attempting to find the optimal solution, but have uncertainty about what that solution is. Participants who alternate between buttons frequently may not be engaging with the task fully, as frequent switching provides no benefit other than novelty and the guarantee of at worst only being "half wrong" if one button is optimal.

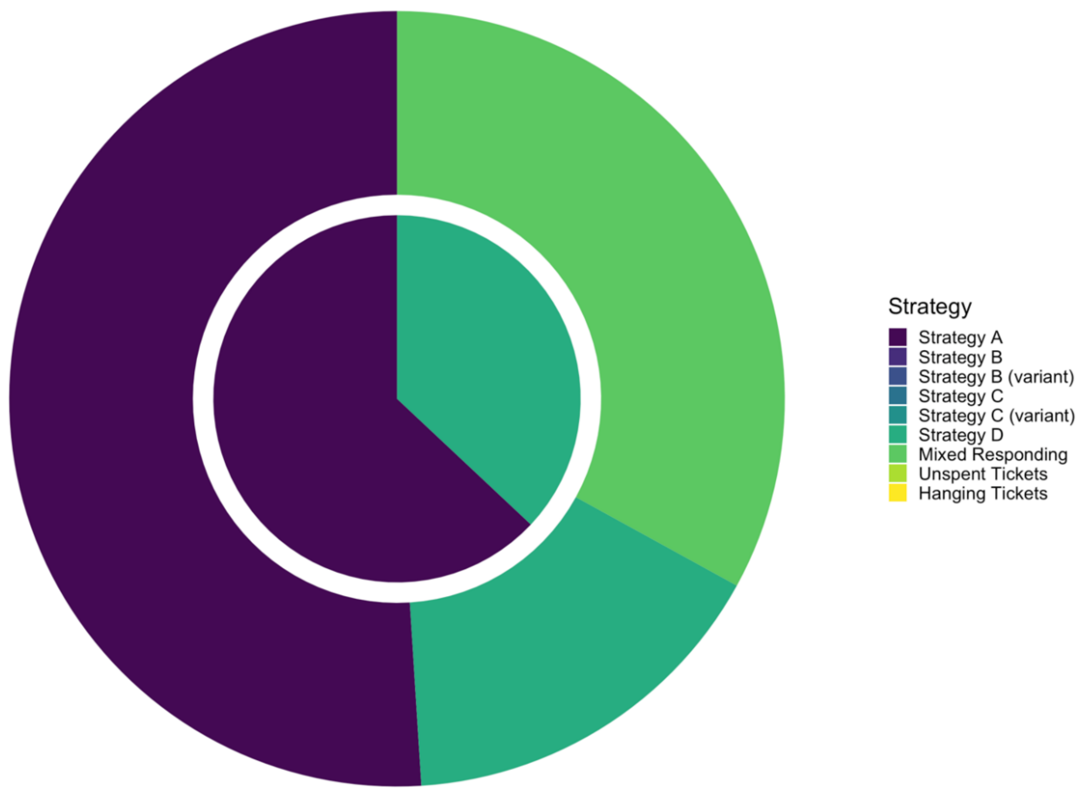
Figure 7

Condition 1 Primary and High Variance Sequences

The chi-square goodness of fit test on the data with both primary and high variance sequences included (the outer most ring of Figure 8) is statistically significant $X^2 = 11$, $p = .003$. This significance is driven by the fact that the majority of responses fall under the "Strategy A" cluster or "Mixed Strategies" cluster, rather than being evenly spread out across all three clusters. This is reflected in Figure 8, where "Strategy A" occupies the largest area of the outer most ring, "Mixed Responding" occupies a smaller but still substantial area, and "Strategy D" occupies a relatively small area. Therefore, with high variance data included Strategy A is the dominant strategy for condition 1 when considering both primary and high variance responses, but a meaningful number of responses also reflect some confusion or disengagement from the task. These results suggest that when presented with choices that are not associated, most people bracket narrowly.

Figure 8

Condition 1 Sunburst Chart



Condition 2

It was hypothesized that Strategy B would be the dominant strategy in Condition 2. Figure 9 presents the primary sequences for condition 2. This graph shows that the majority of participants (n = 22) displayed a pattern of responding that is consistent with Strategy B. Many participants (n = 12) also responded in a manner consistent with Strategy A, and a limited number (n = 3) displayed a pattern reflecting Strategy D. A chi-square goodness of fit test indicated that the proportion of responses falling into different clusters was statistically significant, $X^2 = 27$, $p < .001$, indicating that Strategy B is the dominant strategy among the primary responses in Condition 2.

Figure 9

Condition 2 Primary Sequences

Figure 9 also shows that two participants displayed unexpected patterns that were similar enough to one another, and different enough from the other strategies, to warrant assignment to a unique cluster. Visual inspection of these patterns suggests that these participants followed a strategy that is a variant of Strategy B—they acquired tickets and then redeemed them, and concluded the experiment by pressing the “Get 5 Points” button repeatedly.

Figure 10 presents the primary and high variance sequences for condition 2. The majority of participants (n = 24) followed a strategy that is consistent with Strategy B. A further 7 participants followed a strategy consistent with the variant on Strategy B just described. 10 participants followed a strategy consistent with Strategy D—almost exclusively pressing the "Play Roulette #1" button. A chi-square goodness of fit test was statistically significant, $X^2 = 13$, $p = .006$, indicating that Strategy B is the dominant strategy for condition 2 when considering both primary and high variance responses. In conclusion, when presented with choices that are probabilistically associated, most people bracket broadly.

Figure 10

Condition 2 Primary and High Variance Sequences

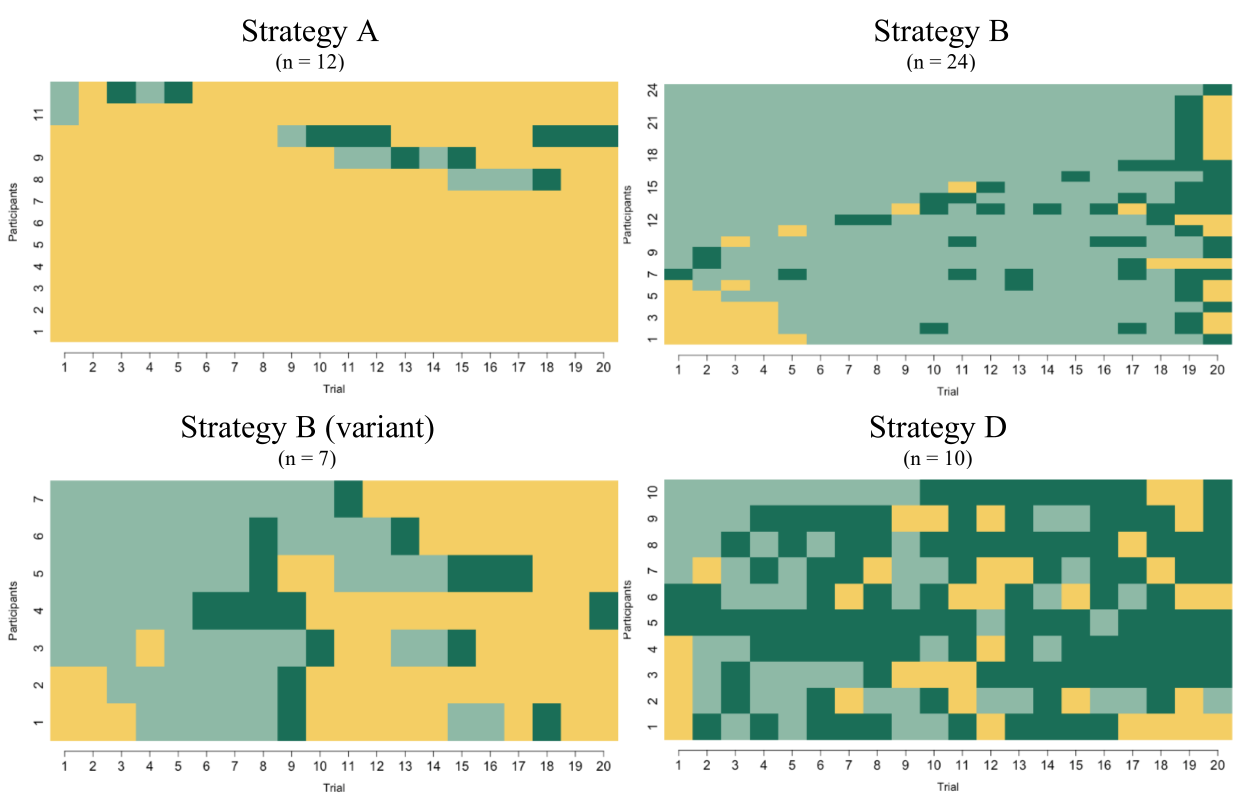


Figure 11 displays sequences (n = 2) from Condition 2 that include unredeemed tickets. Both participants appear to follow a variant of Strategy B—one follows a typical Strategy B pattern of accruing and then redeeming tickets for the first 8 trials until switching their behaviour and concluding the remainder of the experiment by pressing the “Get 5 Points” button repeatedly. The other participant generally follows Strategy B, but with some instances of pressing the “Play Roulette 1” button without previously acquiring tickets.

Figure 11

Condition 2 Unusual Sequences (Unredeemed Tickets)

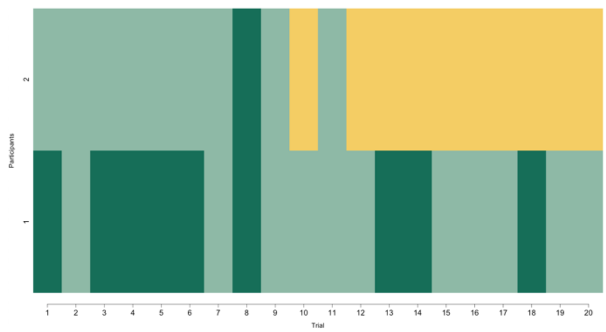


Figure 12 displays sequences from condition 2 that include hanging tickets. 4 participants follow a pattern of responding that is close to Strategy B—they accrue tickets and redeem all their tickets at the end of the task by playing roulette #1. An additional 3 participants (“Strategy B variant”) also accrue and redeem tickets, but these participants have longer runs of pressing the “Get 5 Points” button, and/or shorter runs of accruing tickets before redeeming them. These participants may be bracketing broadly, but have ambivalence about whether Strategy B or simply pressing the “Get 5 Points” button is optimal. The remaining participants display patterns of responding that do not convincingly indicate the use of any of the discussed strategies, and may reflect disengaged or thoughtless responding.

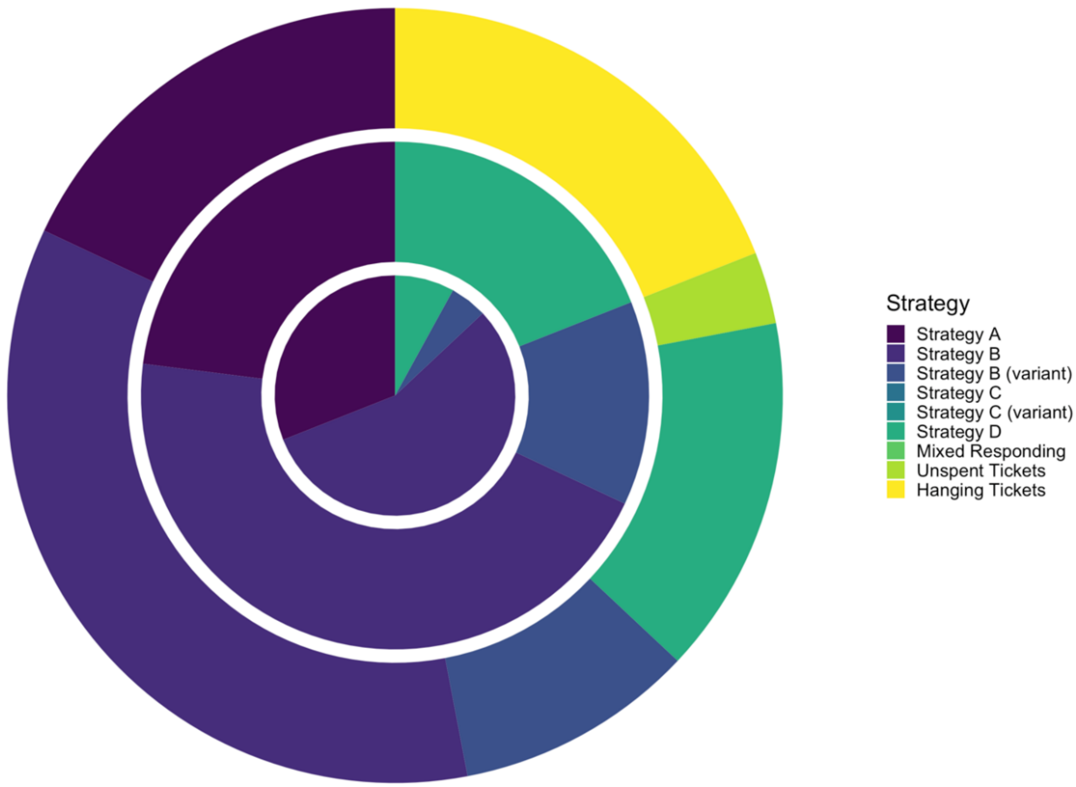
Figure 12

Condition 2 Unusual Sequences (Hanging Tickets)

See Figure 13 for the sunburst chart for condition 2. Here the just described proportion of responses can be visualized. In the innermost ring, Strategy B occupies the largest area. Strategy A occupies over 25% of the area—a prominent but secondary strategy. Strategy D and the variant on Strategy B occur much less frequently. As we move to the second ring, which includes both primary and high variance sequences, these proportions remain relatively stable. Together, Strategy B and its variant occupy a similar area on the chart, as does Strategy A. Strategy D increases in frequency, but remains a much less frequently chosen strategy. Moving finally to the outermost ring, which includes all responses including unusual responses, we can see that unusual responses occupy under 25% of the chart. Strategy B and its variant occupy the most substantial area on the chart by far, and Strategies A and D occur with similar frequency.

Figure 13

Condition 2 Sunburst Chart



Condition 3

It was hypothesized that Strategy C would be the dominant strategy in condition 3. Figure 14 presents the primary sequences for condition 3. 7 participants demonstrated a pattern of responding consistent with Strategy C. 6 participants demonstrated a pattern of responding consistent with Strategy A. A further 4 participants displayed a pattern of responding that can be considered a variant on Strategy C—participants did buy tickets and subsequently redeemed them, but they started by first accruing points using the “Get 5 Points” button. Given that participants start with no points, and tickets cost 2 points, it is possible that despite being informed that it was acceptable to have negative points these participants spent their early trials building up a base of points to subsequently spend on tickets. The final cluster (n = 3) involves individuals with responses split predominantly between pressing the “Play Roulette #1” and “Get 5 Points” button. Two of these participants spend the vast majority of their trials playing roulette #1 and can therefore be considered to be following Strategy D. The final pattern involves switching regularly between buttons that serve very different purposes, and thus likely reflects uninformed or thoughtless responding.

A chi-square goodness of fit test on the primary sequences for condition 3 is non-significant, $X^2 = 2$, p = .6, indicating that there is no dominant strategy among the condition 3 primary sequences. Assuming that the sequences labelled “Strategy C” and “Strategy C (variant)” reflect the same core strategy, the chi-square test is statistically significant, $X^2 = 6.3$, $p = .04$, indicating that Strategy C and variants on that strategy are the dominant strategy among the primary sequences for condition 3.

Figure 14

Condition 3 Primary Sequences

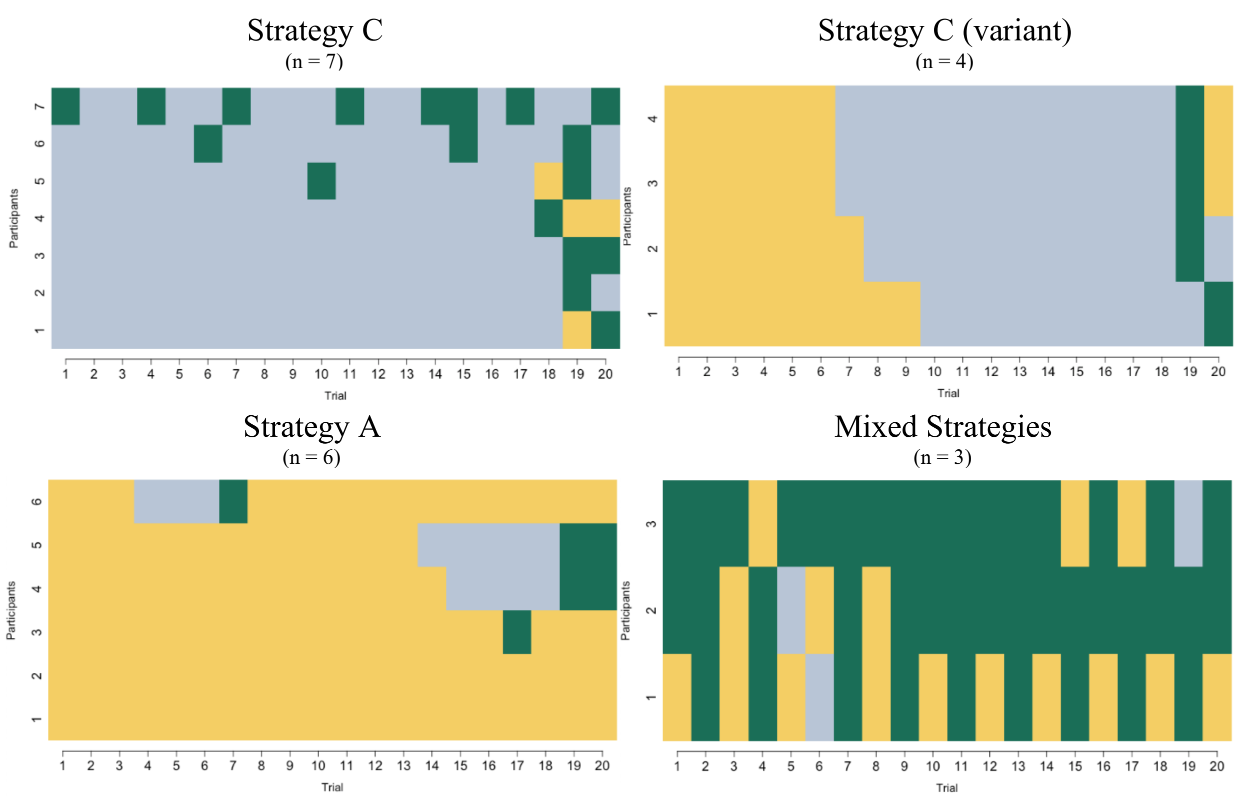


Figure 15 presents the primary and high variance sequences for condition 3. Including high variance data has added a substantial number of patterns to the "Strategy C (variant)" cluster. A chi-square test of goodness of fit is statistically significant, $X^2 = 19$, $p < .001$, indicating that this variant on Strategy C is the dominant strategy for condition 3 when considering both primary and high variance responses. In conclusion, when presented with choices that are deterministically related, most people bracket broadly.

Figure 15

Condition 3 Primary and High Variance Sequences

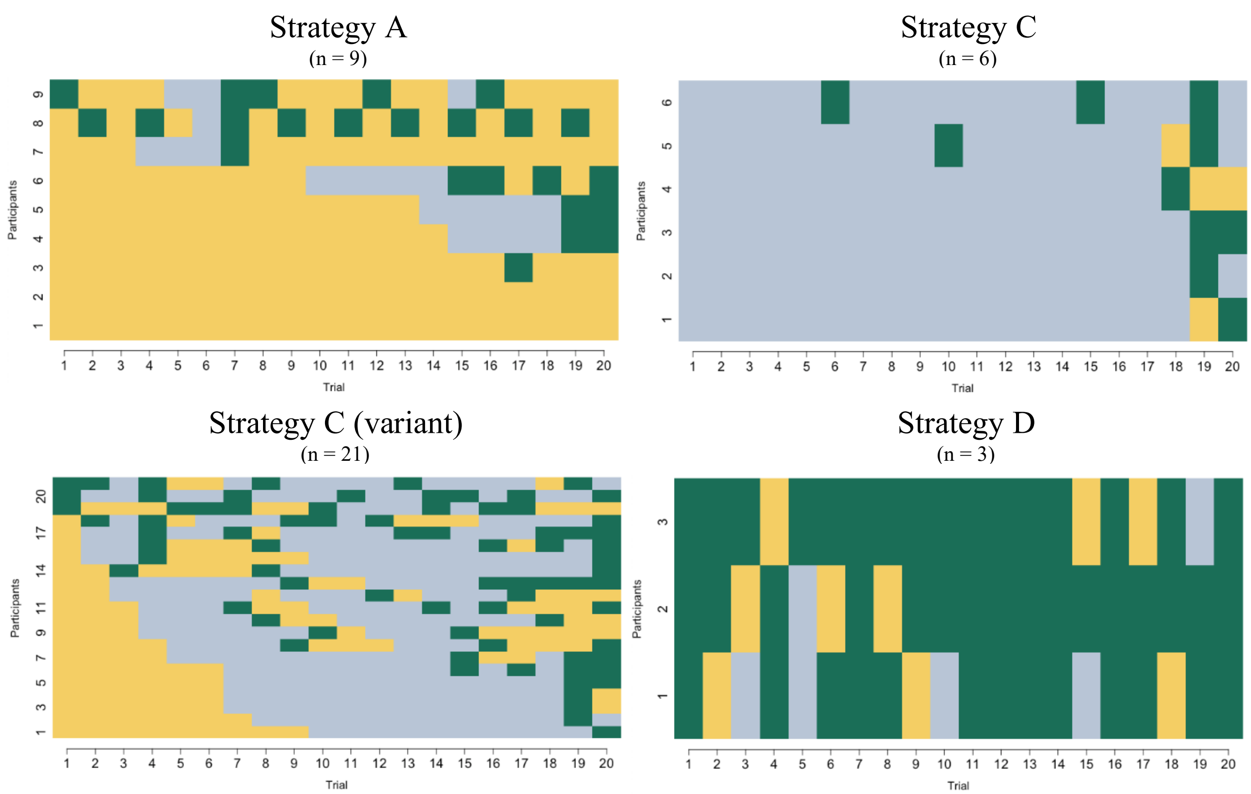


Figure 16 displays sequences from condition 3 with unredeemed tickets. A large number of participants (n = 21) perform behaviours consistent with the Strategy C variant. Some of these participants do redeem tickets at some point during their trials, and others never redeem tickets. The reason why several participants failed to ever redeem tickets is unknown. The similarity of these patterns to established patterns seen earlier suggest that their responding is not thoughtless. It is possible that these participants did not realize that they were on the final trial, and had intended to redeem their tickets then, but ran out of trials to do so. However, participants are clearly instructed as to the number of trials they have, the task shows they which trial they are on in real time, and they had 20 practice trials to gain experience with this feedback. So, these patterns remain peculiar. The remaining patterns shown in Figure 26 do not appear very coherent, and likely reflect disengaged or thoughtless responding.

Figure 16

Condition 3 Unusual Sequences (Unredeemed Tickets)

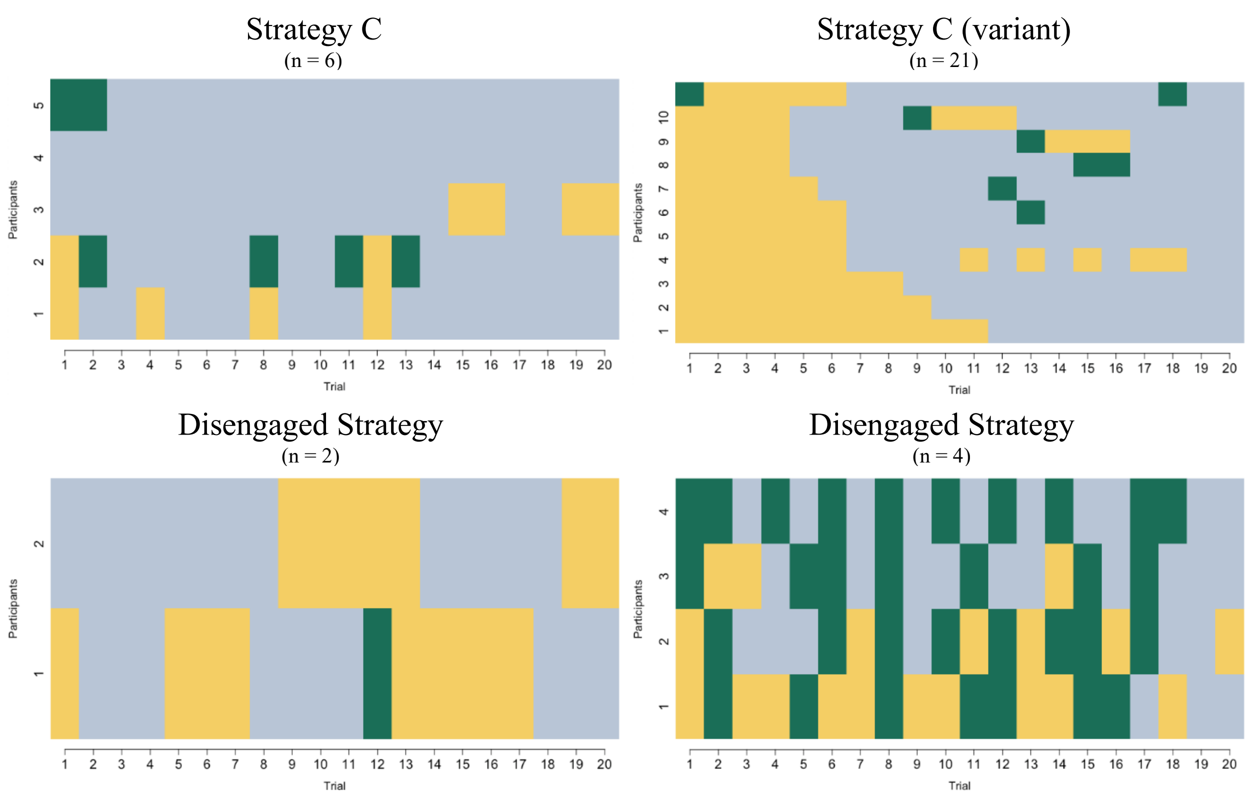
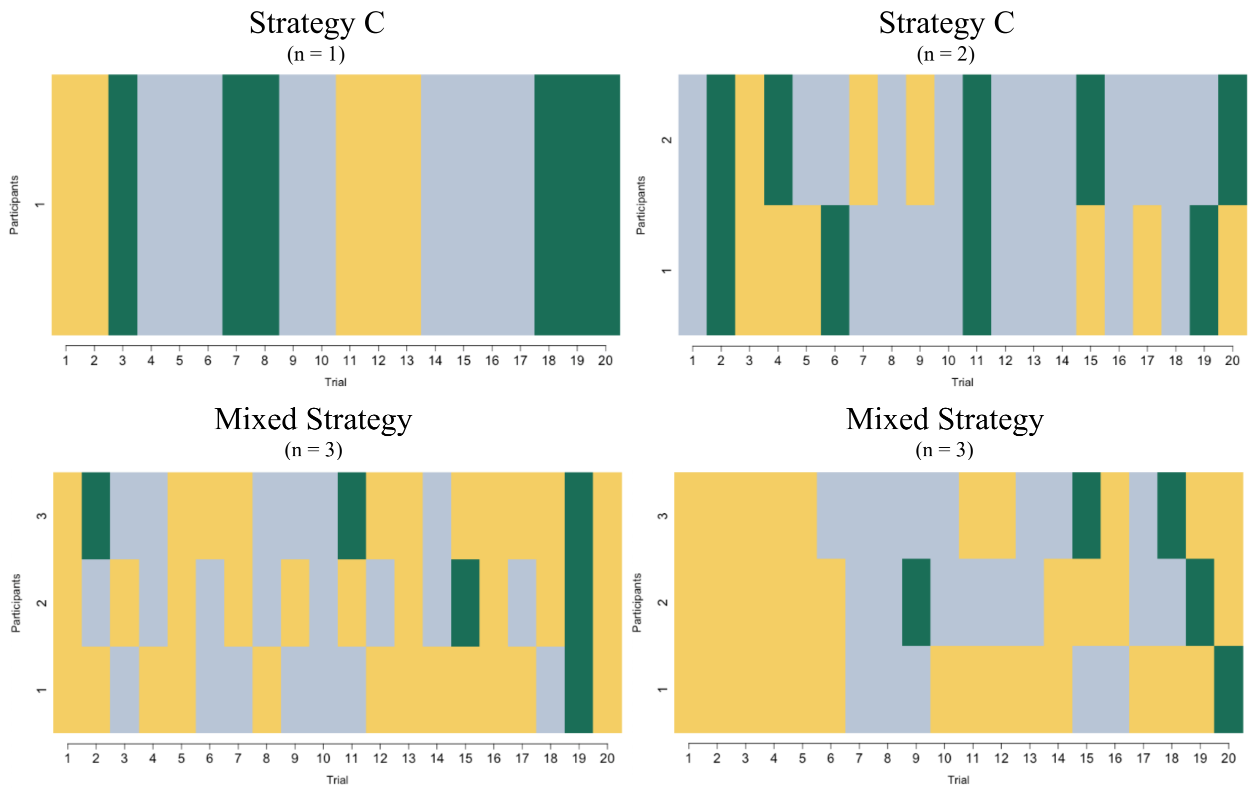


Figure 17 displays sequences from condition 3 with hanging tickets. 3 participants demonstrate patterns consistent with Strategy C, except for brief periods of pressing the “Get 5 Points” button. 6 other participants provide sequences that likely reflect uninformed responding.

Figure 17

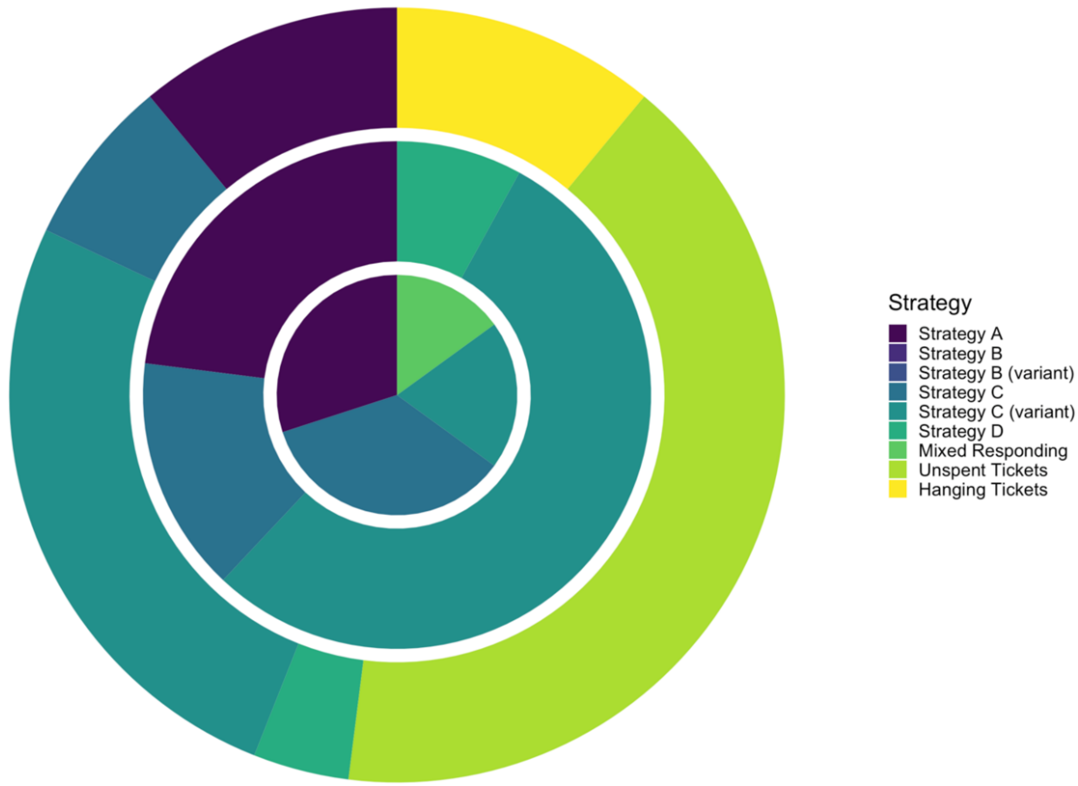
Condition 3 Unusual Sequences (Hanging Tickets)



See Figure 18 for the sunburst chart for condition 3. The innermost ring of this chart visually displays the primary responses for condition 3. Here responses are relatively evenly split between Strategies, likely reflecting the low sample size during this stage in the analysis. Once high variance responses are included (the second ring), we can see that Strategy C and its variant represent well over half of the responses, with Strategy A occurring at same frequency of 25% as seen in condition 2. Moving to the outer most ring, which includes all responses, we can see that unusual sequences (most notably unspent tickets) represent over half of responses.

Figure 18

Condition 3 Sunburst Chart



Condition 4

It was hypothesized that Strategy C would be the dominant strategy in condition 4. Figure 19 displays the primary sequences for condition 4. Here, responses are spread almost evenly between Strategy A (n = 6), Strategy B (n = 7), and Strategy C (n= 7). Two participants responded in a manner consistent with Strategy D and four participants displayed mixed responding that could reflect some ambivalence about whether Strategy B or D is optimal. A chi-square goodness of fit test is non-significant, $X^2 = 3.6$, $p = .5$, indicating that there was no dominant strategy among the primary responses for condition 4.

Figure 19

Condition 4 Primary Sequences

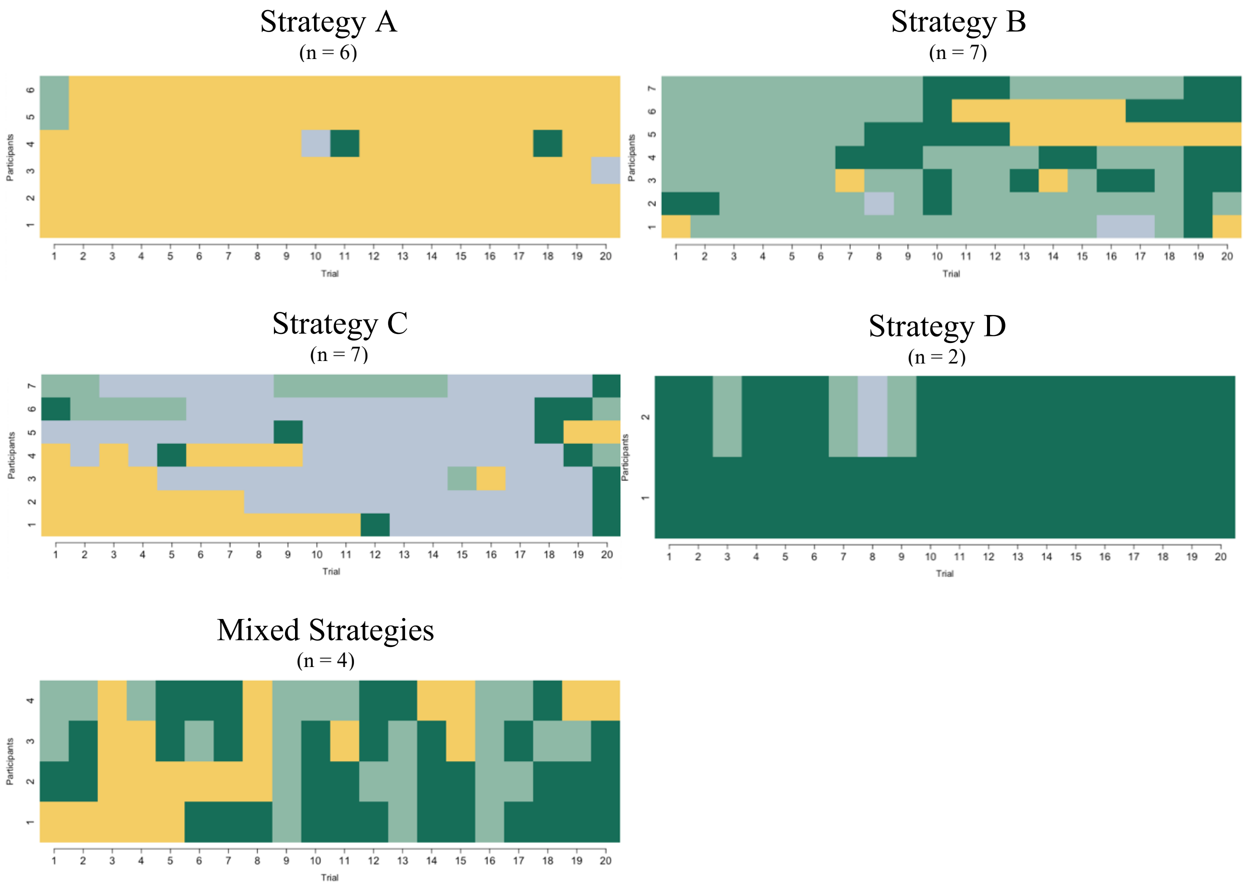


Figure 20 displays the primary and high variance sequences for condition 4. Here, the majority of participants displayed responding consistent with either Strategy B (n = 14) or the Strategy C variant previously identified (n = 13). A modest number of participants displayed strategies consistent with Strategy A (n = 6) or with mixed strategies likely responding either ambivalent or uninformed responding (n = 4). An additional two participants responded in a manner consistent with Strategy D. A chi-square goodness of fit test on this data is statistically significant, $X^2 = 13$, $p = .01$, indicating that Strategy B and the Strategy C variant are the dominant strategies for condition 4 when primary and high variance patterns are considered. In conclusion, when presented with choices that are related, most participants bracket broadly, though the degree of association does not appear to affect strategy preference.

Figure 20

Condition 4 Primary and High Variance Sequences

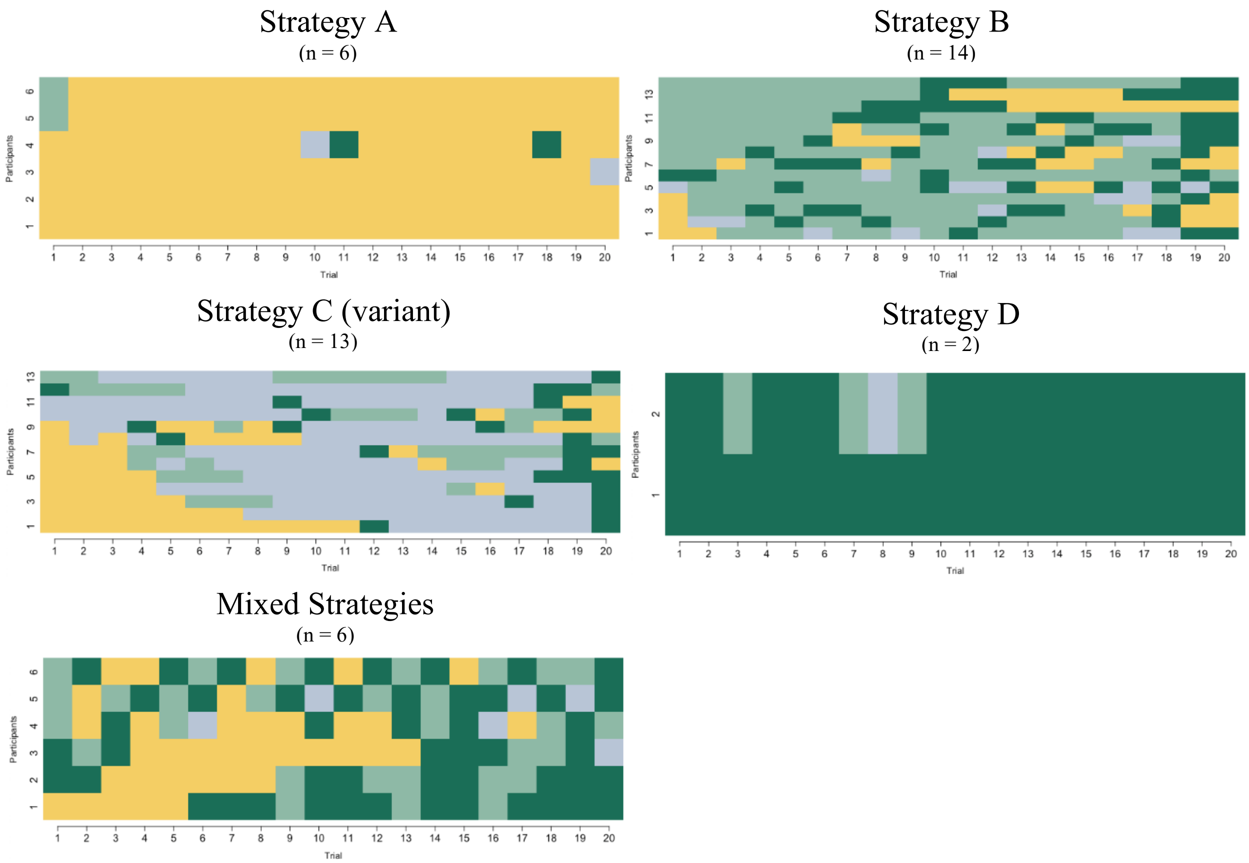


Figure 21 displays sequences from condition 4 with unredeemed tickets. The majority of these participants show various mixed strategies. Some may potentially reflect strategy switching, but most likely reflect uninformed responding. Two participants only pressed the “Buy Ticket” button throughout the experiment, likely indicating disengaged responding.

Figure 21

Condition 4 Unusual Sequences (Unredeemed Tickets)

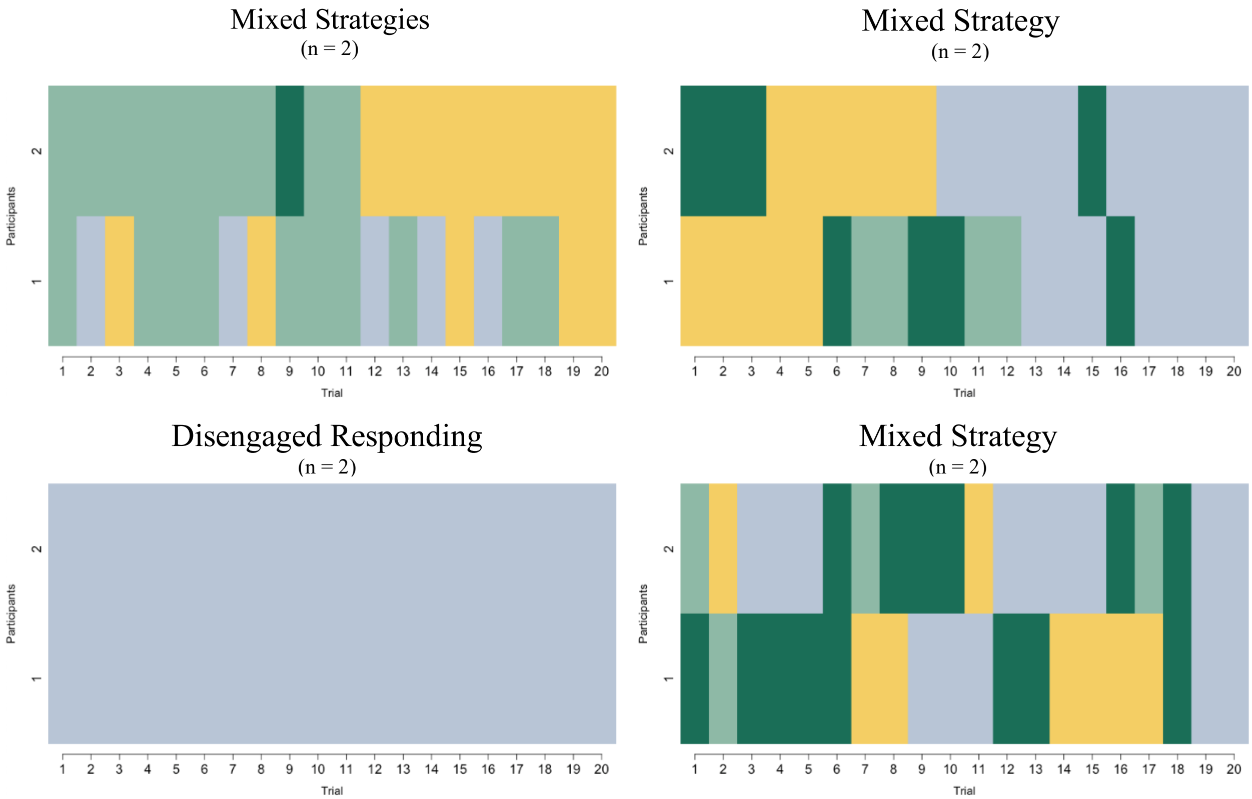


Figure 22 displays sequences from condition 4 with hanging tickets. Several participants across two clusters (n = 2 and n = 3 respectively) appear to switch strategies from either Strategy C or B to Strategy A during task administration. A further five participants demonstrate mixed strategies that likely reflect uninformed responding. Finally, two participants demonstrate a pattern that resembles strategy C, but with brief periods of pressing the "Get 5 Points" button.

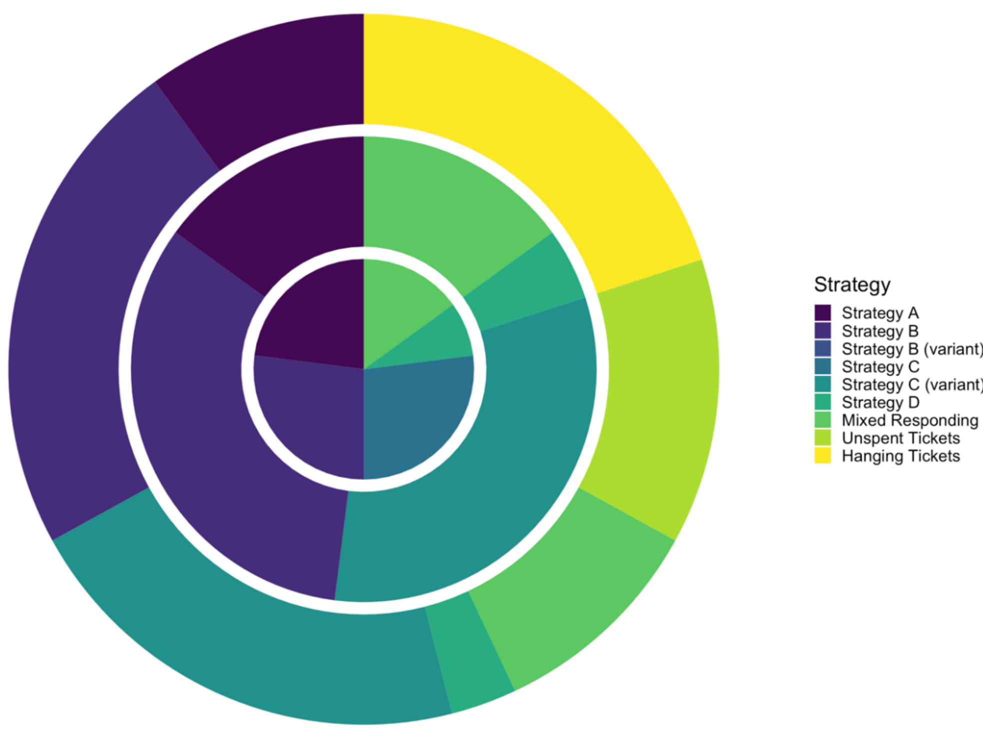
See Figure 23 for the sunburst chart for condition 4. As this chart demonstrates, when only primary sequences are considered (the innermost ring), each strategy is followed with approximately equal frequency. When both primary and high variance sequences are considered (the second ring), Strategy B and Strategy C (and its variant) are the predominate responses and

Figure 22

Condition 4 Unusual Sequences (Hanging Tickets)

Figure 23

Condition 4 Sunburst Chart



occur with roughly equal frequency. When all responses are considered, including unusual responses (the outermost ring) represent a meaningful proportion of responses (over 25%).

Summary

Table 3 summarizes the results of the chi-square goodness of fit tests for all conditions, indicating the dominant strategies in each condition.

As noted in Table 2, the hypothesis that people would autonomously broad bracket when presented with choices that are associated corresponds to a strategy preference ranking such that Strategy C > Strategy B > Strategy A > Strategy D. Consideration of Table 3 suggests that the results support a similar preference ranking: Strategy C (variant) = Strategy B > Strategy A > Strategy D. In other words, participants did autonomously bracket broadly when choices were associated, but the degree of association did not appear to matter in the present study. Additionally, most participants who followed Strategy C did so in a manner different from the prototypical Strategy C pattern—they spent time in the early trials accruing points before subsequently spending them on tickets, potentially because they found the experience of negative points aversive or did not fully understand that was permissible.

Table 3

Dominant Response Patterns Across Conditions and Levels of Interpretation

Level of Interpretation	Condition 1	Condition 2	Condition 3	Condition 4
Primary Sequences	Strategy A	Strategy B	None	None
Primary and High Variance Sequences	Strategy A	Strategy B	Strategy C (variant)	Strategy B & Strategy C (variant)

Discussion

The question that this study aimed to answer was “what prompts people to bracket choices broadly?” This study provided support for one answer—association between choices can prompt broad bracketing. In the process of investigating this hypothesis, additional support was found for the longstanding theory that people tend to bracket choices narrowly by default (Camerer, 2000; Ellis & Freeman, 2020; Hilgers & Wibral, 2014; Kahneman & Lovallo, 1993; Tversky & Kahneman, 1981; Wulf et al., 2015). The results further suggest that, for most people, expected value does not prompt broad choice bracketing.

Some peripheral findings qualify the claim that association between choices can prompt broad bracketing. In condition 4, strategies B and C (variant) were followed with roughly equal frequency—contrary to the hypothesis that strategy C would be dominant. This suggests that the “strong test” of the association hypothesis was not supported. Future research should investigate potential explanations for this. It may be that preferences between Strategy B and C can be explained by individual differences on relevant variables such as loss aversion (i.e., individuals with relatively less loss aversion might find Strategy C preferable because it provides a certain increase in the likelihood of a future gain, at the cost of an immediate reduction in points) or risk aversion (i.e., individuals with relatively less risk aversion might find Strategy B preferable because it does not directly affect one’s current points, but does so at the cost of reduced certainty about increasing the likelihood of a future gain). Alternatively, it may be that Strategy C was not preferred to Strategy B for methodological reasons—in condition 4 the variant on Strategy C was more commonly observed than the more prototypical Strategy C sequence. Potential methodological changes (discussed below) could address the selection of the Strategy C variant over the more prototypical Strategy C. In such a redesign, it is possible that Strategy C would be dominant in condition 4.

In addition to providing an answer to the specific question "what prompts people to bracket choices broadly?", the present results integrate conflicting conceptualizations of choice bracketing. Early conceptualizations of choice bracketing (especially those built around risky choice) painted narrow bracketing as a kind of bias, suggesting that it is a sub-optimal decision making tendency that people struggle to overcome (Kahneman & Lovallo, 1993; Tversky & Kahneman, 1981). More recent texts, however, have suggested that narrow and broad bracketing can both have advantages/drawbacks (e.g., Ariely & Wertenbroch, 2002; Hsiaw, 2018; Koch & Nafziger, 2016; 2020; Soman & Cheema, 2004). Furthermore, research on executive functions such as planning (Banich, 2009; Shallice, 1982) and specific decision making phenomena such as probability matching (Gal & Baron, 1996; Peterson & Ulehla, 1965; Tversky & Edwards, 1966; West & Stanovich, 2003) suggested that there are conditions under which people readily engage in systematic decision making across choices.

The results of the present study suggest that both conceptualizations are accurate under different circumstances. Under circumstances similar to those present in early choice bracketing research, that is, when choices are not associated and the only connection between them is that it is computationally optimal to combine their properties (i.e., calculate expected value), people tend to sub-optimally bracket narrowly. This is reflected in the results of condition 1—participants tended to sub-optimally choose a sure immediate gain over an unlikely chance at winning a large number of points. However, when choices are associated (as is often the case in daily life), many individuals readily engage in systematic decision making across choices. This is reflected in the results of conditions 2 and 3—participants tended to forgo immediate gains (and even in some cases take on costs) to pursue an increased chance of a larger profit later.

These findings are consistent with the earlier-described view of choice bracketing as a key decision making process that helps people structure decision problems. By default, it deploys narrow choice bracketing, thereby preserving cognitive resources and increasing attention to immediate concerns. When the need for more expansive thinking is signaled, such as by associations between choices, it uses broad choice bracketing to assist in the navigation of more complex environments. While this system is important, it is not perfect and often leads to departures from normative decision making. The results of this study showed that under narrow choice bracketing people made less profitable decisions (condition 1), and that they failed to identify situations where broad bracketing would be advantageous (broadly bracketing "Play Roulette 1" button choices across time to arrive at Strategy D, which has the highest expected value).

Modern dual process theories have investigated a question with a similar form to the one under present consideration—what features of a stimulus cue people to engage in deliberative thought (i.e., system 2 processing)? One key finding arising from this area is that conflict between an intuitively generated answer and the features of the decision prompts system 2 processing (De Neys & Glumicic, 2008; Pennycook et al., 2015). For example, imagine I am about to provide you with a brief description of someone randomly selected from a population of 100 people, of which 95% of them prefer wine over beer. Your job is to determine whether this person is more likely to prefer wine or beer. The description goes like this: they are young, male, drive a truck, and love football. Are they more likely to prefer wine or beer? The conflict between the intuitive answer arising from the provided description, and the base rate provided earlier, cues us to engage system 2 to either rationalize our intuitive response or override that response and provide an alternative.

This description of how people generally make the switch from intuitive to analytical reasoning is consistent with the previously described theory of how people make the switch from narrow to broad choice bracketing. By default, we bracket narrowly. But when the choice we are considering has features that reference other choices, there is a conflict between our initial narrowly bracketed response and the content of the stimulus, which prompts us to engage in the more cognitively laborious process of bracketing choices broadly. Another similarity is that even though conflict monitoring is an effective way for people to switch between system 1 and system 2 processing, it is imperfect—there are many situations where people fail to identify the need to switch to system 2 processing or are unable to override system 1 responses.

Limitations. The primary limitation of this study is the complexity of the task. Although many participants provided readily interpretable responses, other participants provided mixed responding, or exhibited behaviour that likely reflects disengaged or uninformed responding. For example, when primary and high variance patterns were considered in condition 1, approximately 33% of participants appeared to follow mixed strategies (i.e., switching from one sequence to another a limited number of times during the task) or largely uninterpretable patterns of responding (i.e., very frequent switching). Furthermore, many participants in this study provided patterns of response that involved unusual sequences (hanging or unredeemed tickets). The most prominent example of this is in condition 3, where over 50% of the entire sample of responses included these unusual sequences. While the otherwise interpretable nature of many of these responses cannot be ignored (many of the condition 3 sequences just described have a striking similarity to the Strategy C variant pattern), the frequency with which unusual behaviour was observed suggests that the task exceeded some participants' cognitive or motivational capacity.

This issue could be addressed in two ways. The first is by reducing the complexity of the task. For example, one aspect of the task that made it unnecessarily complex is the fact that participants cannot easily track how many tickets they currently possess. Some instances of unredeemed or hanging tickets could be explained by uncertainty on the part of participants as to whether they even had tickets to redeem. Future iterations of the task could provide participants with a salient visual representation of tickets they have acquired, to make this aspect of the task easier to track. The second way that the complexity of the task could be addressed is by administering the task to a potentially more motivated sample. Both of the studies described in this manuscript sampled from undergraduate populations that were participating for course credit. As such, some may not have been as attentive to their in-task choices as they would be in their daily lives. Prescreening, or the use of professional participant pools, are intriguing possibilities for future work. A third way would be to increase accuracy motivation (e.g., Simmons, LeBoeuf, & Nelson) by instructing participants to exert increased effort or by rewarding superior performance.

Another important limitation to this study is the frequency with which variant responding was observed. The most prominent example is the observed variant on Strategy C, which was followed more often than Strategy C itself when both primary and high variance patterns were considered. While variant patterns were expected in the context of the present design, they require additional interpretation and potentially signal the opportunity for methodological revisions. With respect to Strategy C, it was suggested earlier that participants who decided to purchase tickets did not wish to do so when they had 0 points (their starting value) as that would mean spending a meaningful portion of their trials with negative points. Thus, they spent their early trials accumulating points through the “Get 5 Points” button, before following a more typical Strategy C pattern of acquiring and redeeming tickets. This potential explanation could be addressed by providing participants with a starting endowment of 100 points, which would allow them to accumulate tickets without ever having negative points.

Future Directions. Scholars should continue to investigate feature-based determinants of broad bracketing. If it is true that the choice bracketing system switches from narrow to broad bracketing when it identifies a need for more expansive thinking, other feature-based determinants such as order (are decisions in the middle of a chain of choices more likely to be bracketed broadly than those at the ends?) or probability (are decisions with low probability outcomes more or less likely to be bracketed together than those with higher probability outcomes?) are worth exploring.

Study 2: Broad Bracketing Mechanisms

Overview

The purpose of the present study is to investigate one possible mechanism by which choice bracketing affects decision making. Specifically, the purpose is to test the hypothesis that narrow choice bracketing reduces risk perception for gambles involving rare serious consequences, and that this is associated with increased risk taking. A repeated-choice decision making task was used, such that participants were offered the opportunity to play a desired number of gambles, which share a common outcome. The experimental task attempted to control for outcome bracketing by providing all participants with multiple forms of aggregate risk information, thus allowing for conclusions to be drawn about choice bracketing specifically. Controlling for outcome bracketing by providing participants with multiple forms of cumulative probability information rules out computational explanations for observed effects. This allows for increased confidence that any differences are the result of non-computational factors, such as risk perception.

Participants were induced to adopt a narrow or broad choice bracket using a presentation manipulation. In this task, participants decide how many risks they wish to take. In the narrow choice bracketing condition, the choice to take a risk is made by pressing a button. In this way, each choice corresponded to its own independent action. In the broad choice bracketing condition, the decision of how many risks to take was determined by a slider. In this way, each choice was grouped together with other choices by being part of the same action. Presentation manipulations have proved effective in previous research (e.g., Moher & Koehler, 2010; Keren & Wagenaar, 1987; Redelmeier & Tversky, 1992; Webb & Shu, 2017) though the precise nature of this manipulation is unique to the present study. Risk-taking was operationalized as the number of gambles participants played on the task. Risk perception was measured using two individual difference questionnaires. Although this design uses individual difference measures to infer state-level differences, this approach is not discordant with surrounding theory. For example, in their discussion of reinforcement sensitivity theory (discussed in more detail later), Corr and McNaughton (2012) write, "Critically, trait factors express their effects on behaviour through state systems and their effects can only be properly explained in the context of an explicit state theory." (p. 30). They additionally write, "Indeed, although superficially a paradox, it can be argued that behaviour analysis is the optimal means of assessing changes in the cognitive structures…that underlie approach-avoidance behaviours." (Corr & McNaughton, 2012, p. 31). In other words, there is precedence for understanding state, trait, and behavioural measures as interrelated facets of an underlying construct. Although state level differences in risk perception are not directly observed in the present study, it is not unreasonable to infer their presence through observations about how trait level indicators of these variables are related to behaviour.

The results of this study will contribute to our understanding of the mechanisms by which choice bracketing affects risky decision making. This is important because risky choice is an extremely important theoretical paradigm in the field of judgment and decision making, and research on choice bracketing has yet to fulsomely explore noncomputational explanations for choice bracketing effects on risk taking. It is also of significant importance for applied considerations, given the commonplace nature of uncertainty in real-world decision making tasks.

Methods

Participants

328 participants were recruited from York University's Undergraduate Research Participant Pool (URPP). This sample size exceeds typical requirements for the planned analyses (e.g., correlations, mean comparisons); however, the convenience of the sample permitted additional participants to be run through the procedure.

Participants were directed to a website that hosted the study materials. 11 participants disconnected from the task website during administration and did not connect again. Because disconnection from the task may represent a withdrawal of consent, these participants were removed from the data analysis. The final sample size was 317.

Participants were aged 18 to 47, with a mean age of M = 19.74. 75.7% of participants identified as female, 24% identified as male, and less than 1% identified as non-binary.

Materials

Task Layout. A digital repeated-choice decision making task was created for use in this study. The objective of the task is to make as many points as possible. This task presents participants with repeated choices in the form of the following gamble: *95% chance of earning 10 points, and a 5% chance of losing all points gained so far.* This gamble has a low probability of resulting in an adverse outcome on any given trial, but a high cumulative probability of resulting in an adverse outcome across multiple trials. Additionally, the magnitude of the adverse consequence is equal to the sum of all previous positive outcomes (i.e., participants lose all points gained so far). This means that participants cannot "offset" losses with gains (a feature common to a different class of gambles that tend to increase risk taking under broad bracketing, as in Benartzi & Thaler, 1995; Keren & Wagenaar, 1987; and Montgomery & Adelbratt, 1982). Thus, participants must balance acquiring a benefit (points) with managing their risk of the adverse event happening even once. In this way, this gamble is designed to have some relevance to real world decision problems discussed before, such as speeding, unprotected sex, smoking, and residence in disaster areas. Participants are tasked with deciding how many of these gambles they wish to take. Participants are randomly assigned to two experimental conditions—a narrow choice bracketing condition and a broad choice bracketing condition. In the narrow choice bracketing condition they decide how many gambles to take, one gamble at a time. They are provided with a button, and every time they press it, they either earn 10 points (95% chance of occurring) or lose all of their points (5% chance of occurring). In the broad bracketing condition, participants decide how many of these gambles they would like to play, all at once. They use a slider to select the desired number of times they wish to play this gamble, and then click a button to finalize their choice. After doing so, they find out whether they earned points (10 points multiplied by the number of gambles taken) or did not earn any. Participants completed 5 practice trials, and 20 main trials of this task. The maximum number of gambles participants were permitted to take on any given trial was 50 (otherwise, participants could theoretically place an infinite number). Points are not carried forward across trials.

In order to make the task more engaging for participants, a visual metaphor for this gamble was used. Gambles were represented by penguins and choosing to take a gamble was represented by placing a penguin on a sheet of ice. If participants lost the gamble, the ice “broke”, participants lost all the points earned on the present trial, and the trial advanced. Figure 24 shows the narrow bracketing version of this task, and Figure 25 shows the broad bracketing version of this task.

Figure 24

Penguin Task (Narrow Choice Bracketing Condition)

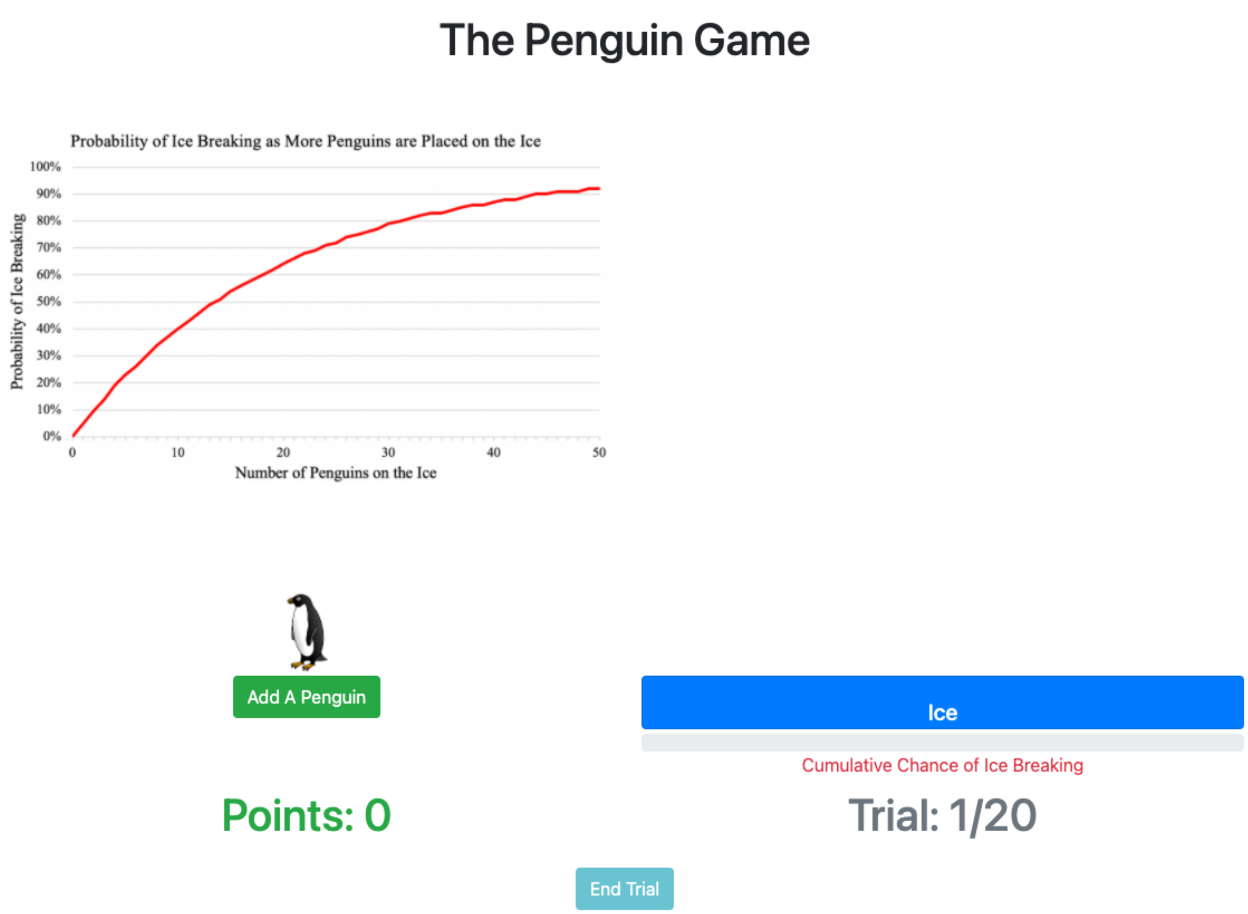
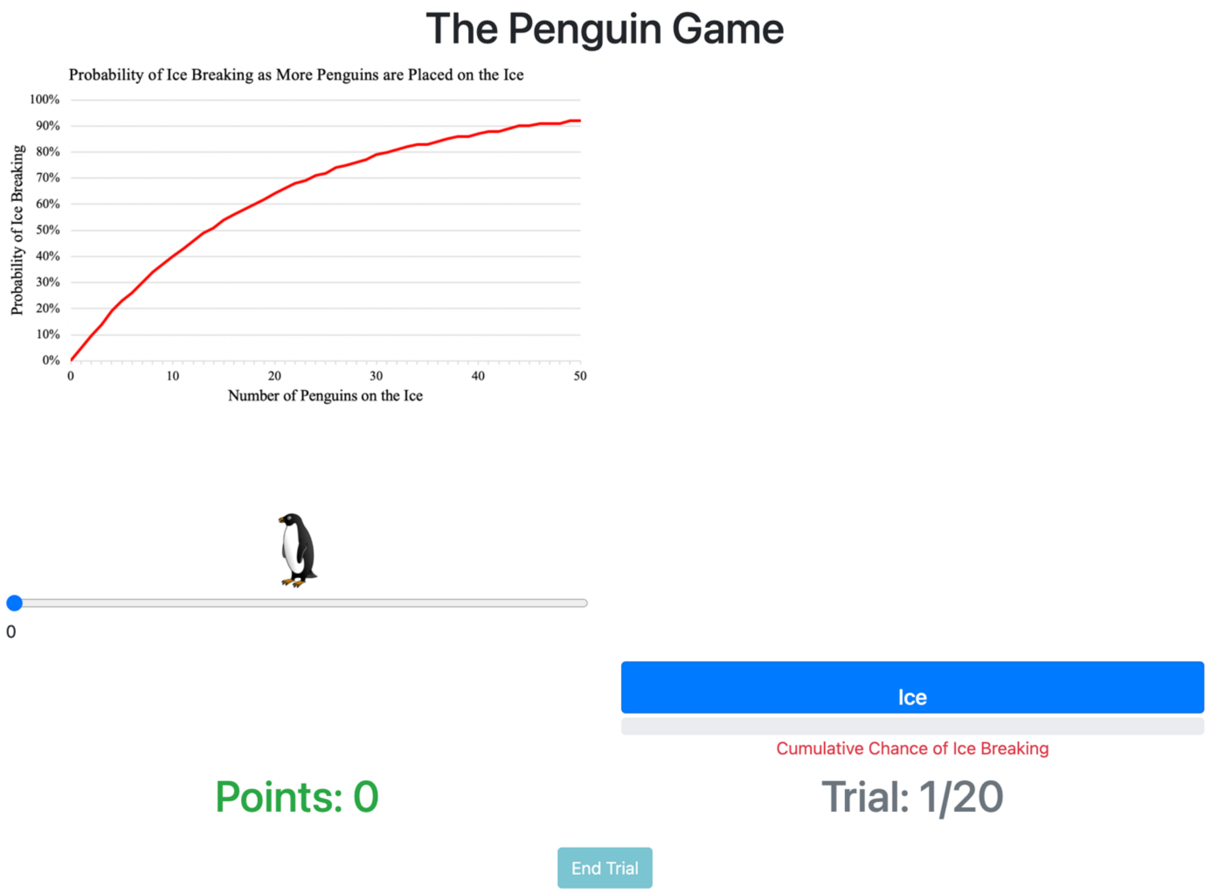


Figure 25

Penguin Task (Broad Choice Bracketing Condition



As these figures show, participants in both conditions were provided with identical pieces of information about risk probabilities. The first piece of information was a static graph, showing the cumulative probability of the ice breaking given any possible number of penguins placed on the ice. Although the probability of the ice breaking when any individual penguin was placed on the ice was always 5%, the likelihood of the ice breaking *at least once* increases as multiple risks are taken. The likelihood of this "at least one" probability can be calculated by the equation $1-P(x)^n$ where $P(x)$ is the probability of the ice not breaking on any given trial (95%) and n is the number of times this risk is taken (the number of penguins placed on the ice). This static graph helps participants visualize this cumulative probability distribution. The second piece of information provided to participants in both conditions is a real-time risk meter (located just below the ice sheet) that displays the cumulative probability of the ice breaking at least once given the number of penguins *currently* placed on the ice. Therefore, participants were provided with explicit information both about 1) the cumulative risk associated with potential subsequent behaviour, and 2) the cumulative risk associated their past behaviour.[1]

Teaching Participants a Complex Task. After being randomly assigned to their experimental conditions, participants read detailed instructions about how each task worked. Please see the Appendix, Figures A12-A37 for images of these instructions. After reading these instructions, participants were provided with 5 practice trials to give them an opportunity to try the task prior to the main 20 trials.

Individual Difference Measures. In addition to the above-described behavioural task, participants completed two self-report questionnaires. These questionnaires were included to investigate the possibility that risk perception is one of the mechanisms by which narrow vs broad choice bracketing affects decision making. It is hypothesized that when bracketing choices narrowly, individuals perceive only the risks associated with the choice immediately under consideration. If the risk posed by that choice is small, then individual differences in risk perception should influence decision making less than when individuals are bracketing narrowly.

The Domain-Specific Risk-Taking Scale. The first individual difference measure used was the Domain-Specific Risk-Taking scale (DOSPERT; Weber et al., 2002). The DOSPERT contains two subscales. The DOSPERT measures both attitudes towards risk taking (Risk-Behaviour; individual differences in the likelihood of engaging in risky activities) and attitudes towards perceived-risk (Risk-Perception; individual differences in perception of the riskiness of various activities). Participants are presented with a list of risky activities in five domains

(Financial, Ethical, Health/Safety, Recreational, Social) and are asked to rate how likely they are to engage in those activities, and how risky they believe them to be. Participants rate activities such as "Betting a day's income at the horse races", "Cheating on an exam", and "Going camping in the wild" using a 5-point likert-type scale. Despite heterogeneity within domains, the DOSPERT total score tends to demonstrate good internal consistency, with Cronbach's alpha values typically exceeding .8 (Shou & Olney, 2020; Weber et al., 2002). It has additionally demonstrated convergent validity with other risk attitudes scales (Frey, et al., 2017), as well as construct validity through its relationship with other conceptually related scales (Faraji-Rad et al., 2017; Koerner et al., 2017; Roalf et al., 2014; Schumpe et al., 2018; Weber et al., 2002)

Behavioural Inhibition/Behavioural Activation Scales. To compliment the DOSPERT, participants additionally completed Carver and White's (1994) BIS/BAS scales. These scales measure the behavioural activation and behavioural inhibition components of Gray's (1972) Reinforcement Sensitivity Theory (RST) of personality. Current descriptions of this theory (see Corr & McNaughton, 2012) outline three interrelated personality factors that affect how an organism responds to reinforcement. The Behavioural Activation System (BAS) is sensitive to rewards, non-punishment, and escape from punishment, and motivates goal-directed action. The Fight-Flight-Freeze system (FFFS) is sensitive to punishment and negative reinforcement, and motivates avoidance of aversive stimuli. The Behavioural Inhibition System (BIS) is sensitive to conflicts between the approach and avoidance systems, and motivates risk assessment (increasing attention to punishing stimuli, and increasing concomitant arousal) and amplifies existing inhibition of behaviour (avoidance).

If it is true that individuals have a diminished ability to perceive risk under narrow bracketing, it should also be true that individual differences in behavioural inhibition (the system that increases attention to potentially punishing stimuli and motivates risk assessment) should be less related to behavioural measures of risk taking under narrow bracketing compared to broad bracketing.

While theory and measurement around RST continue to evolve, Carver and White's (1994) BIS/BAS scales remain a valuable measure. They demonstrate satisfactory reliability, with Cronbach's alpha values ranging from .7-.87 for both the BIS and BAS subscales (Campbell-Sills et al., 2004; Wlodarska et al.,, 2019). Item Response Theory analyses have also found the BIS and BAS subscales to have good discriminatory ability, and an ability to reflect their hypothesized constructs at moderate levels of BIS and BAS (Gomez et al., 2005). The BIS/BAS scales have additionally demonstrated convergent validity with other similar trait scales (Jorm et al., 1998), and criterion validity in predicting affective responses to reward and punishment (Carver & White, 1994).

Procedure

After signing up to participate in the study through the URPP, participants were provided with a URL link that directed them to a website hosting the study materials. Participants were presented with an informed consent form. Participants who did not wish to participate received a debrief form. Participants who consented to participate in the study were then asked to enter their URPP ID (to aide in granting them credits), their age, and their gender identity. Participants were then randomly assigned to one of the two conditions described above.

Immediately after random assignment, participants read the instructions for their task and completed 5 practice trials of the task. Following this they completed the main 20 trials of the task. Subsequently, participants completed the Domain-Specific Risk-Taking scale and the

BIS/BAS scales. Participants were then directed to a debrief form. Finally, participants were informed that the study was over and that they could close their web browser.

Hypotheses

It is hypothesized that participants in the narrow choice bracketing condition will take more risks (place more penguins on the ice), on average across trials, than participants in the broad bracketing condition. It is further hypothesized that risk taking in the narrow choice bracketing condition will be less correlated with Risk-Perception and Behavioural Inhibition than in the broad choice bracketing condition. Finally, it is hypothesized that there will be no significant differences in the association between Risk-Behaviour and Behavioural Activation across experimental conditions.

Results

Risk Taking Across Conditions

Figures 26 and 27 display the distribution of risks taken (the number of penguins placed), collapsed across the main 20 trials, for both conditions. Responses of both 1 and 50 risks taken on a given trial are omitted, in order to evaluate more typical responding and avoid consideration of potential thoughtless responding (i.e., placing as few or as many penguins as possible). Both distributions are positively skewed, with participants in the narrow choice bracketing condition placing an average of $M = 10.49$ and those in the broad choice bracketing condition placing an average of $M = 12.38$. This difference in the mean number of risks taken across condition is statistically significant, $t(5577) = -8.1$, $p < .001$. If all responses on the main 20 trails (responses of 1 and 50 risks) are included, this significant difference remains, $t(5881) = -13$, $p < .001$.

Figure 26

Frequency of Risks Taken, Collapsed Across Trials—Broad Choice Bracketing Condition

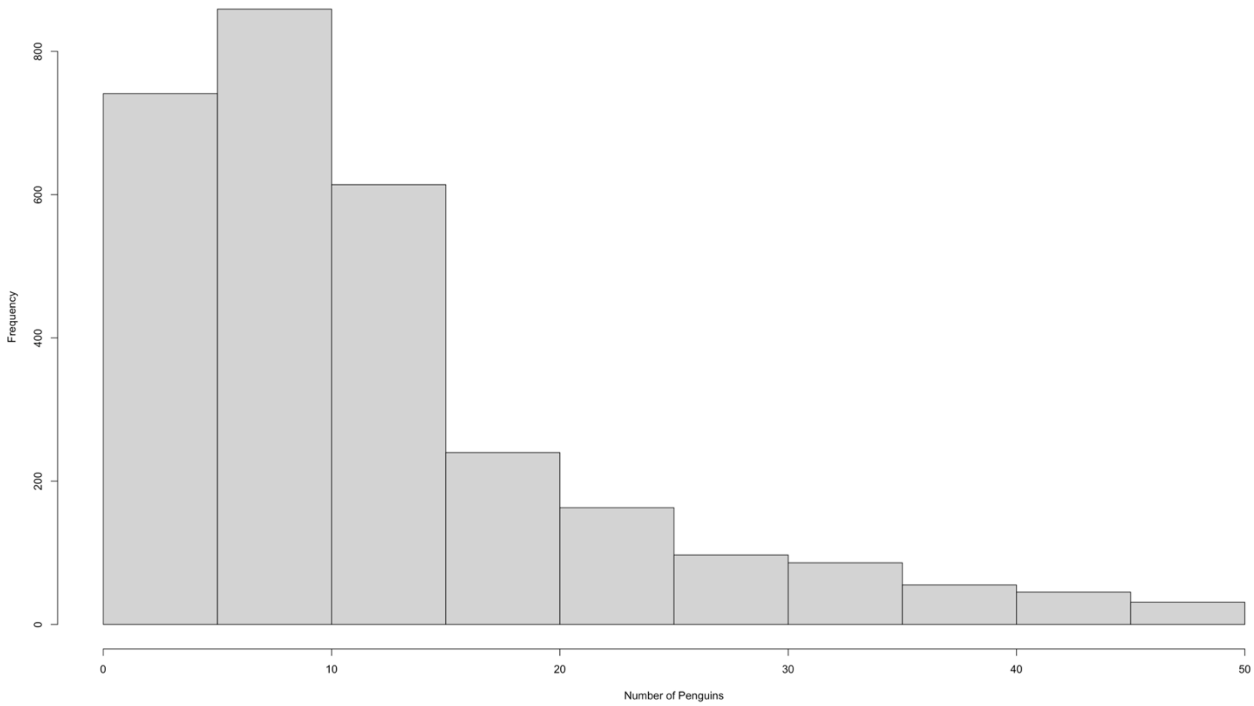
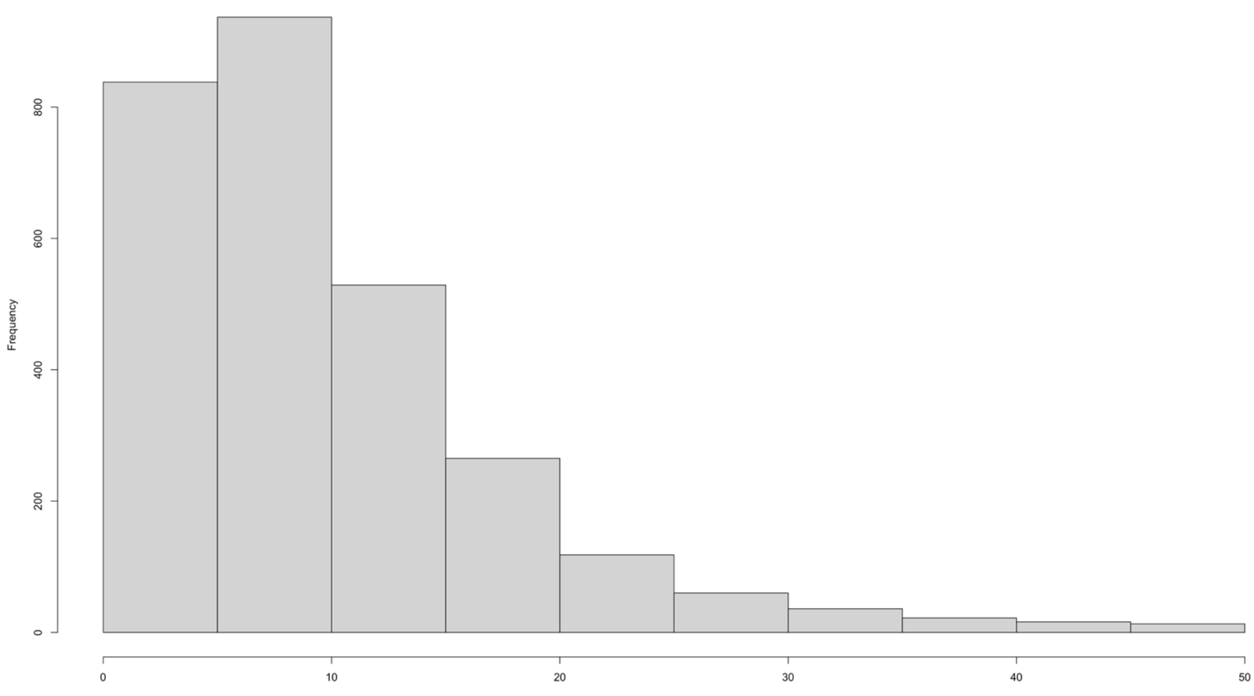


Figure 27

Frequency of Risks Taken, Collapsed Across Trials—Narrow Choice Bracketing Condition



Relationship Between Individual Difference Measures and Risk Taking

Table 4 lists the bivariate Pearson correlations between the individual difference measures used in the present study. These correlations indicate that these scales are operating as intended. Notably, the BIS and BAS scales are uncorrelated, which is consistent with prior analyses (e.g., Gomez et al., 2005). BIS is negatively correlated with Risk-Behaviour and Risk-Perception on the DOSPERT, and BAS is positively correlated with Risk-Behaviour, which is consistent with theoretical considerations discussed earlier in the methods section. BAS is uncorrelated with Risk-Perception, which is somewhat surprising (one might expect individuals with higher reward sensitivity would have reduced risk perception); however this theoretical point was not a consideration in the design of either scale, and is unimportant in this study.

Table 4

Correlations Between Individual Difference Measures

	1	2	3
1. BIS			
2. BAS	.07		
3. Risk-Behaviour	-.16**	.31***	
4. Risk-Perception	.17**	-.06	-.60***

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

Table 5 displays the bivariate spearman correlation coefficients between risk-taking in both conditions and the individual difference measures. Spearman correlations were used due to the non-normality observed in risk taking in both conditions. Here, responses of 1 and 50 penguins were not included, for the same reasons listed above.

Table 5

Correlations Between Individual Difference Measures and Risk-Taking, Collapsed Across Trials

	Risk Taking	
	Narrow Condition	Broad Condition
1. BIS	-.06	-.08
2. BAS	.06	.02
3. Risk-Behaviour	.1	-.01
4. Risk-Perception	.1	-.05

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

Risk taking (the number of penguins placed on the ice) was expected to be less correlated with Risk-Perception and BIS in the narrow choice bracketing condition than in the broad choice bracketing condition. As Table 5 shows, there were no meaningful correlations between the individual difference measures and risk taking in either experimental condition.

Making Sense of Unexpected Differences Between Experimental Conditions

In study 2, it was hypothesized that participants in the narrow bracketing condition would take more risks than those in the broad bracketing condition. This hypothesis was based on a theory that under narrow bracketing, people do not perceive prior risks as connected to current risks—even in the presence of explicit information about cumulative risk—and will therefore underestimate the riskiness of a pattern of behaviour. They simply attend to the choice in front of them, which does not seem too risky, so they go ahead with it. Individuals who are broadly bracketing, though, perceive current risky decisions as connected with past and potential future risks and are therefore more cautious.

Contrary to this hypothesis, the opposite effect was found. Participants in the broad condition took more risks than participants in the narrow condition. While unexpected, this finding is not inconsistent with prior research in this area. Most notably, a similar effect was documented by Redelmeier and Tversky (1992). In their study they presented participants with a variant on Samuelson's (1963) famous gamble: *Imagine that you have the opportunity to play a gamble that offers a 50% chance to win $2,000 and a 50% chance to lose $500. Would you play the gamble?*

Participants were asked whether they would prefer to play this gamble 5 or 6 times, and most participants preferred to play 6 times. With another sample they asked participants to imagine that they had just played the above gamble 5 times, but did not know their wins or losses. They were then asked whether they would like to play an additional time (a 6th time). Most participants rejected this offer. In conclusion, when considering choices together (5 vs. 6 gambles) most people take more risks. When considering choices separately (playing a gamble after having previously played 5 other gambles) people take fewer risks.

Redelmeier and Tversky (1992) offered a computational explanation for the effect described above. They write, "By treating the sixth play as a separate event, rather than combining it with the distribution of outcomes induced by the fivefold play, subjects violate a basic normative principle." (p. 192). In the present study, however, the distribution of outcomes was provided to participants in multiple forms, and they were explicitly instructed to attend to this information. Thus, it is more likely that in the present study, this effect is driven by non-computational factors.

Making sense of this finding is necessarily a speculative exercise. There are two categories of post-hoc explanation for this finding. The first involves explanations where this finding is the result of task structure effects. The second involves theory-based explanations based on relevant decision making research.

Potential Task Structure Effects. One potential feature of the task that could have contributed to fewer risks being taken in the narrow bracketing condition has to do with when the ice breaks. In the narrow bracketing condition, there is a chance that the ice will break each time a penguin is placed on the ice. If a participant wished to put some number of penguins on the ice, but the ice broke prior to them reaching that number, they would be unable to place that desired number. In the broad bracketing condition, however, participants decide how many penguins they want to place on the ice, use the slider to put that number on, and then click the "Finish" button to find out whether the ice broke or not. Thus, in the broad bracketing condition, participants are able to put precisely the number of penguins they desire on the ice.

In this way, the narrow bracketing condition has, by design, a potential artificial limit on the number of risks that a participant can take. However, post-hoc analyses suggest that this does not explain the observed difference in risk-taking across groups. When all trials are included, participants in the narrow bracketing condition placed an average of M = 10.49 penguins, and those in the broad bracketing condition placed an average of M = 12.38 penguins, $t(5577) = -8.1$, $p < .001$. When only those trials where the ice did not break for participants in the narrow bracketing condition are considered (that is, they ended the trial by pressing the "Finish" button), they placed an average of M = 10.4 penguins, and the results of the t-test are virtually unchanged, $t(4126) = -8$, $p < .001$. Thus, the experimental effect remains even when we only consider those individuals in the narrow bracketing condition who were able to take as many risks as they wanted.

Another potential task structure effect that may drive the finding under consideration is fatigue. Participants in the narrow bracketing condition have to press a button every time they want to put a penguin on the ice. Those in the broad bracketing condition simply have to move a slider. It may be that participants in the narrow bracketing condition took fewer risks simply because they were tired of repeatedly pressing buttons and want to be finished the trial earlier.

This explanation is also unlikely to be strongly driving the present results. If this were true, we would expect participants in the narrow bracketing condition to take fewer risks across trials—as they grow more fatigued, they place fewer and fewer penguins as a way to end the trial quickly. Figure 28 displays the average number of penguins placed on each trial for both conditions. Participants in the narrow bracketing condition take fewer risks as the task progresses, whereas those in the broad condition do not. This is reflected by a very small but significant interaction of trial and condition in the prediction of the number of penguins placed, $R = -.16$, $p < .001$. While it is typically unadvisable to interpret main effects in the presence of significant interactions, it is worth noting that the main effect of condition on the number of penguins placed (reflected by the distance between the broad and narrow condition lines on Figure 28) was much stronger ($R = -1.94$, $p < .001$) than the interaction. Thus, experimental condition, rather than trial, appears to be the primary correlate of risk-taking preferences.

To fulsomely explore the potential role of fatigue in these results, the time spent per trial was also examined across conditions. This can be seen in Figure 29. Timing data is trimmed such that time values two standard deviations above the mean are omitted, to ensure that participants who spent very large amounts of time on a given trial (e.g., perhaps they stepped away from their computer) were not included. Additionally, timing data for trial 1 is not considered in this analysis. This is due to a data recording error such that on trial 1 the timer was not reset after participants finished their final practice trial, so the time included them reading the instructions for the main trials.

Figure 28

Average Risks Taken Across Trials

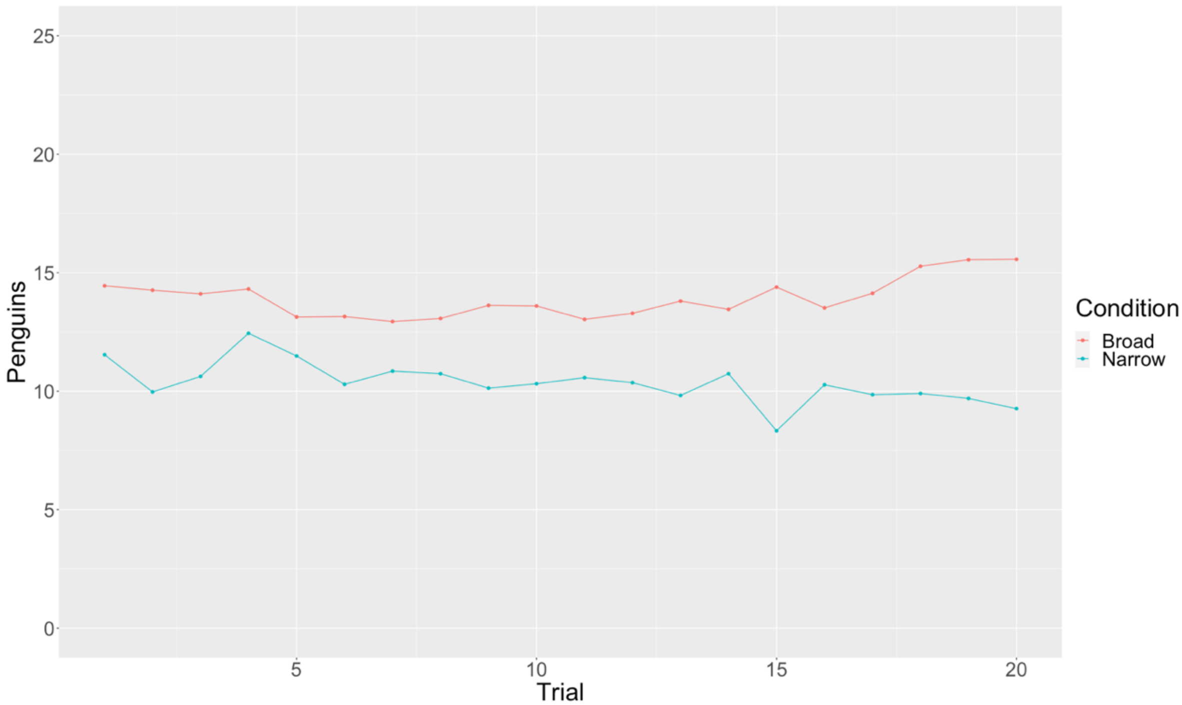


Figure 29

Average Time Elapsed Across Trials

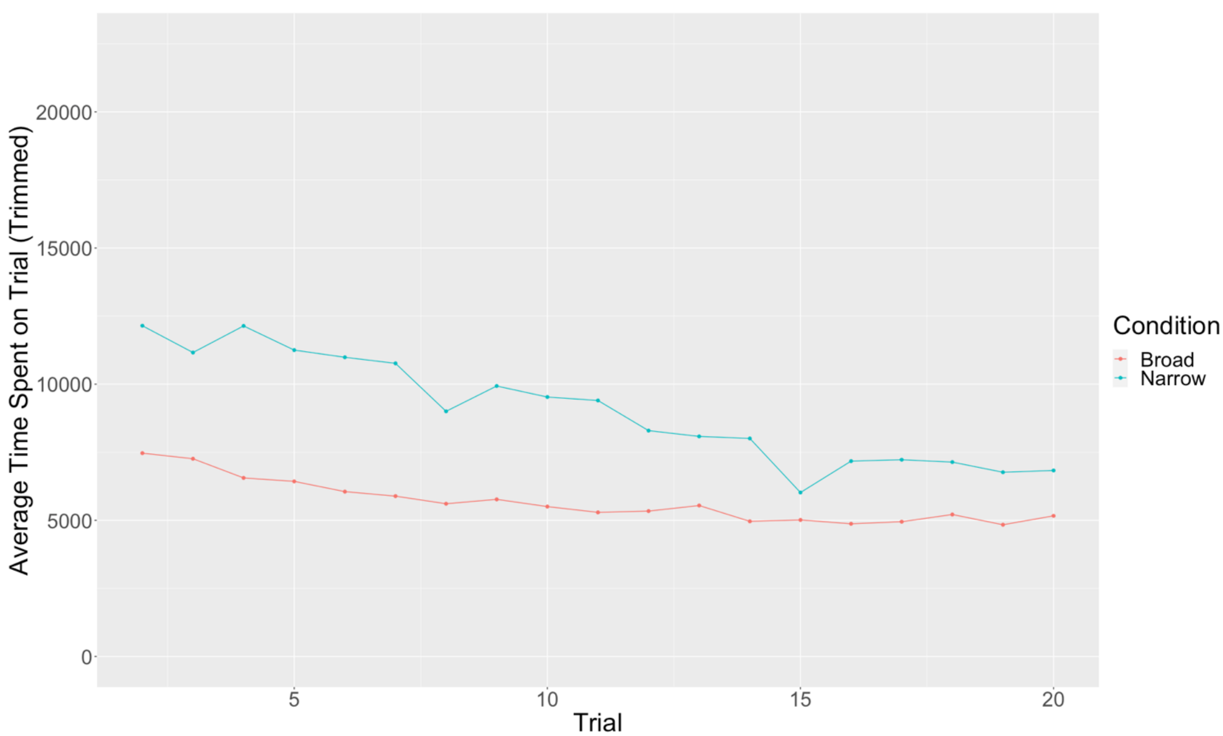


Figure 29 shows that participants in the narrow bracketing condition consistently spend more time on trials compared to those in the broad bracketing condition, which makes sense given that it takes longer to repeatedly press a button than move a slider. Furthermore, there is a reduction in the time spent across trials, with individuals in the narrow condition demonstrating a steeper decrease in the time spent on trials than those in the broad bracketing condition. A linear multiple regression supports these visual observations—a significant interaction of trial and condition in the prediction of time spent was found, $R = -206.6$, $p < .001$.

To review, participants in the narrow bracketing condition placed fewer penguins per trial, and completed their trials more quickly, as the task progressed. These potentially reflect some degree of fatigue. In order to establish whether this speeding effect is related to observed reductions in risk taking, a linear multiple regression was conducted using just data from the narrow bracketing condition, with the number of penguins placed predicted by trial and time elapsed between button presses (the time spent deliberating whether to place another penguin on the ice). If the observed fatigue affected decision making, then deliberation time should be associated with the amount of penguins placed. The results of this regression indicate a small but statistically significant main effect of trial ($R = -.21$, $p <. 001$). Coefficients for button press speed ($R = 0$, $p < . 001$) and the interaction between deliberation time and trial ($R = 0$, $p < .001$) were statistically significant because of the large number of observations (every button press is an observation), but did not constitute a meaningful effect size. In conclusion, it does not appear that fatigue affected risk-taking. This is echoed by Figure 28—despite some differences across trial, participants in the narrow bracketing condition place fewer penguins than those in the broad bracketing condition throughout the entire task. Even if only the middle 50% of trials (trials 5-

15) are considered, participants in the narrow bracketing condition still place fewer penguins (M = 10.3) than those in the broad bracketing condition (M = 12.15), t(3066) = -5.9, $p < .001$.

Potential Theoretical Explanation

The above analyses suggest that while there was a small task effect (fatigue), it is not sufficient to explain the observed difference in risk taking across conditions. Alternative explanations must attempt to understand this finding in the context of judgment and decision making research.

As discussed, prior theories about the reason for the observed effect, such as that offered by Redelmeier and Tversky (1992), emphasize computational factors. Given that those are controlled for in the present study, we are left to consider other explanations. The hypothesized mechanism in this study, risk perception, was not supported.

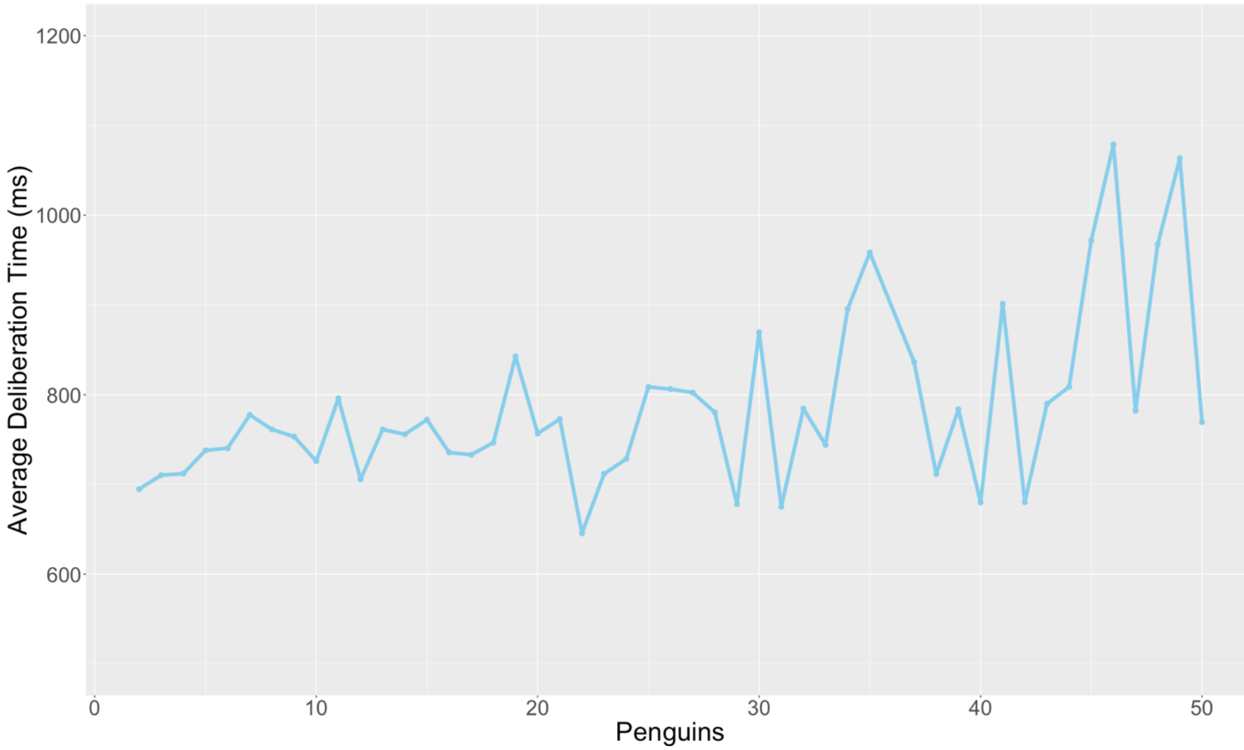
One potential explanation is that participants in the narrow bracketing condition were gambling with realized gains, whereas those in the broad condition were gambling with potential gains. When participants place a penguin on the ice in the narrow bracketing condition, they either gain points or the ice breaks. In the broad condition, participants do not know whether they have gained points until they press the “Finish” button. Of note, the mathematical properties of these decisions are equivalent across conditions—in the broad condition when a participant places an additional penguin on the ice they are effectively expressing a preference that, assuming the ice had not broken given the number they currently have selected, they would choose to add another.

That participants would treat their points differently depending on whether gains are actualized or potential makes sense in the context of other findings in the field of judgment and decision making. Most notably, scholars have differentiated between loss aversion and disappointment aversion. Loss aversion refers to the desire to avoid losing value relative to an exogenous reference point—that is, one's actual current wealth/value status (Kahenman & Tversky, 1979). Disappointment aversion refers to the desire to avoid a probabilistic process that may result in an outcome that falls below an endogenous reference point (Backus et al., 2017; Bell, 1985; Gill & Prowse, 2012; Loomes & Sugden, 1986). Here the reference point is endogenous as opposed to exogenous because it is based on an expectation (that a desirable outcome will be obtained) rather than a current state of affairs. When our current state fails to meet our expectations, we experience disappointment.

If it is true that participants in the narrow condition evaluate the riskiness of adding a penguin relative to their current number of points, then we would expect that the time they spend deliberating over whether to add a penguin would depend on how many penguins they have on the ice. For them, the riskiness of the decision increases not because they attend to the aggregate probability of the ice breaking across trials, but because they stand to lose more points with each penguin placed. Figure 30 visualizes this relationship. As the figure shows, deliberation time does tend to increase as the number of penguins on the ice grows, though there is noteworthy variability in this increase. The spearman correlation between the number of penguins on the ice and average deliberation time is large, $\rho = .48$, $p < .001$. When only 1-15 penguins are considered (a more reasonable range given the mean number of penguins participants placed on the ice in both conditions) this correlation is unchanged.

Figure 30

Average Deliberation Time Depending on Number of Penguins Placed



While there is evidence of an association between the number of penguins on the ice and deliberation time, differences in average deliberation time for common numbers of penguins is slight. For example, the range of average deliberation times from 2-20 penguins is 148 ms—under one fifth of a second. The greatest difference in average deliberation time for all possible number of penguins under consideration (2-50 penguins) is 970ms, just less than a second.

Thus, there is modest evidence that is consistent with the theory that participants in different conditions used different reference points when making their choices. In further considering this theory, it is informative to examine how expected value calculations would look for participants using these different reference points. Here expected value is simply being used as a thought experiment for how participants may have perceived the profitability of their decisions—it is not being suggested that participants were actually making decisions based on expected value. If the theory under consideration is true, we would expect that broad bracketing participants would consider potential winnings together for every given number of penguins (e.g., adding an eighth penguin represents a possible 80 points rather than a possible 10 points), and disappointment would correspond to losing the expected value associated with the number of penguins to be placed on the ice. Expected value here is an appropriate metric because disappointment aversion is a function of the magnitude of the expected outcome (points) and the likelihood of being disappointed (the ice breaking).

Table 6 displays a range of expected value calculations based on a broad bracket, as just described. The highlighted row indicates the average number of penguins placed by participants in the broad condition. It is noteworthy that participants in the broad bracketing condition stop adding penguins near where expected value begins to level off/rise less steeply (12/13 penguins), and just before losing (being disappointed) becomes equally likely as winning.

Table 7 displays a range of expected value calculations based on a narrow bracket. The highlighted row indicates the average number of penguins placed by participants in the narrow condition. Here all prior winnings are considered together (they are the new reference point), only immediate potential winnings are considered, and only the probability of the ice breaking on the present trial is considered. It is interesting to note that here as well participants, on average, stop placing penguins at the point where expected value levels off.

In summary, the theory that in the present experiment participants in the narrow choice bracketing condition used an exogenous reference point (the number of points they had acquired), and thus experienced loss aversion, whereas those in the broad choice bracketing condition used an endogenous reference point (the number of points they hoped to gain) and thus experienced disappointment aversion, has some support in the data, and expected value calculations designed to capture this process are consistent with average risk preferences in both conditions.

Table 6

Expected Value Based on a Broad Bracket

Penguins	Success %	Potential Winnings	Expected Value
7	70%	70	56
8	66%	80	59.4
9	63%	90	63
10	60%	100	66
11	57%	110	68.4
12	54%	120	70.2
13	51%	130	71.4
14	49%	140	73.5
15	46%	150	73.6
16	44%	160	74.8
17	42%	170	75.6
18	40%	180	76

Table 7

Expected Value Based on a Narrow Bracket

Penguins	Success %	Potential Winnings	Potential Losses	Expected Value
7	0.95	10	-60	6.5
8	0.95	10	-70	6
9	0.95	10	-80	5.5
10	0.95	10	-90	5
11	0.95	10	-100	4.5
12	0.95	10	-110	4
13	0.95	10	-120	3.5
14	0.95	10	-130	3
15	0.95	10	-140	2.5
16	0.95	10	-150	2
17	0.95	10	-160	1.5
18	0.95	10	-170	1

Discussion

The question that this study aimed to answer was “by what mechanism does choice bracketing affect decision making?” The present study did not find support for the hypothesized answer—that narrow choice bracketing reduces risk perception for gambles involving rare, serious consequences (and therefore increases risk taking). However, given that outcome bracketing was controlled for across conditions, it did still find support for the notion that noncomputational mechanisms play a role in choice bracketing effects on risky choice. Thus, this study is consistent with other research indicating that computational factors cannot fully explain differences in risky decision making under narrow and broad bracketing (Chen & Corter, 2006; Li, 2003; Montgomery & Adelbratt, 1982; Simonson, 1989; Simonson & Tversky, 1992).

Although additional research is required, post-hoc analyses suggest that one possible noncomputational effect that may have been operating in the present study is differences in reference points. If this theory is true, it says something interesting about the nature of choice bracketing. It suggests that even when we have very good information about where our decisions will lead us, that the act of making decisions together vs. apart affects the criteria we use to evaluate our options. Participants in the narrow bracketing condition based their decisions on a reference point that moved with each decision, and as a result became increasingly cautious as the experiment went on. They had the tools required to make an overarching decision about their risk tolerance, but instead they made their choices off of what was going on for them in the moment—specifically how many points they had earned. Importantly, this occurred despite excellent outcome information—it was the act of making the choices one-by-one that led them to behave this way. In contrast, participants in the broad condition made decisions ahead of time, and so they compared the advisability of a group of decisions to their starting status and expectations. They were more comfortable with risk because they did not have to experience the stress of risking points they had earned, only points they *could* earn.

Future Directions. The theory outlined above was generated after receiving unexpected results and is supported by findings that are consistent with but do not prove it. Future work should modify the penguin task to empirically test the theory that participants in the narrow bracketing condition update their reference point each time they place a penguin on the ice, and broad bracketing participants do not.

One way to do this would be to add an additional narrow bracketing condition and an additional broad bracketing condition. These two new experimental conditions would be identical to the current task except in one way—participants would start the task with an endowment of 100 points that is unaffected by the ice breaking. In these conditions, the minimum number of points a participant could have is 100; even if the ice breaks, their endowment is unaffected. These points would still be summed with points earned by placing penguins, to prevent participants from categorizing these points in different mental accounts.

Adding 100 points to participants' totals and preventing them from ever losing those points will decrease the perceived magnitude of both gains and losses, as research indicates that people evaluate magnitude relative to anchors (Furnham & Boo, 2011; Kahneman, 1992; Oppenheimer et al., 2008). Decreasing the perceived magnitude of both gains and losses is likely to increase risk-taking in both conditions. However, if it is true that participants in the narrow bracketing condition update their reference point each time a penguin is placed on the ice, and those in the broad bracketing condition do not, this manipulation is likely to have a greater effect for narrow bracketing participants.

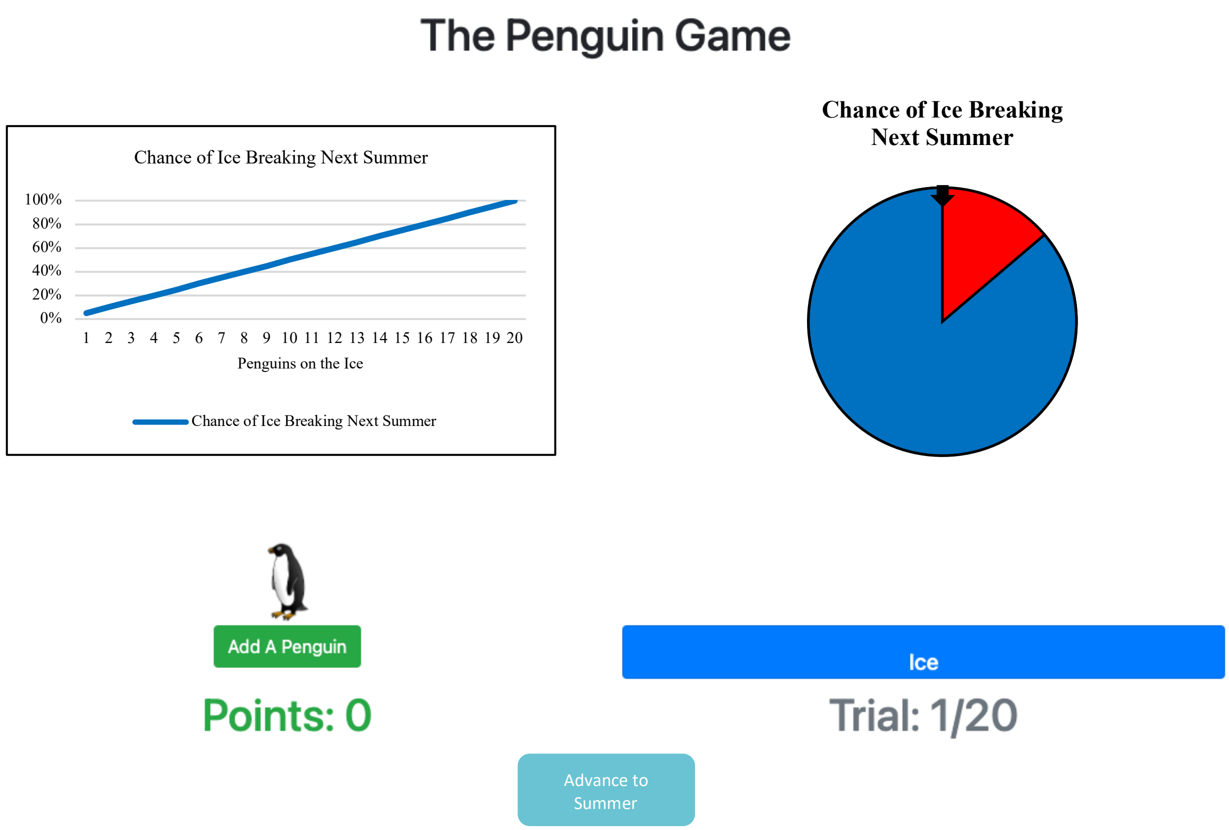
The reason for this has to do with the difference between loss aversion and disappointment aversion. As stated, loss aversion refers to the fact that people dislike losing value relative to their actual utility status. If participants in the narrow bracketing condition update their reference point every time they add a penguin to the ice, then they perceive the ice breaking as a loss in points. Disappointment aversion refers to the fact that people dislike unactualized expected gains (Gul, 1991) or missing out on the superior of some number of outcomes (Sonsino, 2006). Thus, participants in the narrow bracketing condition are expected to evaluate changes in points relative to an exogenous reference point—their current number of points—and individuals in the broad condition are expected to be evaluating changes relative to an endogenous reference point—the number of points they hope to make. Reducing the perceived magnitude of outcomes is expected to attenuate both loss and disappointment aversion. However, it is expected that this manipulation will affect narrow bracketing individuals more, as disappointment (missing out on earning points) is expected to be less powerful than loss (losing points). As such, if this manipulation was applied, we would expect that risk-taking would be more similar across conditions than it is in the present experiment.

Redesigning the Penguin Task. The above revision to the penguin task would allow us to test whether the previously described theory about reference points is driving behaviour on the penguin task (rather than the hypothesized mechanism—risk perception). A different, and arguably more important, initiative is redesigning the penguin task to 1) control for this potential competing explanation, and 2) allow the original hypothesis about risk perception to be tested.

Reference Point Differences. Controlling for potential reference point differences could be addressed by revising the task to resemble Figure 31. Here, each trial is broken into two phases or “seasons”—winter and summer. During winter, participants decide how many penguins to place on the ice and receive points accordingly. During summer, participants find out whether the ice has broken or not and lose points if it has.

Figure 31

Revised Penguin Task Concept (Narrow Choice Bracketing Condition)



In order to inform their decision, participants are provided with both a static graph, and a roulette wheel that displays the current likelihood of the ice breaking in summer given the number of penguins on the ice. Each time participants add a penguin to the ice, they receive 10 points and the red area on the "Chance of Ice Breaking Next Summer" roulette wheel increases 5%. When they are satisfied with that number, they press the "Advance to Summer" button. A dialog box appears, telling them how many points they earned during winter. In summer, the roulette wheel spins; if it lands on the blue area the ice does not break, participants are informed that their points were recorded, their points then reset, and they advance to the next trial. If it lands on the red area, the ice breaks, participants are informed that all their points on that trial were lost, and they advance to the next trial. The broad bracketing version of this task would be identical, except that participants would add participants with a slider.

This redesign involves two significant changes. First, outcomes are received at different times in the original and revised versions of the task. In the original task, narrow bracketing participants knew whether or not their current points were secure after every button press, because they knew whether the ice had broken or not. In the broad bracketing condition, participants did not know whether their current points were secure when they moved the slider, because they did not know whether the ice would break for that amount of penguins or not. In the revised task, receiving points and the ice breaking are two separate outcomes. Participants always receive points for the number of penguins they place on the ice. However, they do not know whether they will lose these points during summer, because they both do not know whether the ice will break or not. By framing the reception of points as a gain across conditions, it is expected that participants across conditions will update their reference point after adding their desired number of penguins. Therefore, the ice breaking will be viewed as a loss (rather than a disappointment) in both conditions.

The second change is that the risk that each penguin represents to the ice breaking is different in the original task and this redesign. In the original task, each penguin represents an independent 5% chance of the ice breaking. Therefore, in the original task risk increased asymptotically. In the redesign, each penguin increases the chance of the ice breaking during summer by 5%. Here, risk increases linearly. This change was necessitated by the fact that in the redesign, both conditions only have one opportunity to find out whether the ice has broken on the current trial. It also has the advantage of being more intuitive—although participants received very clear outcome information about risk in the current version of the task, the idea of additive risk is likely more comprehensible and fits the task's visual metaphor more closely than asymptotic risk.

Additional modifications to the design could further increase confidence that observed differences across conditions are not the result of reference point differences. For instance, think aloud protocols (Fonteyn et al., 1993) could be used to explore participants' thought processes as they complete the task.

Risk Perception. The present study was designed to test the hypothesis that participants would take fewer risks under narrow bracketing because they would perceive only the riskiness of their immediate behaviour (i.e., the riskiness of placing one penguin on the ice) and not the riskiness of their pattern of behaviour (i.e., the riskiness of repeatedly placing penguins on the ice). Differences in risk perception during task completion were inferred by differences in the degree to which individual difference measures of risk perception and related constructs (behavioural inhibition) were associated with task behaviour across the narrow and broad choice bracketing conditions.

No associations were found between the individual difference measures and risk-taking, regardless of experimental condition. There could be three plausible (and not mutually exclusive) explanations for this. First, it may be that differences in risk taking across conditions were purely the result of the reference point issues just described, and risk perception is unrelated to this effect. The second is that individual differences in risk perception may not be associated with actual risk taking on the current task. The third is that risk perception does not underlie differences in risk taking under narrow and broad choice bracketing.

The first of these explanations would be addressed by the redesign described above. The second concern could be addressed by adding an additional component to the redesign. This component would be state-level measures of risk perception. The third would require null results from this redesign, and the formulation and testing of alternative theories that contradict empirical and theoretical work outlined in the introduction. As such, the first and second explanations are the most sensible avenues for future work.

With respect to state-level measures of risk perception, it would be ideal to use neurological or physiological measures to evaluate risk perception during task administration. For example, skin conductance measures could be used to provide real-time data on participants' risk perception, as such measures have been used previously to measure anticipation of risk in tasks such as the Iowa Gambling Task (Bechara et al., 1997; Dawson et al., 2011).

A more practical alternative would be to use a self-report question about perceived risk during the experiment. The risk perception scale proposed by Wilson, Zwickle, and Walpole (2018, also see Walpole & Wilson, 2021) is a multidimensional risk perception scale that was designed to be adapted to measure risk perception across a broad range of contexts. This scale has four dimensions (affect, susceptibility, exposure, and severity). The theory I have articulated in this manuscript revolves around the affect component of risk perception—that felt experience of riskiness (Fischhoff et al., 1978; Loewenstien et al., 2001) that automatically tells organisms they are taking a chance (Bechara et al., 1997). As such, this self-report question could take inspiration from one of the "affect" items on Walpole and Wilson's (2021) perception scale: "How concerned are you, if at all, about X?" (where X is the possible negative outcome of the risky prospect). In order to avoid demand characteristics, participants would also be asked about possibly avoiding negative outcomes using the following item: "How optimistic are you, if at all, about Y?" (where Y is the absence of the possible negative outcome).

This question could be inserted into the design in the following way. A dialog box could appear after participants finish the "summer" phase of the revised experiment. Participants would respond to the questions "How concerned are you, if at all, about the ice breaking during summer?" and "How optimistic are you, if at all, about the ice not breaking during summer?" Mixed models could be used to evaluate the relationship between risk perception and risk taking across time, condition, and risk levels (number of penguins).

Precision and Applicability. Taken together, these two sets of revisions would control for potential reference point differences across conditions and would offer state-based measurements of risk perception. This would allow for more precise testing of the theory that narrow choice bracketing restricts risk perception (specifically the affective "gut feeling" of risk) to just the immediate choice under consideration, even in the presence of broad outcome bracketing.

This redesign also allows for more straightforward extensions to examples of real-world behaviour where this hypothesized effect may be relevant. For example, consider the first example of narrow choice bracketing given by Read, Loewenstein, and Rabin (1999)—smoking. They suggest that under narrow bracketing people pay attention to immediate consequences; a single cigarette provides pleasure, and by itself presents very little risk, so smoking always looks like a good idea in the moment. The problem with this example is that smoking has little to do with a lack of comprehension; for example, in a systematic review of school-based smoking prevention trials, only one was found to reduce smoking prevalence (Wiehe et al., 2005). The theory presented in this paper is that people are aware of where smoking will lead them, but in addition to being presented with the insidiousness of physical addiction, the blunting of risk perception under narrow bracketing makes it hard to appreciate the connection between the cigarette in one's hands and the ailments from which they may soon suffer.

General Discussion

The purpose of the present manuscript was to answer two questions about choice bracketing: 1) "What prompts people to bracket choices broadly?", and 2) "By what mechanism does choice bracketing affect decision making?". In addition to being important in their own right, these questions could provide greater insight into and support for the previously described conceptualization of choice bracketing as an adaptive cognitive process that helps people structure decision making problems.

Study 1 provided support for the theory that people bracket narrowly by default and switch to broad bracketing when they identify a need for more expansive thinking. Specifically, it showed that one of the situational determinants of this switch is an association between choices—when people perceive that choices affect the form of other choices, they readily form and follow systematic, interconnected patterns of decision making. While this hypothesis is novel, it is in some ways a return to early descriptions of choice bracketing which, until today, have not been empirically tested. For example, in addition to the definition of choice bracketing quoted at the beginning of this manuscript, Read, Loewenstein, and Rabin (1999) state, "A set of choices are *bracketed together* when they are made by taking into account the effect of each choice on all other choices in the set" (p. 172).

Study 2 provided support for the theory that noncomputational mechanisms play an important role in the effect of choice bracketing on risky decision making and clarified that this noncomputational effect works independently of outcome bracketing. The nature of this noncomputational mechanism remains unknown, however. Risk perception remains a strong candidate, but study 2 did not find evidence to support this hypothesis. Alternative designs that would allow for this hypothesis to be tested with greater precision, and that would address potential methodological issues, are described in study 2's discussion section.

Theoretical Implications

From a theoretical perspective, these findings integrate apparently contradictory conceptualizations of choice bracketing (Ding, 2012; Hsiaw, 2019; Kahneman & Lovallo, 1993; Koch & Nafziger, 2016; Koch & Nafziger, 2020; Soman & Cheema, 2004; Tversky & Kahneman, 1981; Webb & Shu, 2017), and corroborates speculation that choice bracketing has noncomputational effects in the domain of risky choice as well (Chen & Corter, 2006; Li, 2003; Montgomery & Adelbratt, 1982; Simonson, 1989; Simonson & Tversky, 1992). They additionally reinforce the importance of distinguishing between choice and outcome bracketing (Moher & Koehler, 2010; Webb & Shu, 2017)

In integrating these conceptualizations, the results of this manuscript support the earlier-described theory that choice bracketing is a decision making process that assists individuals in matching the scope of their consideration to the needs of the situation. Study 1 demonstrated that when the environment contains independent or seemingly isolated choices, people bracket narrowly by default. This has the advantage of preserving cognitive resources. In line with this notion of preserving cognitive resources, study 2 provided additional evidence that choice bracketing works at least partially through non-computational mechanisms, though questions remain about the specific nature of this mechanism. Study 1 additionally showed that when the environment cues people to the fact that choices are associated or interdependent, people readily bracket choices broadly. In this way, the choice bracketing system helps people structure decision problems in a way that either preserves cognitive resources, or that enables systematic decision making across choices.

While I describe the choice bracketing system as adaptive, it does not always perform well. Panglossian statements (see Stanovich, 2010), such as that bracketing narrowly by default makes sense because life presents us with decisions one at a time, or that noncomputational mechanisms makes sense from an evolutionary standpoint where rapid good-or-bad judgments are more valuable than mathematical precision, are valid. However, so too are Meliorist-style observations that both narrow (e.g., bracketing investment choices narrowly; Benartzi & Thaler, 1995) and broad choice bracketing (e.g., bracketing consumption choices broadly; Read & Loewenstein, 1995) can lead to sub-optimal solutions. For instance, in both of the studies discussed here individuals made sub-optimal decisions under narrow choice bracketing. Another Meliorist critique is that narrow and broad choice brackets are frequently mis-applied. For example, in Camerer et al.'s (1997) field study with taxi drivers, the fact that people were not cued to bracket broadly in the face of varying resource availability, so as to capitalize on periods of abundance and preserve energy during periods of scarcity, is at odds with Panglossian notions of naturally selected reasoning.

Applied Implications

Panglossian and Meliorist perspectives point to different types of interventions. Panglossians advocate for adjusting environments to match human reasoning (i.e., choice architecture) whereas Meliorists advocate for education and the provision of information to improve thinking. Given that there is room for both perspectives in describing how the choice bracketing system operates (and how it fails), both types of interventions may be valuable.

Meliorist interventions may be particularly helpful for some of the decision errors arising out of choice bracketing. In their discussion of revised dual process models, De Neys and Pennycook (2019) suggest that intuitive logical knowledge results from learning and practice, until the application of that knowledge becomes automatic. Decision errors related to choice bracketing may be related to automatic judgments, and could benefit from training. For example, Soman and Cheema (2004) observed people's tendency to deviate further from an all-or-nothing goal after initially violating that goal. Gyms looking to retain clients who set overly ambitious new year's resolutions might experiment with messaging that emphasizes that partially reaching exercise goals is better than quitting.

As another example, given that there is gathering evidence for noncomputational effects of choice bracketing on decision making, there may be value in attempting to target these mechanisms specifically in situations where choice bracketing is likely to trigger them. For instance, as previously discussed, loss and risk aversion are well documented under narrow bracketing. Sokol-Hessner et al. (2009) found that asking participants to "think like a trader" reduced physiological arousal and subsequent behavioural loss aversion, which indicates that people may be able to use emotion regulation strategies to mitigate some of the affective factors that lead them to make decision errors under narrow bracketing.

Panglossian interventions may be particularly helpful for addressing the misapplication of narrow/broad choice brackets to decision problems. Structuring environments to create the perception that choices are associated or to make the associations between choices more salient may be a useful way to prompt broad bracketing in situations where it should be occurring with greater frequency. For example, banks could experiment with framing new savings deposits as making previously deposited money "work harder", because of compound interest. As another example, one less frequently discussed hurdle in the rollout of Covid-19 vaccines is getting people to return for additional doses after their initial vaccination (Wood & Schulman, 2021). Framing doses as associated (e.g., describing the initial dose as a "primer") rather than as separate units with different efficacy rates, could potentially increase regimen completion.

Choice architecture could also be helpful in situations where individuals erroneously bracket choices together because of perceived associations between choices. For example, in the same way that people infer underlying causal mechanisms when presented with stochastic processes such as basketball shot accuracy, so too might people be prone to pick investments on the basis of perceived underlying causal mechanisms (e.g., macroeconomic forces). This may be an additional partial explanation for findings such as those offered by Thaler and Benartzi (1995), Haigh & List (2005), and Larson, List, and Metcalfe (2016) showing that traders invest more in equities when they are prevented from checking their portfolios more frequently. In addition to attenuating loss aversion, this manipulation can head off the often incorrect inference that stock changes are the result of causal mechanisms that will continue (i.e., a stock has lost value because the market has changed, and thus is likely to continue to fall).

While I have highlighted that Panglossian and Meliorist perspectives may be ideally suited to address different types of problems related to choice bracketing, there is value in looking at each approach for both types of problems. For example, Meliorist interventions may also help address the misapplication of narrow and broad choice bracketing. It is possible that providing people with additional information can improve their ability to notice associations between choices. Research has shown that people are more sensitive to covariation in making a determination about causal relations when they have pre-existing beliefs that the stimuli under consideration are causally related (Fugelsang & Thompson, 2000, 2003). In this way, content-specific knowledge about the association between choices may help some people be more quick to identify those associations when they arise, and bracket choices broadly as a result.

Future Directions

Much work remains to be done to unravel the mysteries of choice bracketing. Most immediately, the redesigns described earlier can resolve unnecessary complexities in the task used for Study 1 and address potential methodological issues in Study 2.

Extensions of the current work could investigate additional feature-based determinants of broad choice bracketing and explore other noncomputational mechanisms that might underly differences in risky choice under narrow and broad choice bracketing.

Other areas of work on choice bracketing, outside the scope of the present manuscript, are also important avenues for future research. For instance, in this manuscript I have followed in the tradition of presenting choice bracketing as a dichotomous phenomenon—people either bracket choices narrowly or broadly. However, scholars have long speculated that things are not so simple. For example, Redelmeier and Tversky (1992) stated that "At one extreme, the decision maker may evaluate each prospect as a separate independent event. At the other extreme, one may evaluate the overall distribution of outcomes that results by aggregating all the prospects." (p. 191). The use of the word "extremes" here implies that some middle ground might be possible—where the individual only considers some choices together, or maintains a dim awareness that the present choice does not exist in a cognitive vacuum. As another example, Read, Loewenstein, and Rabin (1999) embrace some fuzziness with respect to the number of choices required for a bracket to be narrow/broad when they write, "When the sets are small, containing one or very few choices, we say that bracketing is *narrow*, while when the sets are large, we say that it is *broad*." (p. 172). However, as other judgment and decision making research has demonstrated, “small” and “large” are relative terms, which adds unexplored nuance to the notion of what constitutes narrow and broad bracketing. Similarly, Ellis and Freeman (2020) postulated that decision-makers might “partially” bracket their choices narrowly, suggesting a more continuous view of choice bracketing.

Another related future direction is to investigate the exclusivity of narrow and broad choice bracketing. Read, Loewenstein, and Rabin postulate that individuals might be able to intentionally use broad and narrow choice bracketing to tackle difficult tasks. They give the example of an individual looking to stop using alcohol and describe a strategy of broadly bracketing to first set the goal of not drinking for the rest of one’s life, and then bracketing narrowly (they use the metaphor of cutting up a larger task into individual sub-tasks like slicing salami) to focus on simply not drinking for the present day. They write, “The decision to undertake the task in the first place, and then to bracket each choice separately, is made by an ‘executive’ decision maker who presumably brackets broadly to begin with but then uses the salami strategy to get its untrustworthy self to accomplish the task.” (Read, Loewenstein, & Rabin, 1999, p. 192). Elaborating this theory of an ‘executive’ decision maker that intentionally nests narrow bracketing within a larger broad bracket, and incorporating it into theoretical models of choice bracketing, would be a substantial contribution to the field.

References

Abbott, A. (1995). Sequence analysis: New methods for old ideas. *Annual Review of Sociology*, *21*(1), 93-113. https://doi.org/10.1146/annurev.so.21.080195.000521

Abbott, A., & Forrest, J. (1986). Optimal matching methods for historical sequences. *The Journal of Interdisciplinary History*, *16*(3), 471-494. https://doi.org/10.2307/204500

Abbott, A., & Hrycak, A. (1990). Measuring resemblance in sequence data: An optimal matching analysis of musicians' careers. *American Journal of Sociology*, *96*(1), 144-185. https://doi.org/10.1086/229495

Abeler, J., & Marklein, F. (2007). *Fungibility, labeling, and consumption*. (IZA Working Paper, No. 3500). IZA Institute of Labor Economics.

Anderson, N. H., & Grant, D. A. (1957). A test of a statistical learning theory model for two-choice behavior with double stimulus events. *Journal of Experimental Psychology*, *54*(5), 305-317. https://doi.org/10.1037/h0044347

Ariely, D., & Wertenbroch, K. (2002). Procrastination, deadlines, and performance: Self-control by precommitment. *Psychological Science*, *13*(3), 219-224. https://doi.org/10.1111/1467-9280.00441

Backus, M., Blake, T., Masterov, D. V., & Tadelis, S. (2017). *Expectation, disappointment, and exit: Reference point formation in a marketplace* (NBER Working Paper No. w23022). National Bureau of Economic Research. https://doi.org/10.3386/w23022

Banich, M. T. (2009). Executive function: The search for an integrated account. *Current directions in psychological science*, *18*(2), 89-94. https://doi.org/10.1111/j.1467-8721.2009.01615.x

Barasz, K., John, L. K., Keenan, E. A., & Norton, M. I. (2017). Pseudo-set framing. *Journal of Experimental Psychology: General*, *146*(10), 1460. https://doi.org/10.1037/xge0000337

Bar-Hillel, M. (1973). On the subjective probability of compound events. *Organizational Behavior and Human Performance*, *9*(3), 396-406. https://doi.org/10.1016/0030-5073(73)90061-5

Barberis, N., Huang, M., & Thaler, R. (2006). Individual preferences, monetary gambles and stock market participation: A case for narrow framing. *American Economic Review, 96*(4), 1069-1090. https://doi.org/10.1257/000282806779468652

Bechara, A., Damasio, H., Tranel, D., & Damasio, A. R. (1997). Deciding advantageously before knowing the advantageous strategy. *Science*, *275*(5304), 1293-1295. https://doi.org/10.1126/science.275.5304.1293

Bell, D. E. (1985). Disappointment in decision making under uncertainty. *Operations Research*, *33*(1), 1-27. https://doi.org/10.1287/opre.33.1.1

Benartzi, S., & Thaler, R.H. (1995). Myopic loss aversion and the equity premium puzzle. *The Quarterly Journal of Economics, 110*(1), 73-92. https://doi.org/10.3386/w4369

Berg, E. A. (1948). A simple objective technique for measuring flexibility in thinking. *The Journal of General Psychology*, *39*(1), 15-22. https://doi.org/10.1080/00221309.1948.9918159

Berns, G. S., Laibson, D., & Loewenstein, G. (2007). Intertemporal choice–toward an integrative framework. *Trends in Cognitive Sciences*, *11*(11), 482-488. https://doi.org/10.1016/j.tics.2007.08.011

Blair-Loy, M. (1999). Career patterns of executive women in finance: An optimal matching analysis. *American Journal of Sociology*, *104*(5), 1346-1397. https://doi.org/10.1086/210177

Busemeyer, J. R. (1982). Choice behavior in a sequential decision-making task. *Organizational Behavior and Human Performance*, *29*(2), 175-207. https://doi.org/10.1016/0030-5073(82)90255-0

Camerer, C. F. (2000). Prospect theory in the wild: Evidence from the field. In D. Kahneman & A. (Eds.), *Choices, Values, and Frames,* (pp. 207-300). Cambridge University Press. https://doi.org/10.1017/cbo9780511803475.017

Camerer, C., Babcock, L., Loewenstein, G., & Thaler, R. (1997). Labor supply of New York City cabdrivers: One day at a time. *The Quarterly Journal of Economics, 112*(2), 407-441. https://doi.org/10.1162/003355397555244

Campbell-Sills, L., Liverant, G. I., & Brown, T. A. (2004). Psychometric evaluation of the behavioral inhibition/behavioral activation scales in a large sample of outpatients with anxiety and mood disorders. *Psychological Assessment*, *16*(3), 244-254. https://doi.org/10.1037/1040-3590.16.3.244

Carver, C. S., & White, T. L. (1994). Behavioral inhibition, behavioral activation, and affective responses to impending reward and punishment: the BIS/BAS scales. *Journal of Personality and Social Psychology*, *67*(2), 319-333. https://doi.org/10.1037/0022-3514.67.2.319

Chaudhry, S. J., Hand, M., & Kunreuther, H. (2020). *Broad bracketing for low probability events* (NBER Working Paper No. 27319). https://doi.org/10.3386/w27319

Chen, Y. & Corter, J.E. (2006). When mixed options are preferred in multiple-trial decisions. *Journal of Behavioral Decision Making, 19,* 17-42. https://doi.org/10.1002/bdm.512

Cochran, W. & Tesser, A. (1996). The 'what the hell' effect: Some effects of goal proximity and goal framing on performance. In L.L. Maartin & A. Tesser (Eds.), *Striving and Feeling: Interactions Among Goals, Affect, and Self-Regulation* (pp. 99-120). Lawrence Erlbaum Associates.

Coombs, C. H., & Bowen, J. N. (1971). A test of VE-theories of risk and the effect of the central limit theorem. *Acta Psychologica*, *35*(1), 15-28. https://doi.org/10.1016/0001-6918(71)90028-x

Corr, P. J., & McNaughton, N. (2012). Neuroscience and approach/avoidance personality traits: A two stage (valuation–motivation) approach. *Neuroscience & Biobehavioral Reviews*, *36*(10), 2339-2354. https://doi.org/10.1016/j.neubiorev.2012.09.013

Dai, H., Milkman, K. L., & Riis, J. (2014). The fresh start effect: Temporal landmarks motivate aspirational behavior. *Management Science*, *60*(10), 2563-2582. https://doi.org/10.1037/e513702014-058

Dawson, M. E., Schell, A. M., & Courtney, C. G. (2011). The skin conductance response, anticipation, and decision-making. *Journal of Neuroscience, Psychology, and Economics*, *4*(2), 111-116. https://doi.org/10.1037/a0022619

De Neys, W., & Glumicic, T. (2008). Conflict monitoring in dual process theories of thinking. *Cognition*, *106*(3), 1248-1299. https://doi.org/10.1016/j.cognition.2007.06.002

De Neys, W., & Pennycook, G. (2019). Logic, fast and slow: Advances in dual-process theorizing. *Current Directions in Psychological Science*, *28*(5), 503-509. https://doi.org/10.1177/0963721419855658

Ding, J. (2012). *A portfolio of dilemmas: Experimental evidence on choice bracketing in a mini-trust game.* (Working Paper 2012-6). Max Planck Institute for Collective Goods. https://doi.org/10.2139/ssrn.2041155

Doyle, J.K. (1997). Judging cumulative risk. *Journal of Applied Social Psychology, 26*(7), 500-524. https://doi.org/10.1111/j.1559-1816.1997.tb00644.x

Edwards, W. (1962). Dynamic decision theory and probabilistic information processings. *Human Factors*, *4*(2), 59-74. https://doi.org/10.1177/001872086200400201

Ellis, A. & Freeman, D. J. (2020). *Revealing choice bracketing*. (Working Paper). Simon Fraser University. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.418.9525&rep=rep1&type=pdf

Evans, J. S. B. (1996). Deciding before you think: Relevance and reasoning in the selection task. *British Journal of Psychology*, *87*(2), 223-240. https://doi.org/10.1111/j.2044-8295.1996.tb02587.x

Evers, E. R., Inbar, Y., & Zeelenberg, M. (2014). Set-fit effects in choice. *Journal of Experimental Psychology: General*, *143*(2), 504-509. https://doi.org/10.1037/a0033343

Fantino, E., & Esfandiari, A. (2002). Probability matching: Encouraging optimal responding in humans. *Canadian Journal of Experimental Psychology*, *56*(1), 58-63. https://doi.org/10.1037/h0087385

Faraji-Rad, A., Melumad, S., & Johar, G. V. (2017). Consumer desire for control as a barrier to new product adoption. *Journal of Consumer Psychology*, *27*(3), 347-354. https://doi.org/10.1016/j.jcps.2016.08.002

Fiedler, K. (2007). Construal level theory as an integrative framework for behavioral decision-making research and consumer psychology. *Journal of Consumer Psychology*, *17*(2), 101-106. https://doi.org/10.1016/s1057-7408(07)70015-3

Fischhoff, B., Slovic, P., Lichtenstein, S., Read, S., & Combs, B. (1978). How safe is safe enough? A psychometric study of attitudes towards technological risks and benefits. *Policy Sciences*, *9*(2), 127-152. https://doi.org/10.1007/bf00143739

Fonteyn, M. E., Kuipers, B., & Grobe, S. J. (1993). A description of think aloud method and protocol analysis. *Qualitative Health Research*, *3*(4), 430-441. https://doi.org/10.1177/104973239300300403

Fox, C.R., Rather, R.K., & Lieb, D.S. (2005). How subjective grouping of options influences choice and allocation: Diversification bias and the phenomenon of partition dependence. *Journal of Experimental Psychology: General, 134*(4), 538-551. https://doi.org/10.1037/0096-3445.134.4.538

Frey, R., Pedroni, A., Mata, R., Rieskamp, J., & Hertwig, R. (2017). Risk preference shares the psychometric structure of major psychological traits. *Science Advances*, *3*(10), e1701381. https://doi.org/10.1126/sciadv.1701381

Fugelsang, J. A., & Thompson, V. A. (2000). Strategy selection in causal reasoning: When beliefs and covariation collide. *Canadian Journal of Experimental Psychology*, *54*(1), 15-32. 10.1037/h0087327

Fugelsang, J. A., & Thompson, V. A. (2003). A dual-process model of belief and evidence interactions in causal reasoning. *Memory & Cognition*, *31*(5), 800-815. https://doi.org/10.3758/bf03196118

Fujita, K., & Carnevale, J. J. (2012). Transcending temptation through abstraction: The role of construal level in self-control. *Current Directions in Psychological Science*, *21*(4), 248-252. https://doi.org/10.1177/0963721412449169

Fujita, K. & Roberts, J.C.. (2010). Promoting prospective self-control through abstraction. *Journal of Experimental Social Psychology, 46*, 1049-1054. https://doi.org/10.1016/j.jesp.2010.05.013

Funder, D. C., & Ozer, D. J. (2019). Evaluating effect size in psychological research: Sense and nonsense. *Advances in Methods and Practices in Psychological Science*, *2*(2), 156-168. https://doi.org/10.1177/2515245919847202

Furnham, A., & Boo, H. C. (2011). A literature review of the anchoring effect. *The Journal of Socio-economics*, *40*(1), 35-42. https://doi.org/10.1016/j.socec.2010.10.008

Gabadinho, A., Ritschard, G., Müller, N.S. & Studer, M. (2011). Analyzing and visualizing state sequences in R with TraMineR. *Journal of Statistical Software, 40*(4), 1-37. https://doi.org/10.18637/jss.v040.i04

Gal, I, & Baron, J. (1996). Understanding repeated simple choices. *Thinking & Reasoning*, *2*(1), 81-98. https://doi.org/10.1080/135467896394573

Gao, J., & Corter, J. E. (2015). Striving for perfection and falling short: The influence of goals on probability matching. *Memory & Cognition*, *43*(5), 748-759. https://doi.org/10.3758/s13421-014-0500-4

Gill, D., & Prowse, V. (2012). A structural analysis of disappointment aversion in a real effort competition. *American Economic Review*, *102*(1), 469-503. https://doi.org/10.1257/aer.102.1.469

Gilovich, T., Vallone, R., & Tversky, A. (1985). The hot hand in basketball: On the misperception of random sequences. *Cognitive Psychology*, *17*(3), 295-314. https://doi.org/10.1017/cbo9780511808098.035

Gomez, R., Cooper, A., & Gomez, A. (2005). An item response theory analysis of the Carver and White (1994) BIS/BAS scales. *Personality and Individual Differences*, *39*(6), 1093-1103. https://doi.org/10.1016/j.paid.2005.03.015

Green, L., Fristoe, N., & Myerson, J. (1994). Temporal discounting and preference reversals in choice between delayed outcomes. *Psychonomic Bulletin & Review*, *1*(3), 383-389. https://doi.org/10.3758/bf03213979

Gneezy, U., & Potters, J. (1997). An experiment on risk taking and evaluation periods. *The Quarterly Journal of Economics, 112*, (2), 631-645. https://doi.org/10.1162/003355397555217

Gourville, J. T. (1998). Pennies-a-day: The effect of temporal reframing on transaction evaluation. *Journal of Consumer Research*, *24*(4), 395-408. https://doi.org/10.1086/209517

Grant, D. A., & Berg, E. (1948). A behavioral analysis of degree of reinforcement and ease of shifting to new responses in a Weigl-type card-sorting problem. *Journal of Experimental Psychology*, *38*(4), 404-411. https://doi.org/10.1037/h0059831

Gray, J. A. (1972). The psychophysiological nature of introversion—extraversion: A modification of Eysenck's theory. In V. D. Nebylitsyn (Ed.) *Biological bases of individual behaviors* (pp. 182-201). Academic Press. https://doi.org/10.1016/b978-0-12-515350-8.50017-x

Gray, L. N., & Tallman, I. (1984). A satisfaction balance model of decision making and choice behavior. *Social Psychology Quarterly*, *47*(2), 146-159. https://doi.org/10.2307/3033943

Gul, F. (1991). A theory of disappointment aversion. *Econometrica: Journal of the Econometric Society*, 667-686. https://doi.org/10.2307/2938223

Hadar, L., Danziger, S., & Morwitz, V. G. (2020). Choice bracketing and experience-based choice. *Journal of Behavioral Decision Making,* 1-14. https://doi.org/10.1002/bdm.2218

Haigh, M. S., & List, J. A. (2005). Do professional traders exhibit myopic loss aversion? An experimental analysis. *The Journal of Finance*, *60*(1), 523-534. https://doi.org/10.1111/j.1540-6261.2005.00737.x

Hassin, R., Bargh, J., & Uleman, J. (2002). Spontaneous causal inferences. *Journal of Experimental Social Psychology, 38*, 515-522. https://doi.org/10.1016/s0022-1031(02)00016-1

Havlicek, J. (2010). Patterns of movement in foster care: An optimal matching analysis. *Social Service Review*, *84*(3), 403-435. https://doi.org/10.1086/656308

Herndon, B., & Lewis, K. (2015). Applying sequence methods to the study of team temporal dynamics. *Organizational Psychology Review*, *5*(4), 318-332. https://doi.org/10.1177/2041386614538276

Herrnstein, R.J. & Prelec, D. (1991). Melioration: A theory of distributed choice. *Journal of Economic Perspectives, 5*(3), 137-156. https://doi.org/10.1257/jep.5.3.137

Heyman, G. M. (1996). Resolving the contradictions of addiction. *Behavioral and Brain Sciences*, 19, 561-610. https://doi.org/10.1017/s0140525x00042990

Hilgers, D. & Wibral, M. (2014). *How malleable are choice brackets? The case of myopic loss aversion*. (Working Paper). University of Bonn. http://researchers-sbe.unimaas.nl/gsbe-etbc/wp-content/uploads/sites/38/2014/11/JMP-HilgersWibral-Malleability.pdf

Holmes, M. E. (1997). Optimal matching analysis of negotiation phase sequences in simulated and authentic hostage negotiations. *Communication Reports*, *10*(1), 1-8. https://doi.org/10.1080/08934219709367654

Hsee, C. K., Loewenstein, G. F., Blount, S., & Bazerman, M. H. (1999). Preference reversals between joint and separate evaluations of options: a review and theoretical analysis. *Psychological Bulletin*, *125*(5), 576-590. https://doi.org/10.1037/0033-2909.125.5.576

Hsee, C. K., Rottenstreich, Y., & Xiao, Z. (2005). When is more better? On the relationship between magnitude and subjective value. *Current Directions in Psychological Science*, *14*(5), 234-237. https://doi.org/10.1111/j.0963-7214.2005.00371.x

Hsiaw, A. (2018). Goal bracketing and self-control. *Games and Economic Behavior, 111*, 100-121. https://doi.org/10.1016/j.geb.2018.06.005

Jorm, A. F., Christensen, H., Henderson, A. S., Jacomb, P. A., Korten, A. E., & Rodgers, B. (1998). Using the BIS/BAS scales to measure behavioural inhibition and behavioural activation: Factor structure, validity and norms in a large community sample. *Personality and individual Differences*, *26*(1), 49-58. https://doi.org/10.1016/s0191-8869(98)00143-3

Kalayci, K., & Serra-Garcia, M. (2012). *Complexity and biases: An experimental study*. (Working Paper). University of Queensland.

Kahneman, D. (1992). Reference points, anchors, norms, and mixed feelings. *Organizational Behavior and Human Decision Processes*, *51*(2), 296-312. https://doi.org/10.1016/0749-5978(92)90015-y

Kahneman, D. & Lovallo, D. (1993). Timid choices and bold forecasts: A cognitive perspective on risk taking. *Management Science, 39*(1), 17-31. https://doi.org/10.1017/cbo9780511803475.023

Keatley, D. A., & Clarke, D. D. (2020). Crime linkage: Finding a behavioral fingerprint using the "path similarity metric". *Journal of Police and Criminal Psychology*, *35*(2), 240-246. https://doi.org/10.1007/s11896-019-9315-3

Keren, G. (1991). Calibration and probability judgements: Conceptual and methodological issues. *Acta Psychologica*, *77*(3), 217-273. https://doi.org/10.1016/0001-6918(91)90036-y

Keren, G. & Wagenaar, W.A. (1987). Violation of utility theory in unique and repeated gambles. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 13*(3), 387-391. https://doi.org/10.1037/0278-7393.13.3.387

Kim, H., Schnall, S., & White, M. P. (2013). Similar psychological distance reduces temporal discounting. *Personality and Social Psychology Bulletin*, *39*(8), 1005-1016. https://doi.org/10.1177/0146167213488214

Knetsch, J. L., & Sinden, J. A. (1984). Willingness to pay and compensation demanded: Experimental evidence of an unexpected disparity in measures of value. *The Quarterly Journal of Economics*, *99*(3), 507-521. https://doi.org/10.2307/1885962

Koch, A.K. & Nafziger, J. (2016). Goals and bracketing under mental accounting. *Journal of Economic Theory, 162*, 305-351. https://doi.org/10.1016/j.jet.2016.01.001

Koch, A.K. & Nafziger, J. (2019). Correlates of narrow bracketing. *The Scandanavian Journal of Economics, 121*(4), 1441-1472. https://doi.org/10.1111/sjoe.12311

Koch, A.K. & Nafziger, J. (2020). Motivational goal bracketing: An experiment. *Journal of Economic Theory, 185*, 104949. https://doi.org/10.1016/j.jet.2019.104949

Koerner, N., Mejia, T., & Kusec, A. (2017). What's in a name? Intolerance of uncertainty, other uncertainty-relevant constructs, and their differential relations to worry and generalized anxiety disorder. *Cognitive Behaviour Therapy*, *46*(2), 141-161. https://doi.org/10.1080/16506073.2016.1211172

Langer, T., & Weber, M. (2001). Prospect theory, mental accounting, and differences in aggregated and segregated evaluation of lottery portfolios. *Management Science*, *47*(5), 716-733. https://doi.org/10.1287/mnsc.47.5.716.10483

Larson, F., List, J. A., & Metcalfe, R. D. (2016). *Can myopic loss aversion explain the equity premium puzzle? Evidence from a natural field experiment with professional traders* (NBER Working Paper No. w22605). National Bureau of Economic Research: https://www.nber.org/papers/w22605.pdf.

Lauriola M., Panno, A., Levin, I.P., Lejuez, C. W. (2013). Individual differences in risky decision making: A meta-analysis of sensation seeking and impulsivity with the balloon analogue risk task. Journal of Behavioral Decision Making, 27(1), 20-36. https://doi.org/10.1002/bdm.1784

Lejuez, C. W., Aklin, W., Daughters, S., Zvolensky, M., Kahler, C., & Gwadz, M. (2007). Reliability and validity of the youth version of the Balloon Analogue Risk Task (BART–Y) in the assessment of risk-taking behavior among inner-city adolescents. *Journal of*

Clinical Child and Adolescent Psychology, *36*(1), 106-111. https://doi.org/10.1207/s15374424jccp3601_11

Lejuez, C.W., Read, J.P., Kahler, C. W., Richards, J.B., Ramsey, S.E., Stuart, G.L., Strong, D.R., Brown, R.A. (2002). Evaluation of a behavioral measure of risk taking: The balloon analogue risk task (BART). *Journal of Experimental Psychology: Applied, 8*(2), 75-84. https://doi.org/10.1037/1076-898x.8.2.75

Leopard, A. (1978). Risk preference in consecutive gambling. *Journal of Experimental Psychology: Human Perception and Performance, 4*(3), 521-528. https://doi.org/10.1037/0096-1523.4.3.521

Lermer, E., Streicher, B., Sachs, R., Raue, M., & Frey, D. (2015). The effect of construal level on risk-taking. *European Journal of Social Psychology*, *45*(1), 99-109. https://doi.org/10.1002/ejsp.2067

Li, S. (2003). The role of expected value illustrated in decision-making under risk: Single-play vs multiple-play. *Journal of Risk Research*, *6*(2), 113-124. https://doi.org/10.1080/1366987032000078893

Loewenstein, G. F., Weber, E. U., Hsee, C. K., & Welch, N. (2001). Risk as feelings. *Psychological Bulletin*, *127*(2), 267-286. https://doi.org/10.1037/0033-2909.127.2.267

Loomes, G., & Sugden, R. (1986). Disappointment and dynamic consistency in choice under uncertainty. *The Review of Economic Studies*, *53*(2), 271-282. https://doi.org/10.2307/2297651

Lopes, L. (1981). Decision making in the short run. *Journal of Experimental Psychology: Human Learning and Memory, 7*(5), 377–385. https://doi.org/10.1037/0278-7393.7.5.377

McCracken, J., Osterhout, C., & Voss, J. F. (1962). Effects of instructions in probability learning. *Journal of Experimental Psychology*, *64*(3), 267-271. https://doi.org/10.1037/h0044543

Moher, E., & Koehler, D.J. (2010). Bracketing effects on risk tolerance: Generalizability and underlying mechanisms. *Judgment and Decision Making, 5*(5), 339-346. http://www.sjdm.org/~baron/journal/10/10422/jdm10422.pdf

Montgomery, H. & Adelbratt, T. (1982). Gambling decisions and information about expected value. *Organizational Behavior and Human Performance, 29*(1), 39-57. https://doi.org/10.1016/0030-5073(82)90241-0

Morewedge, C. K., & Kahneman, D. (2010). Associative processes in intuitive judgment. *Trends in Cognitive Sciences*, *14*(10), 435-440. https://doi.org/10.1016/j.tics.2010.07.004

Newell, B. R., Koehler, D. J., James, G., Rakow, T., & Van Ravenzwaaij, D. (2013). Probability matching in risky choice: The interplay of feedback and strategy availability. *Memory & Cognition*, *41*(3), 329-338. https://doi.org/10.3758/s13421-012-0268-3

Oncken, C., McKee, S., Krishnan-Sarin, S., O'Malley, S., & Mazure, C. M. (2005). Knowledge and perceived risk of smoking-related conditions: a survey of cigarette smokers. *Preventive Medicine*, *40*(6), 779-784. https://doi.org/10.1016/j.ypmed.2004.09.024

Oppenheimer, D. M., LeBoeuf, R. A., & Brewer, N. T. (2008). Anchors aweigh: A demonstration of cross-modality anchoring and magnitude priming. *Cognition*, *106*(1), 13-26. https://doi.org/10.1016/j.cognition.2006.12.008

Payne, J.W. (1973). Alternative approaches to decision making under risk: Moments versus risk dimensions. *Psychological Bulletin, 80*(6), 439-453. https://doi.org/10.1037/h0035260

Peterson, C. R., & Ulehla, Z. J. (1965). Sequential patterns and maximizing. *Journal of Experimental Psychology*, *69*(1), 1-4. https://doi.org/10.1037/h0021597

Pennycook, G., Fugelsang, J. A., & Koehler, D. J. (2015). What makes us think? A three-stage dual-process model of analytic engagement. *Cognitive Psychology*, *80*, 34-72. https://doi.org/10.1016/j.cogpsych.2015.05.001

Poole, M. S., & Holmes, M. E. (1995). Decision development in computer-assisted group decision making. *Human Communication Research*, *22*(1), 90-127. https://doi.org/10.1111/j.1468-2958.1995.tb00363.x

Rachlin, H. (1995). Self-control: Beyond commitment. *Behavioral and Brain Sciences,* 18, 109-159. https://doi.org/10.1017/s0140525x00037602

Rachlin, H., Logue, A. W., Gibbon, J., & Frankel, M. (1986). Cognition and behavior in studies of choice. *Psychological Review*, *93*(1), 33-45. https://doi.org/10.1037/0033-295x.93.1.33

Rabin, M. & Weizsäcker, G. (2009). Narrow bracketing and dominated choices. *American Economic Review, 99*(4), 1508-1543. https://doi.org/10.1257/aer.99.4.1508

Rao, H., Korczykowski, M., Pluta, J., Hoang, A., & Detre, J. A. (2008). Neural correlates of voluntary and involuntary risk taking in the human brain: an fMRI Study of the Balloon Analog Risk Task (BART). *Neuroimage*, *42*(2), 902-910. https://doi.org/10.1016/j.neuroimage.2008.05.046

Rapoport, A., & Wallsten, T. S. (1972). Individual decision behavior. *Annual Review of Psychology*, *23*(1), 131-176. https://doi.org/10.1146/annurev.ps.23.020172.001023

Read, D., Antonides, G., Ouden, L. & Trienekens, H. (2001). Which is better: Simultaneous or sequential choice? *Organizational Behavior and Human Decision Processes, 84*(1), 54-70. https://doi.org/10.1006/obhd.2000.2917

Read, D., & Loewenstein, G. (1995). Diversification bias: Explaining the discrepancy in variety seeking between combined and separated choices. *Journal of Experimental Psychology*, *1*(1), 34-49. https://doi.org/10.1037/1076-898x.1.1.34

Read, D., Loewenstein, G., & Kalyanaraman, S. (1999). Mixing virtue and vice: Combining the immediacy effect and the diversificiation heuristic. *Journal of Behavioral Decision Making, 12*, 257-273. https://doi.org/10.1002/(sici)1099-0771(199912)12:4<257::aid-bdm327>3.0.co;2-6

Read, D., Loewenstein, G., & Rabin, M. (1999). Choice bracketing. *Journal of Risk and Uncertainty, 19*, 171-197. https://doi.org/10.1023/a:1007879411489

Redelmeier, D. A., & Tversky, A. (1992). On the framing of multiple prospects. *Psychological Science*, *3*(3), 191-193. https://doi.org/10.1111/j.1467-9280.1992.tb00025.x

Roalf, D. R., Gur, R. E., Ruparel, K., Calkins, M. E., Satterthwaite, T. D., Bilker, W. B., ... & Gur, R. C. (2014). Within-individual variability in neurocognitive performance: Age-and sex-related differences in children and youths from ages 8 to 21. *Neuropsychology*, *28*(4), 506-518. https://doi.org/10.1037/neu0000067

Salvato, C. (2009). *The contribution of event-sequence analysis to the study of organizational routines*. In M. C. Becker, & N. Lazaric (Eds.), *Organizational routines: Advancing Empirical Research* (pp. 68-102). Edward Elgar.

Samuelson, P.A. (1963). Risk and uncertainty: A fallacy of large numbers. *Scientia, 98*, 108-113.

Savani, K., Weber, E., & Johnson, E. (2011). There is light at the end of the tunnel: Helping consumers avoid financial decision making biases by inducing broad bracketing. *Advances in Consumer Research, 39,* 180.

Schumpe, B. M., Brizi, A., Giacomantonio, M., Panno, A., Kopetz, C., Kosta, M., & Mannetti, L. (2017). Need for cognitive closure decreases risk taking and motivates discounting of delayed rewards. *Personality and Individual Differences*, *107*, 66-71. https://doi.org/10.1016/j.paid.2016.11.039

Shallice, T. (1982). Specific impairments of planning. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, *298*(1089), 199-209. https://doi.org/10.1098/rstb.1982.0082

Shanks, D. R. (2007). Associationism and cognition: Human contingency learning at 25. *Quarterly Journal of Experimental Psychology*, *60*(3), 291-309. https://doi.org/10.1080/17470210601000581

Shanks, D. R., Tunney, R. J., & McCarthy, J. D. (2002). A re-examination of probability matching and rational choice. *Journal of Behavioral Decision Making*, *15*(3), 233-250. https://doi.org/10.1002/bdm.413

Shannon, C. E. (1948). A mathematical theory of communication. *The Bell System Technical Journal*, *27*(3), 379-423. https://doi.org/10.1002/j.1538-7305.1948.tb01338.x

Shou, Y., & Olney, J. (2020). Assessing a domain-specific risk-taking construct: A meta-analysis of reliability of the DOSPERT scale. *Judgment and Decision Making, 15*(1), 112-134. https://psycnet.apa.org/record/2020-10523-008

Simmons, J. P., LeBoeuf, R. A., & Nelson, L. D. (2010). The effect of accuracy motivation on anchoring and adjustment: Do people adjust from provided anchors?. *Journal of Personality and Social Psychology*, *99*(6), 917-932. http://dx.doi.org/10.1037/a0021540

Simonson, I. (1990). The effect of purchase quantity and timing on variety seeking behaviour. *Journal of Marketing Research,* 32, 150-162. https://doi.org/10.2307/3172842.

Simonson, I., & Tversky, A. (1992). Choice in context: Tradeoff contrast and extremeness aversion. *Journal of Marketing Research*, *29*(3), 281-295. https://doi.org/10.2307/3172740

Smith, R. W., Faro, D., & Burson, K. A. (2013). More for the many: The influence of entitativity on charitable giving. *Journal of Consumer Research*, *39*(5), 961-976. https://doi.org/10.1086/666470

Sokol-Hessner, P., Hsu, M., Curley, N.G., Delgado, M.R., Camerer, C.F., Phelps, E.A. (2009). Thinking like a trader selectively reduces individuals' loss aversion. *Proceedings of the National Academy of Sciences*, *106*(13), 5035–5040. https://doi.org/10.1073/pnas.0806761106

Soman, D., & Cheema, A. (2004). When goals are counterproductive: The effects of violation of a behavioral goal on subsequent performance. *Journal of Consumer Research*, *31*(1), 52-62. https://doi.org/10.1086/383423

Sonsino, D. (2008). Disappointment aversion in internet bidding-decisions. *Theory and Decision*, *64*(2), 363-393. https://doi.org/10.1007/s11238-007-9055-1

Stanovich, K.E. (2010). *Rationality and the reflective mind*. Oxford University Press. https://doi.org/10.1093/acprof:oso/9780195341140.001.0001

Steingroever, H., Wetzels, R., Horstmann, A., Neumann, J., & Wagenmakers, E. J. (2013). Performance of healthy participants on the Iowa Gambling Task. *Psychological Assessment*, *25*(1), 180-193. https://doi.org/10.1037/a0029929

Stracke, R., Kerschbamer, R., & Sunde, U. (2015). *Prevalence and determinants of choice bracketing—Experimental evidence* [Paper presentation]. Vereins für Socialpolitik 2015: Ökonomische Entwicklung - Theorie und Politik: Competition and Collusion. Hamburg, Germany. https://www.econstor.eu/bitstream/10419/113092/1/VfS_2015_pid_141.pdf

Thaler, R. H. (1990). Anomalies: Saving, fungibility, and mental accounts. *Journal of Economic Perspectives*, *4*(1), 193-205. https://doi.org/10.1257/jep.4.1.193

Toda, M. (1962). The design of a fungus-eater: A model of human behavior in an unsophisticated environment. *Behavioral Science*, *7*(2), 164-183. https://doi.org/10.1002/bs.3830070203

Trautmann, S. T., & van de Kuilen, G. (2012). Prospect theory or construal level theory?: Diminishing sensitivity vs. psychological distance in risky decisions. *Acta psychologica*, *139*(1), 254-260. https://doi.org/10.1016/j.actpsy.2011.08.006

Trope, Y., & Liberman, N. (2003). Temporal construal. *Psychological Review*, *110*(3), 403-421. https://doi.org/10.1037/0033-295x.110.3.403

Trope, Y. & Liberman, N. (2011). Construal level theory. In P.A.M Van Lange, A.W. Kruglanski, & E.T. Higgins (Eds.), *Handbook of Theories of Social Psychology: Volume 1* (pp. 118-134). Sage.

Tversky, A. & Bar-Hillel, M. (1983). Risk: The long and the short. *Journal of Experimental Psychology: Learning, Memory and Cognition, 9*, 713-717. https://doi.org/10.1037/0278-7393.9.4.713

Tversky, A., & Edwards, W. (1966). Information versus reward in binary choices. *Journal of Experimental Psychology*, *71*(5), 680-683. https://doi.org/10.1037/h0023123

Tversky, A., & Kahneman, D. (1977). Causal thinking in judgment under uncertainty. In R. E. Butts & J. Hintikka (Eds.), *Basic problems in methodology and linguistics* (pp. 167-190). Springer. https://doi.org/10.1007/978-94-017-0837-1

Tversky, A., & Kahneman, D. (1979). Prospect theory: An analysis of decision under risk. *Econometrica, 47*(2), 263-291. https://doi.org/10.2307/1914185

Tversky, A. & Kahneman, D. (1981). The framing of decisions and the psychology of choice. *Science, 211*(4481), 453-458. https://doi.org/10.1126/science.7455683z

Van Laer, S., & Elen, J. (2018). Adults' self-regulatory behaviour profiles in blended learning environments and their implications for design. *Technology, Knowledge and Learning*, *25*, 509-539. https://doi.org/10.1007/s10758-017-9351-y

Verplanken, B., Walker, I., Davis, A., & Jurasek, M. (2008). Context change and travel mode choice: Combining the habit discontinuity and self-activation hypotheses. *Journal of Environmental Psychology*, *28*(2), 121-127. https://doi.org/10.1016/j.jenvp.2007.10.005

Wagemans, J., Elder, J. H., Kubovy, M., Palmer, S. E., Peterson, M. A., Singh, M., & von der Heydt, R. (2012). A century of Gestalt psychology in visual perception: I. Perceptual grouping and figure–ground organization. *Psychological Bulletin*, *138*(6), 1172-1217. https://doi.org/10.1037/a0029333

Wakslak, C., & Trope, Y. (2009). The effect of construal level on subjective probability estimates. *Psychological Science*, *20*(1), 52-58. https://doi.org/10.1111/j.1467-9280.2008.02250.x

Walpole, H. D., & Wilson, R. S. (2021). Extending a broadly applicable measure of risk perception: The case for susceptibility. *Journal of Risk Research*, *24*(2), 135-147. https://doi.org/10.1080/13669877.2020.1749874

Ward, J. H. (1963). Hierarchical grouping to optimize an objective function. *Journal of the American Statistical Association*, *58*(301), 236-244. https://doi.org/10.1080/01621459.1963.10500845

Webb, E. C. & Shu, S.B. (2013). *Choice bracketing and construal level theory: The effects of problem representation and mental representation on sequential risk-taking.* (Working Paper). UCLA Anderson School of Management, Department of Marketing. https://doi.org/10.1037/e513702014-045

Webb, E.C. & Shu, S.B. (2017). Is broad bracketing always better? How broad decision framing leads to more optimal preferences over repeated gambles. *Judgement and Decision Making, 12*(4), 382-395. http://finzi.psych.upenn.edu/journal/17/17317/jdm17317.pdf

Webb, E.C. & Shu, S.B. (2018). The effect of perceived similarity on sequential risk taking. *Journal of Marketing Research, 55*(6), 916-933. https://doi.org/10.1177/0022243718810800

Weber, E. U., Blais, A. R., & Betz, N. E. (2002). A domain-specific risk-attitude scale: Measuring risk perceptions and risk behaviors. *Journal of Behavioral Decision Making*, *15*(4), 263-290. https://doi.org/10.1002/bdm.414

Wedell, D.H. & Böckenhold, U. (1990). Moderation of preference reversals in the long run. *Journal of Experimental Psychology: Human Perception and Performance, 16*(2), 429-438. https://doi.org/10.1037/0096-1523.16.2.429

Wedell, D. H., & Böckenhold, U. (1994). Contemplating single versus multiple encounters of a risky prospect. *The American Journal of Psychology, 107*(4), 499-518. https://doi.org/10.2307/1422997

West, R. F., & Stanovich, K. E. (2003). Is probability matching smart? Associations between probabilistic choices and cognitive ability. *Memory & Cognition*, *31*(2), 243-251. https://doi.org/10.3758/bf03194383

Wiehe, S. E., Garrison, M. M., Christakis, D. A., Ebel, B. E., & Rivara, F. P. (2005). A systematic review of school-based smoking prevention trials with long-term follow-up. *Journal of Adolescent Health*, *36*(3), 162-169. https://doi.org/10.1016/j.jadohealth.2004.12.003

Wilson, R. S., Zwickle, A., & Walpole, H. (2019). Developing a broadly applicable measure of risk perception. *Risk Analysis*, *39*(4), 777-791. https://doi.org/10.1111/risa.13207

White, T. L., Lejuez, C. W., & de Wit, H. (2008). Test-retest characteristics of the Balloon Analogue Risk Task (BART). *Experimental and Clinical Psychopharmacology*, *16*(6), 565-570. https://doi.org/10.1037/a0014083

Włodarska, K. A., Zyskowska, E., Terebus, M. K., & Rogoza, R. (2019). The dark triad and BIS/BAS: A meta-analysis. *Current Psychology*, 1-9. https://doi.org/10.1007/s12144-019-00467-8

Wood, W., Tam, L., & de Witt, M. G. (2005). Changing circumstances, disrupting habits. *Journal of Personality and Social Psychology*, *88*(6), 918-933. https://doi.org/10.1037/0022-3514.88.6.918

Wood, S. & Schulman, K. (2021). Beyond politics – promoting Covid-19 vaccination in the United States. *The New England Journal of Medicine, 384*(7), e23. 10.1056/NEJMms2033790

Wulff, D. U., Hills, T. T., & Hertwig, R. (2015). How short-and long-run aspirations impact search and choice in decisions from experience. *Cognition*, *144*, 29-37. https://doi.org/10.1016/j.cognition.2015.07.006

Zanesco, A. P. (2020). Quantifying streams of thought during cognitive task performance using sequence analysis. *Behavior Research Methods*, *52*(6), 2417-2437. https://doi.org/10.3758/s13428-020-01416-1

Zellermayer, O. (1996). *The pain of paying* [Unpublished doctoral dissertation]. Carnegie Mellon University.

Zemack-Rugar, Y., Corus, C., & Brinberg, D. (2012). The "response-to-failure" scale: Predicting behavior following initial self-control failure. *Journal of Marketing Research*, *49*(6), 996-1014.

Footnotes

[1]This task is quite similar to the Balloon Analogue Risk Task (BART; Lejuez et al., 2002). On the BART, participants inflate a balloon with button-presses, and receive in-task money each time they inflate the balloon without it popping. They can, at any point, decide to stop inflating the balloon and collect the money they have earned so far. If the balloon pops, they lose all the money that had accrued by pumping up that specific balloon. They are presented with multiple balloons, and money earned is kept across balloons.

There are also some important differences between the BART and the task used in the present study. First, in the present task participants know how many points they have earned and stand to earn at all times during task administration; participants completing the BART do not know how much money they earn per pump of the balloon, and they do not know how much they have earned on a given balloon until they decide to collect the money for that balloon. One of the main goals of the present study is to understand the unique effect of choice bracketing, separate from outcome bracketing, on risk-taking. Thus, it was important to provide participants with very clear information about the quantity of points that corresponds to their past, current, and potential, risky behaviours.

A second difference involves distinguishing between present and cumulative risks. On both tasks, the present risk is the probability that the balloon or ice will break the next time a gamble is taken (the balloon is pumped with air, a penguin is placed on the ice). On the BART, present risks increase depending on how many previous risks have been taken—the more inflated the balloon is, the more likely it is that the next pump will pop the balloon. On the penguin task, present risks are always 5%. Risk increases cumulatively on both tasks because the risk of the ice breaking or balloon popping *at least once* increases as multiple risks are taken.

Risks were made to be independent on the present task to avoid interfering with the choice bracketing manipulation. If participants learn/infer that choices are associated—that is, that taking a gamble at one point in time changes the probabilities associated with a future gamble, that incentivizes them to bracket those choices broadly (see study 1 for evidence to this fact).

A third difference is that on the BART, participants keep the money they have earned across balloons. In the penguin task, participants do not keep the points across trials. The reason that there are multiple trials on the penguin task is to increase the precision of any quantitative estimates, not because there are hypotheses about changes in behaviour across trials. Maintaining points across trials introduces the possibility that participants will base their behaviour on the outcome of previous trials, which was not desirable in the present experiment.

Therefore, although the BART and the present task are quite similar, they are different in ways that are important to the research question under consideration (does choice bracketing affect risk perception?). The task introduced in this study should not be considered a replacement or alternative to the BART, which was designed as an assessment tool (Lejuez et al., 2002), and has shown utility in that role (e.g., Lauriola et al., 2013; Lejuez et al., 2007; Rao et al., 2008; White et al., 2008). The purpose of the present task is simply to allow us to investigate questions about the mechanisms that are affected by narrow vs. broad choice bracketing.

Appendix

Figure A1

Tutorial—Introduction Page

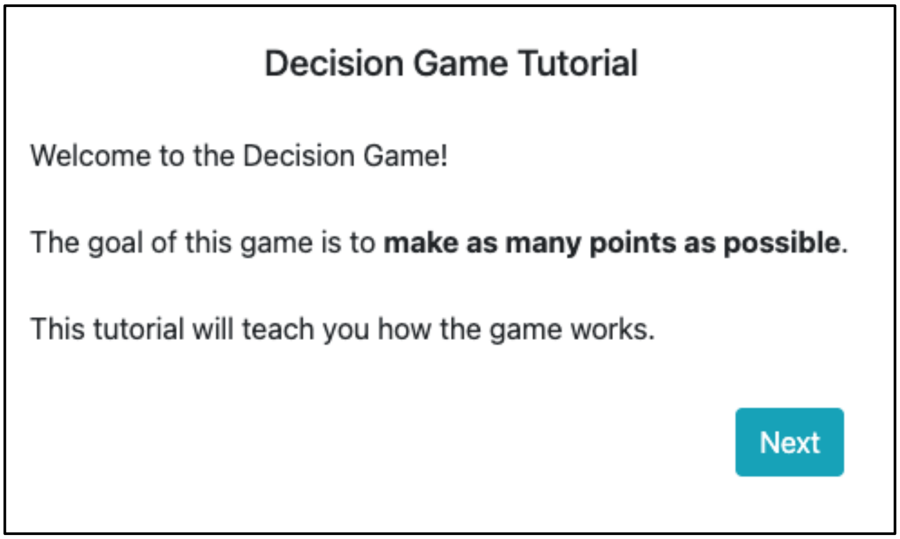


Figure A2

Tutorial—5 Points Button

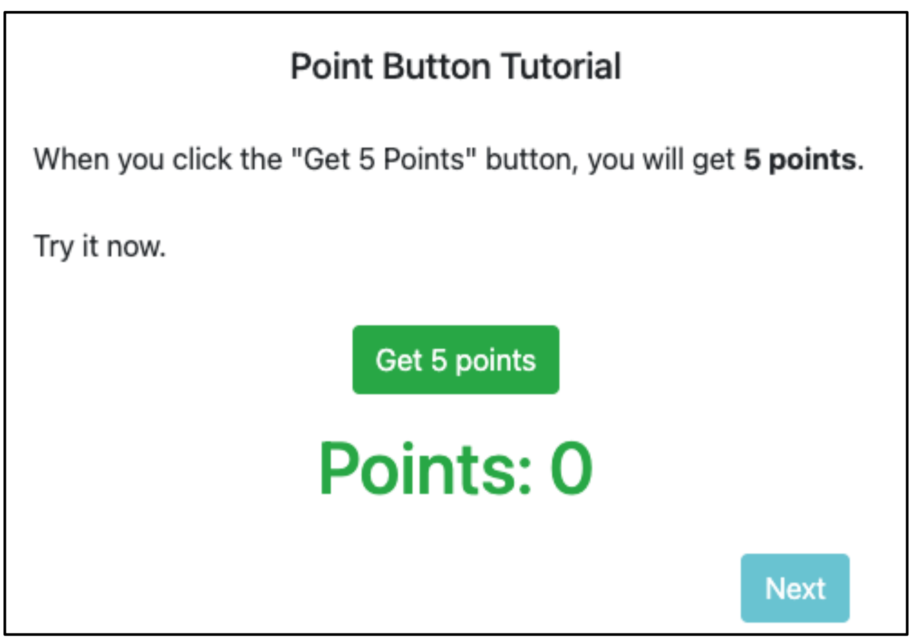


Figure A3

Tutorial—Play Roulette #1 Button

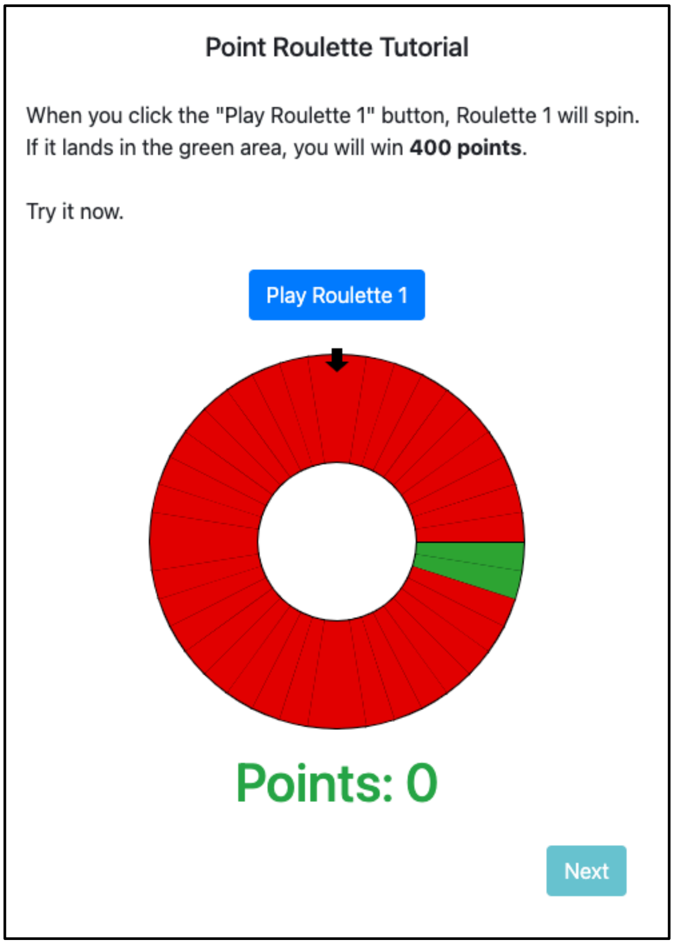


Figure A4

Tutorial—Buy Ticket Button

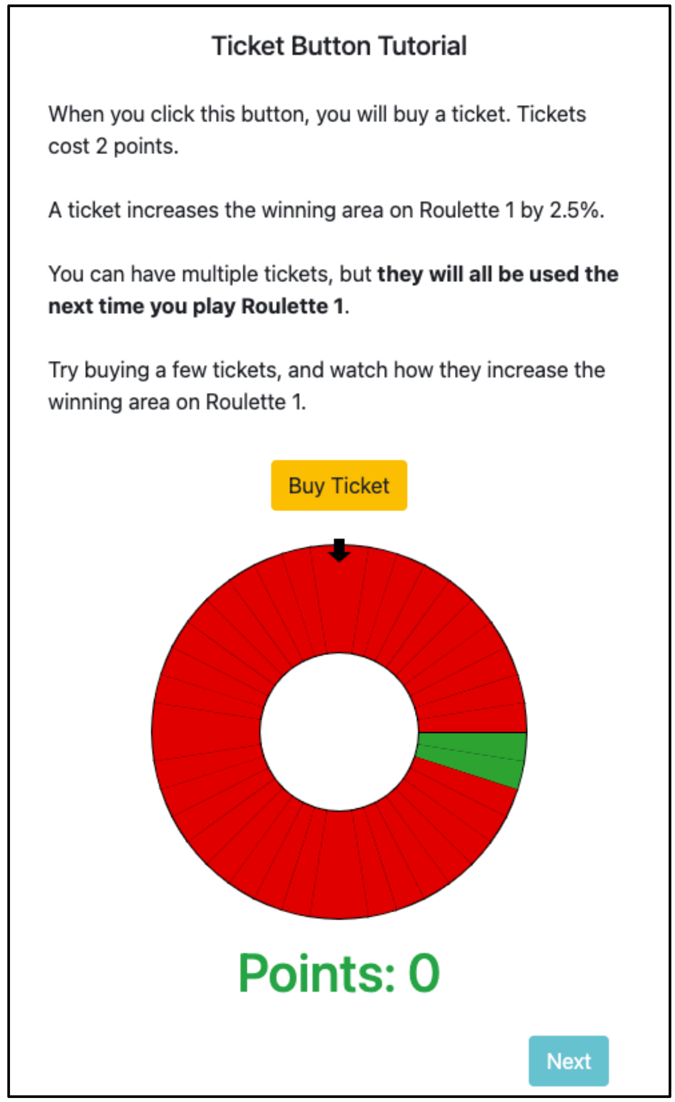


Figure A5

Tutorial—Play Roulette #2 Button

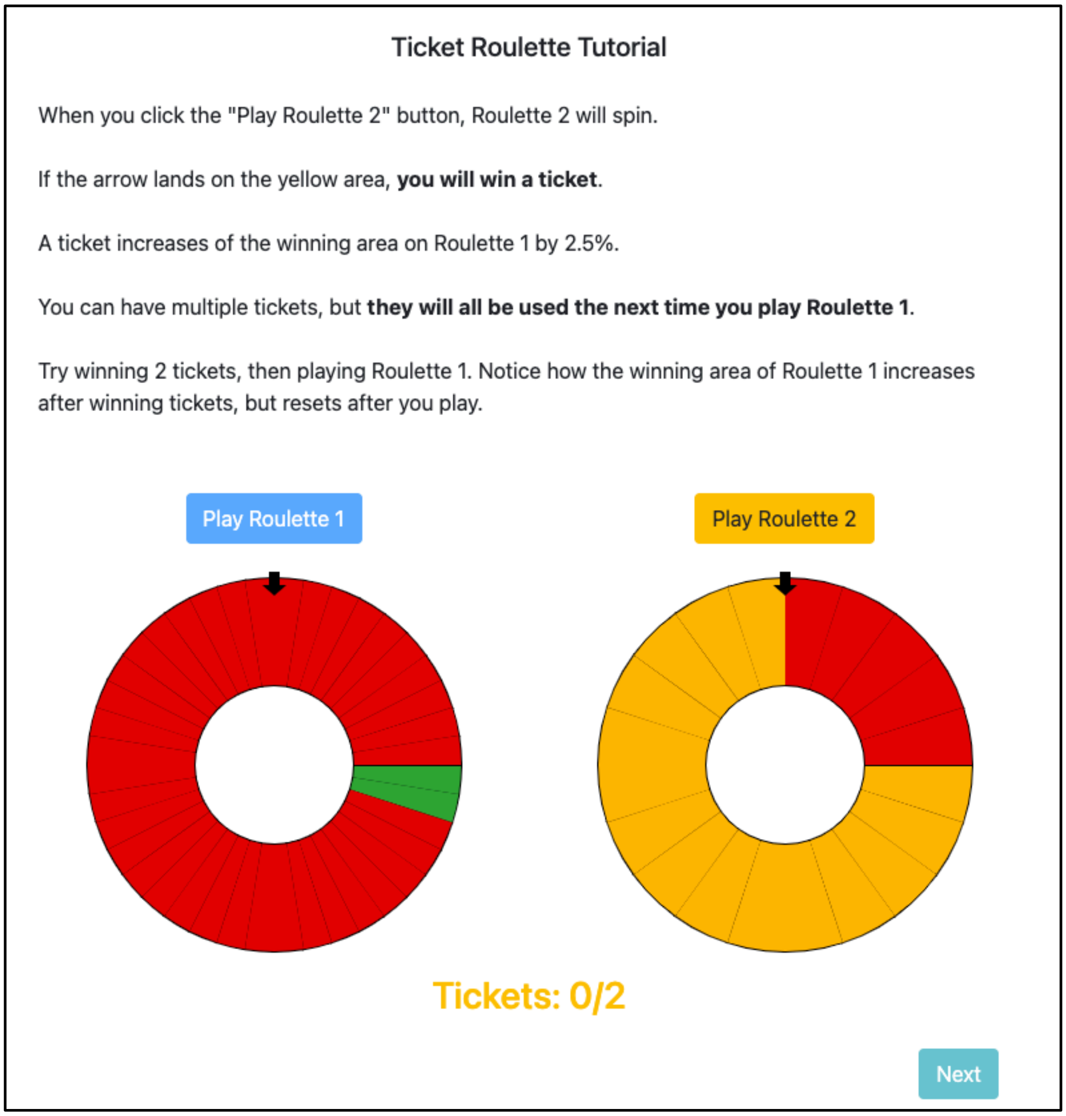


Figure A6

Tutorial—Summary (1 of 2)

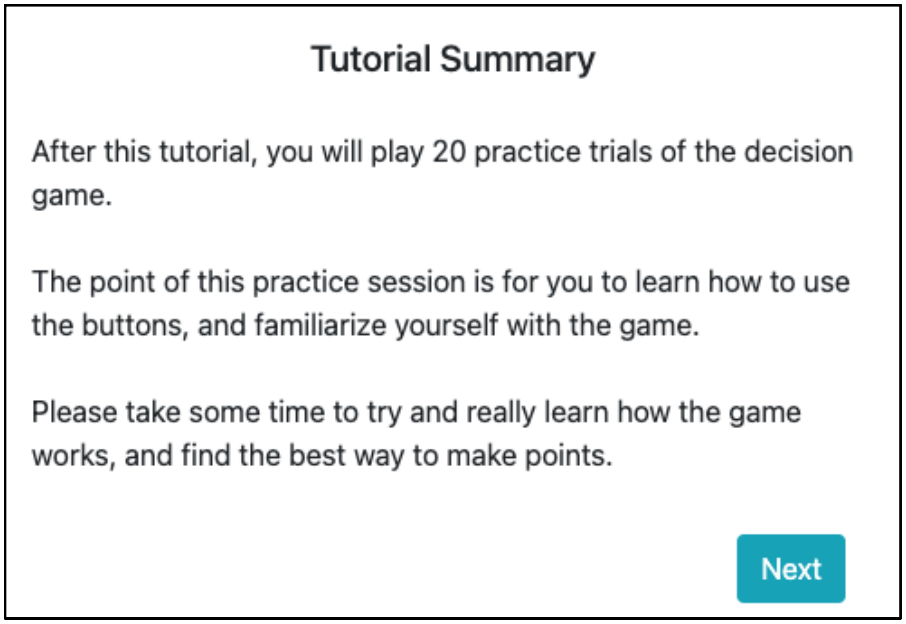


Figure A7

Tutorial—Summary (2 of 2)

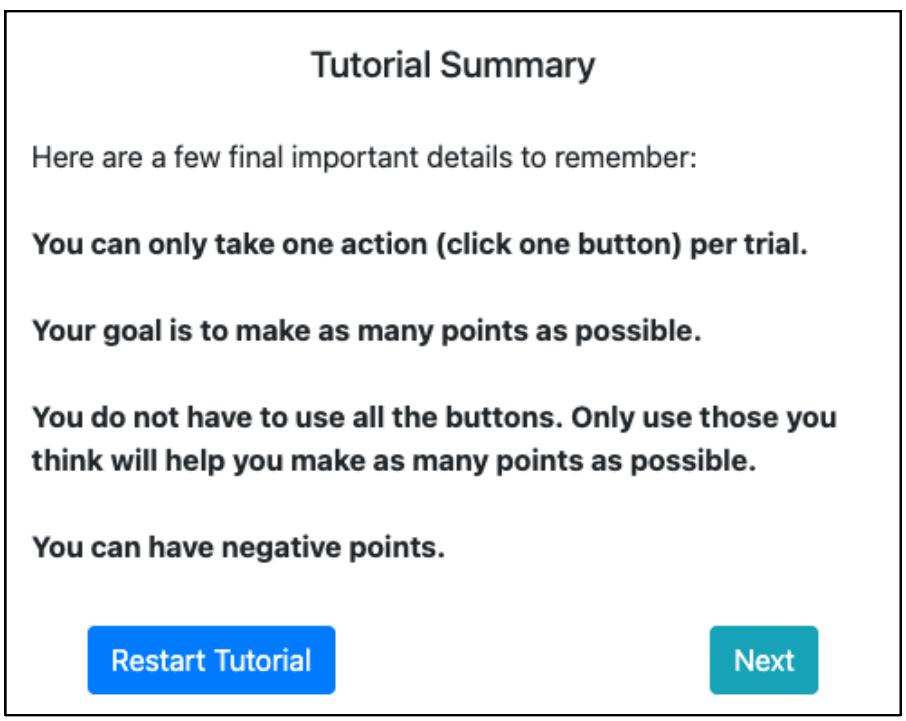


Figure A8

Condition 1—Unassociated Choices

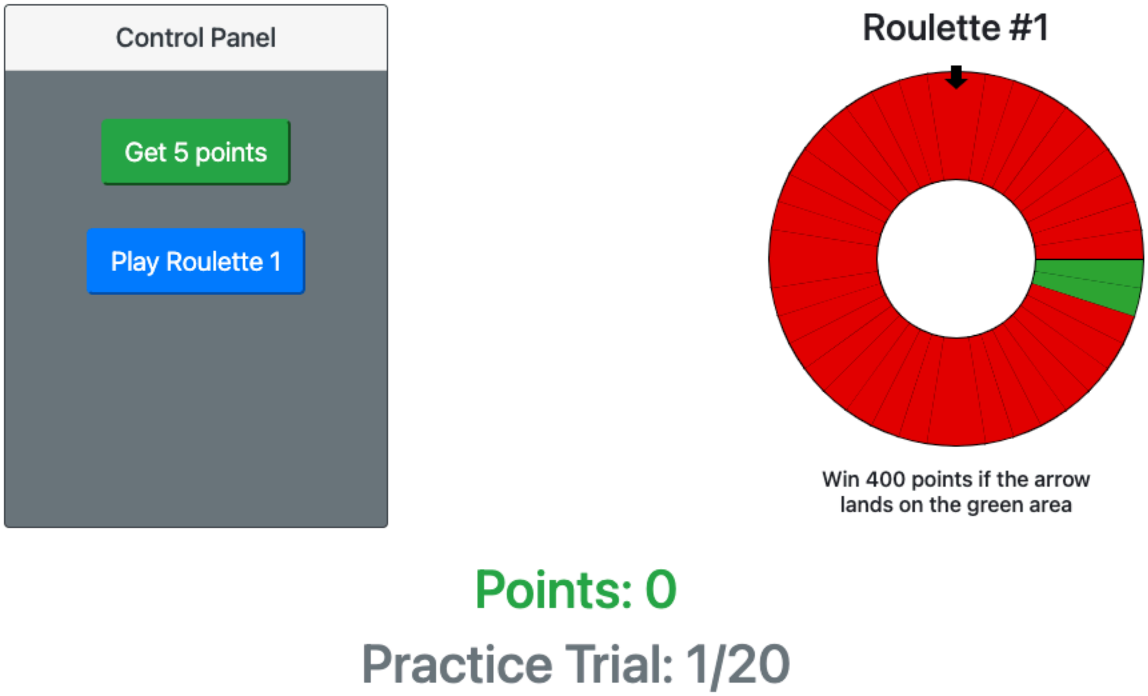


Figure A9

Condition 2—Probabilistic Association Between Choices

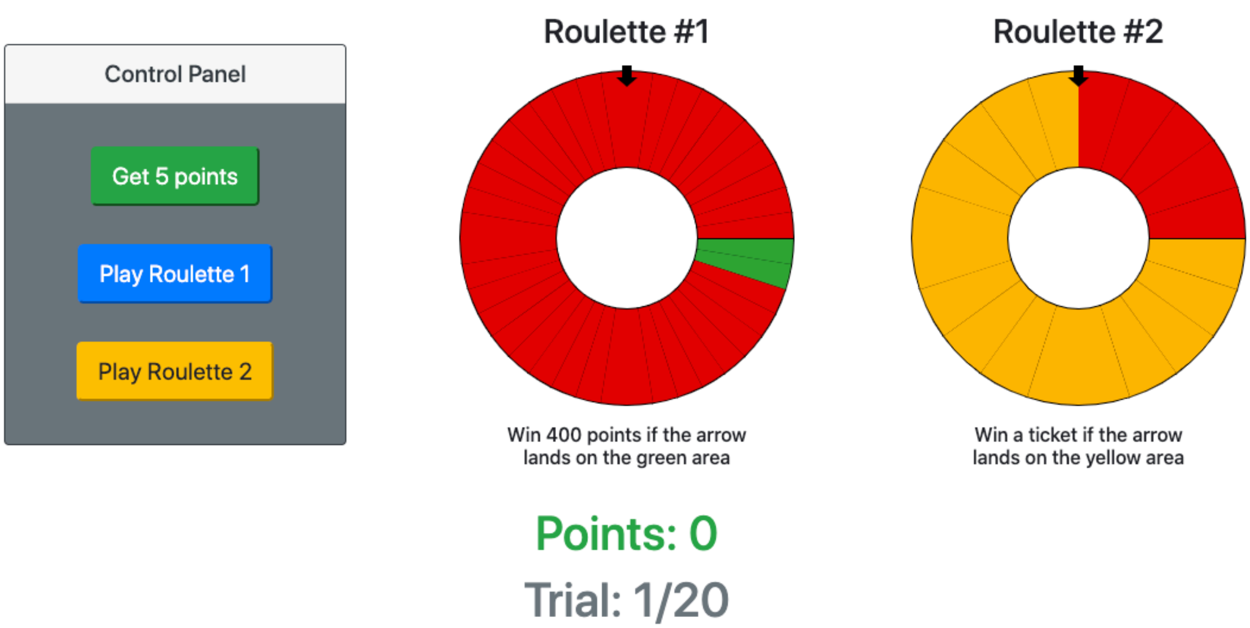


Figure A10

Condition 3—Deterministic Association Between Choices

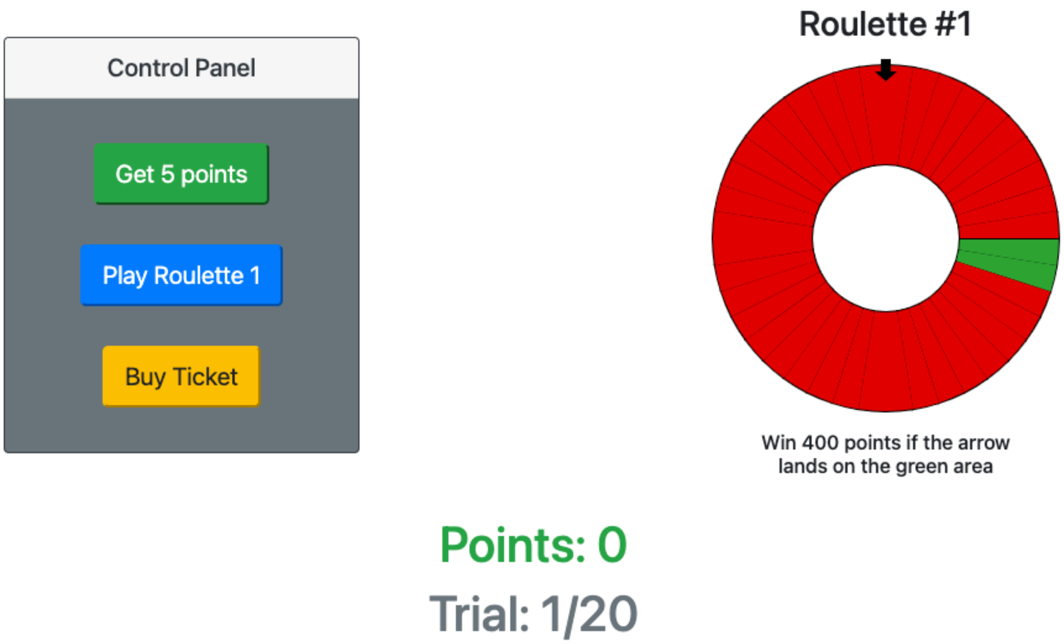


Figure A11

Condition 4—Full Design

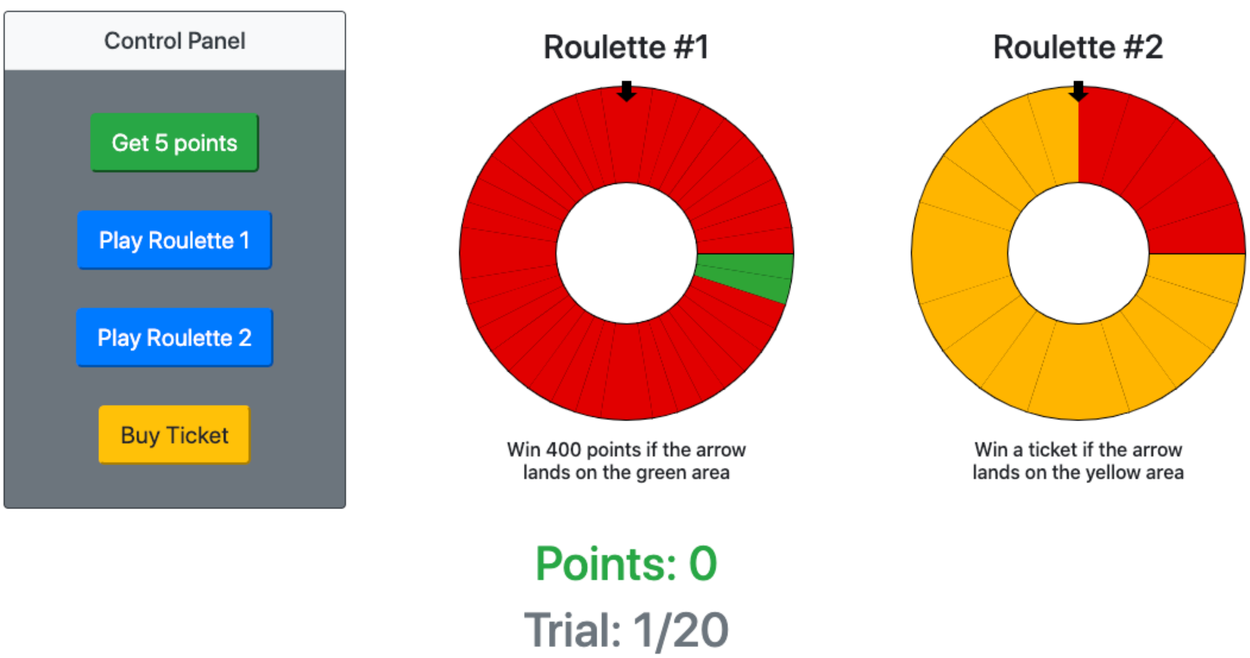


Figure A12

Study 2 Tutorial Page 1, Narrow Bracketing Condition

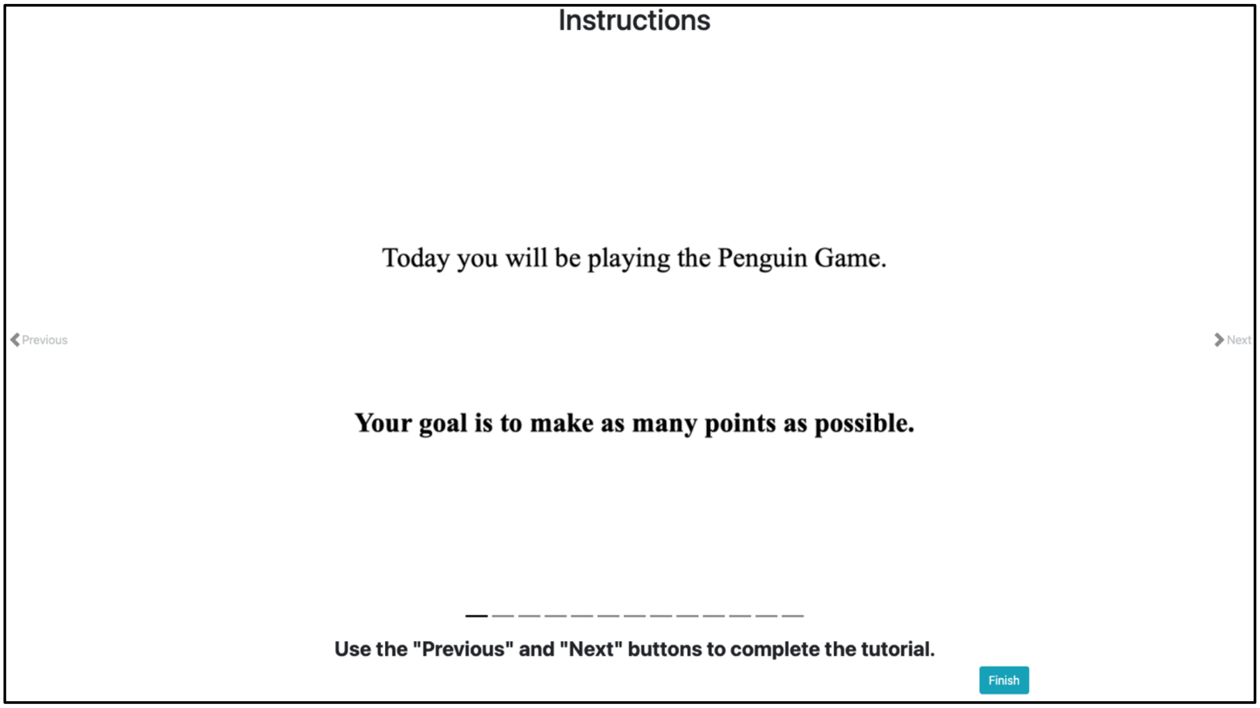


Figure A13

Study 2 Tutorial Page 2, Narrow Bracketing Condition

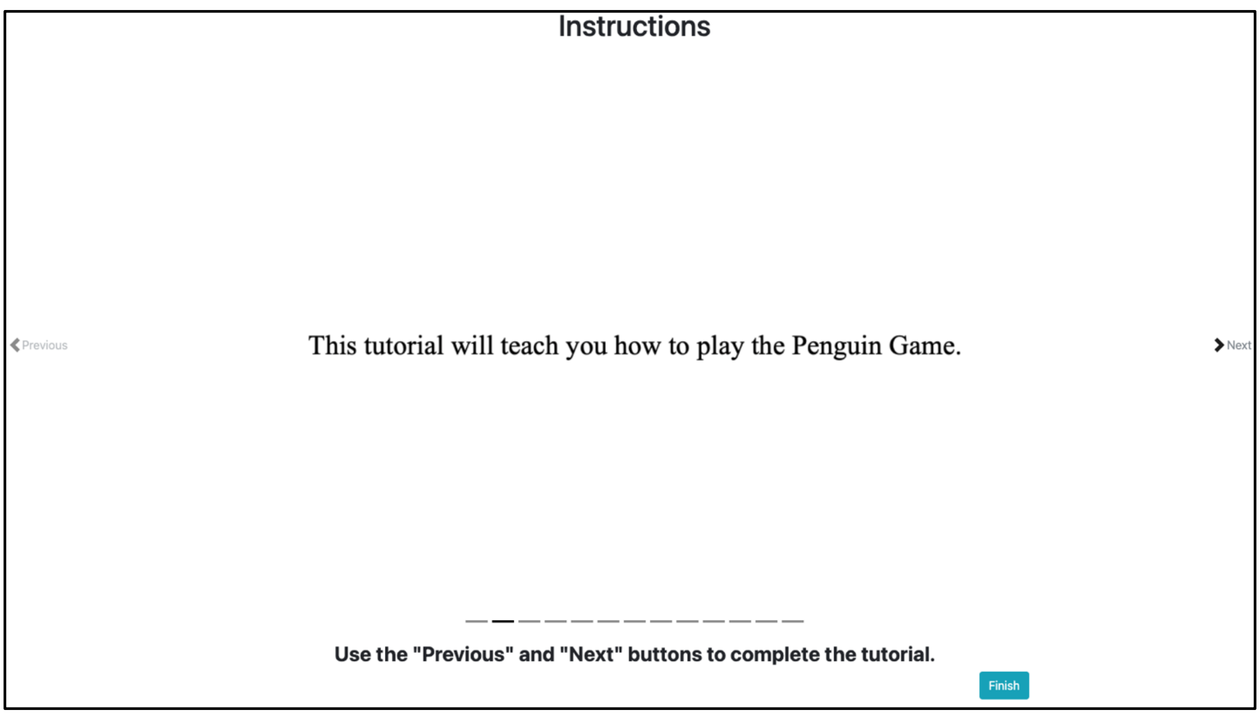


Figure A14

Study 2 Tutorial Page 3, Narrow Bracketing Condition

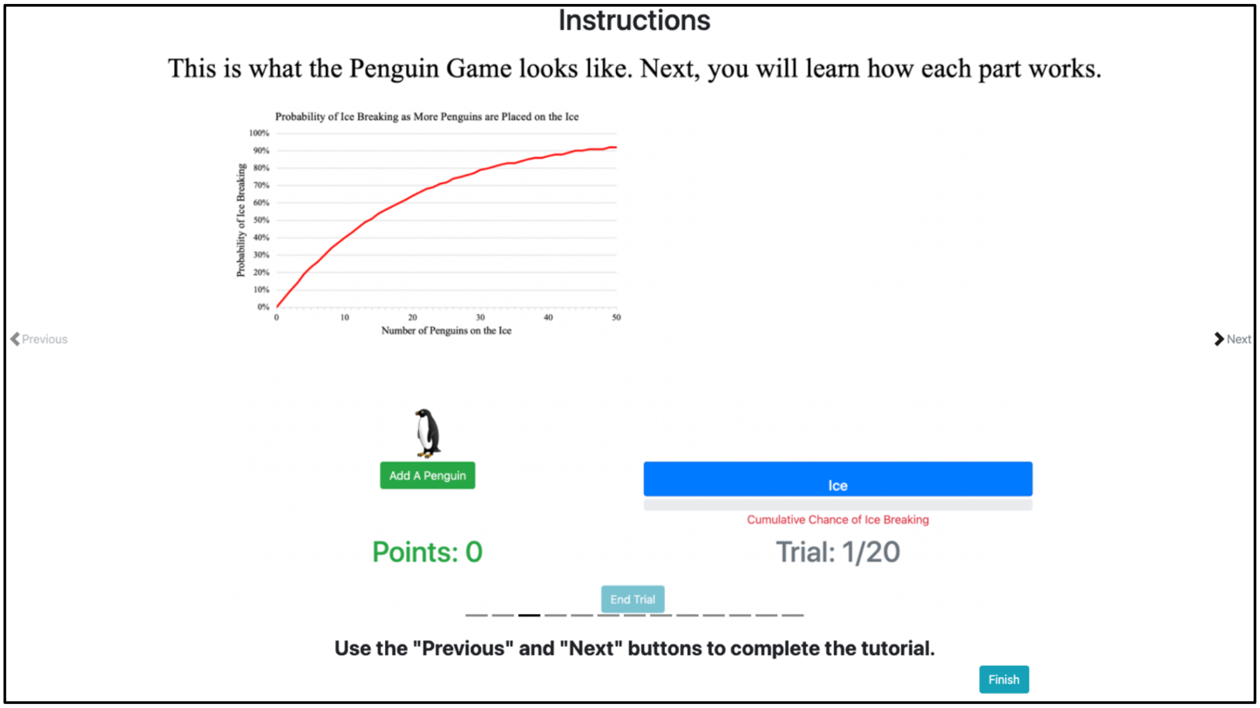


Figure A15

Study 2 Tutorial Page 4, Narrow Bracketing Condition

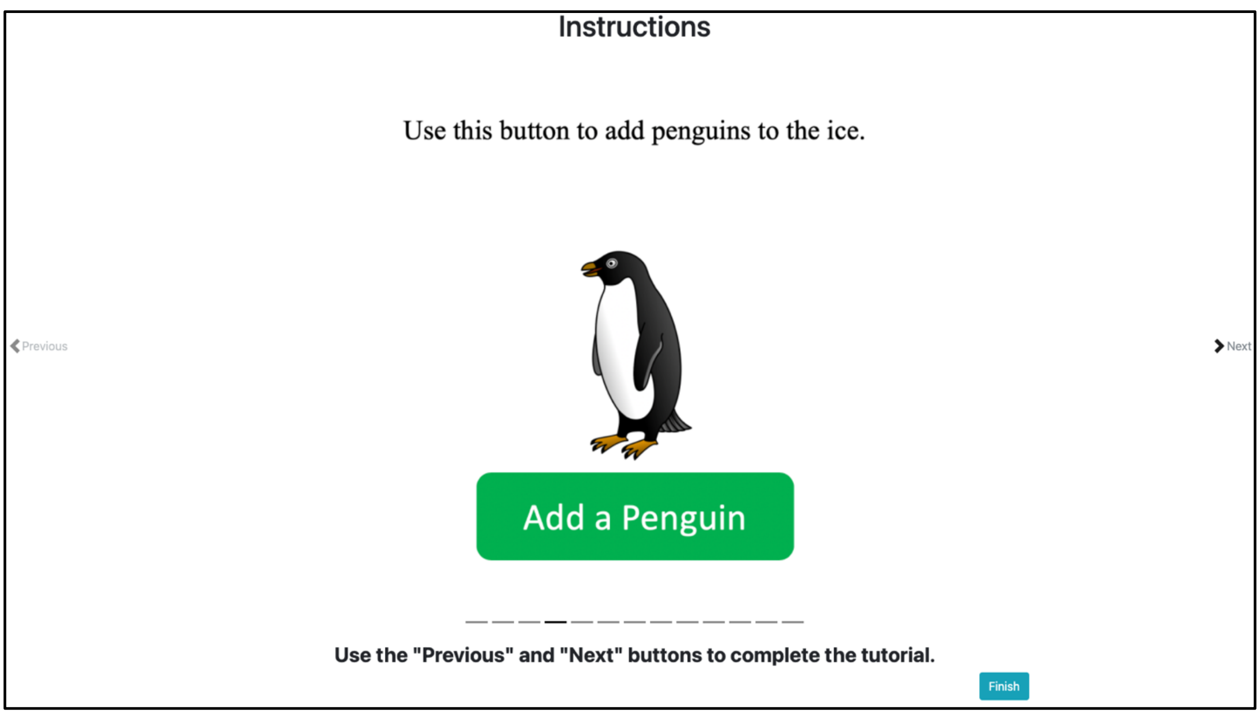


Figure A16

Study 2 Tutorial Page 5, Narrow Bracketing Condition

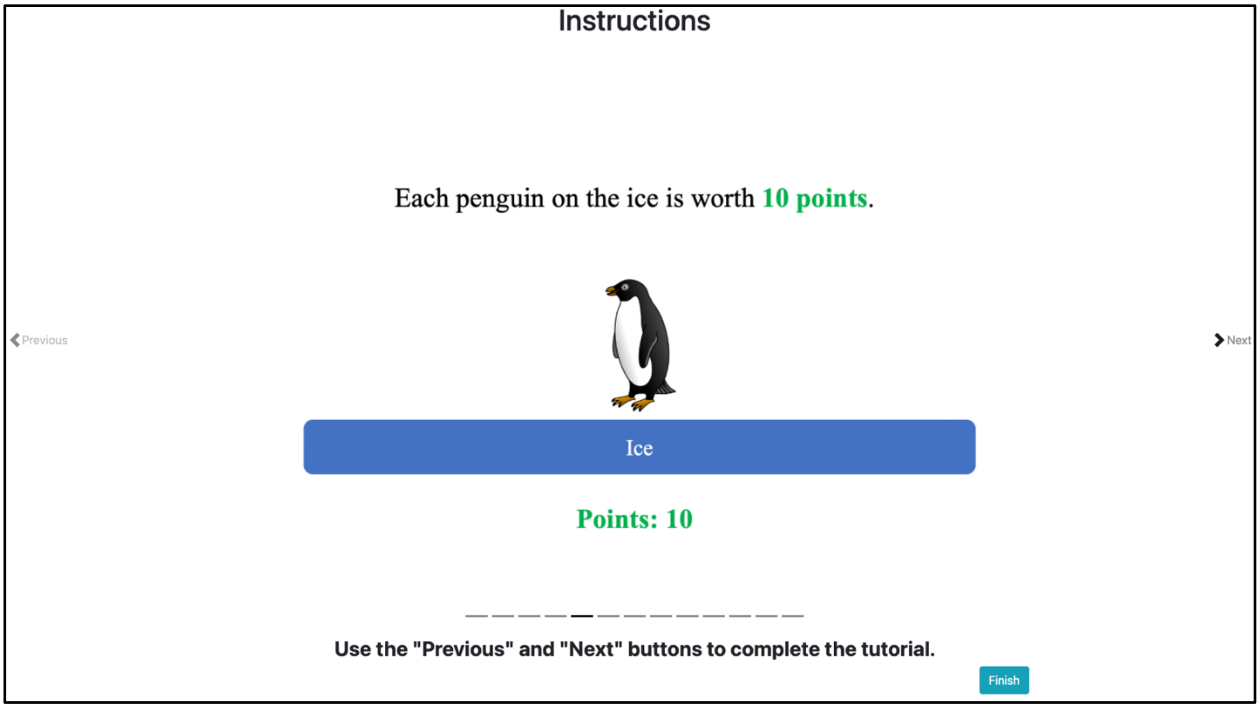


Figure A17

Study 2 Tutorial Page 6, Narrow Bracketing Condition

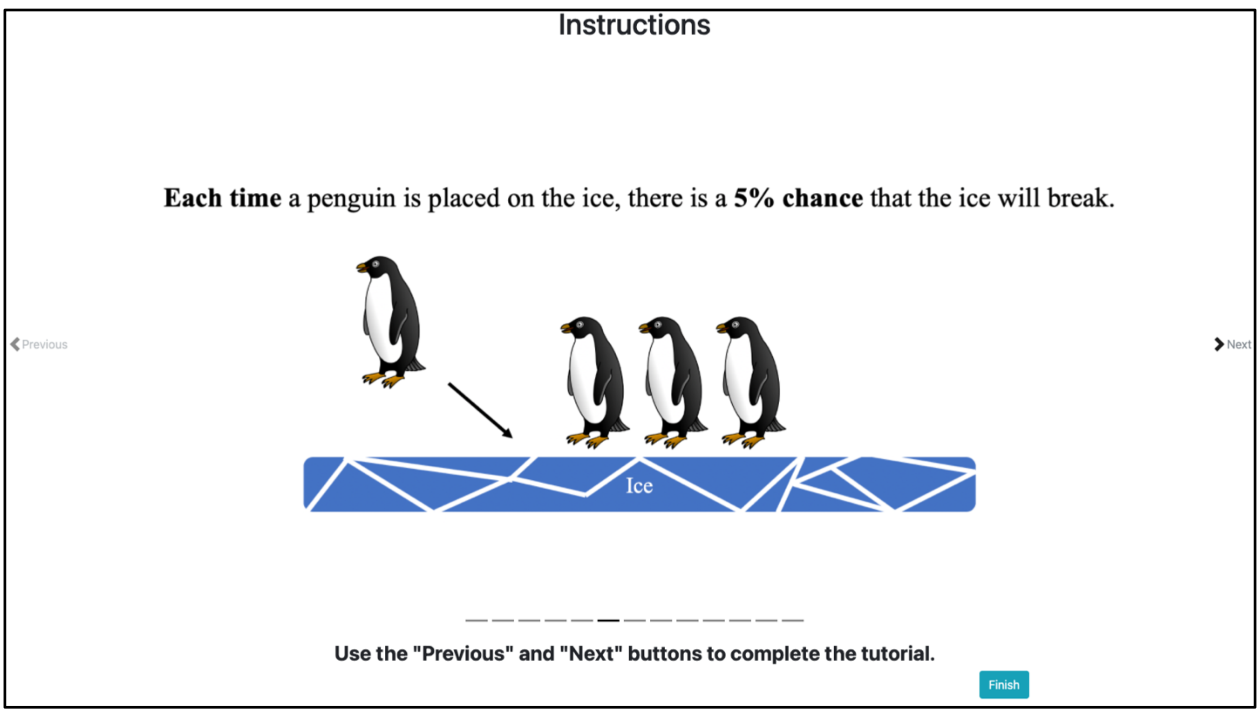


Figure A18

Study 2 Tutorial Page 7, Narrow Bracketing Condition

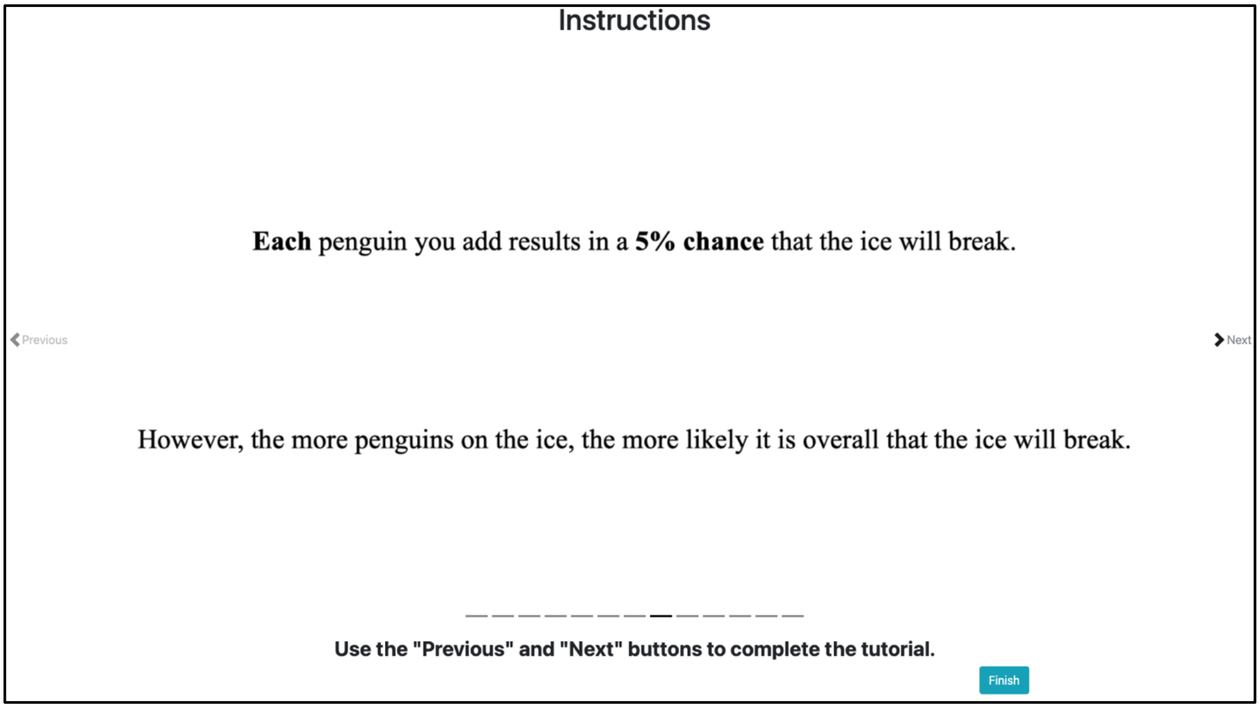


Figure A19

Study 2 Tutorial Page 8, Narrow Bracketing Condition

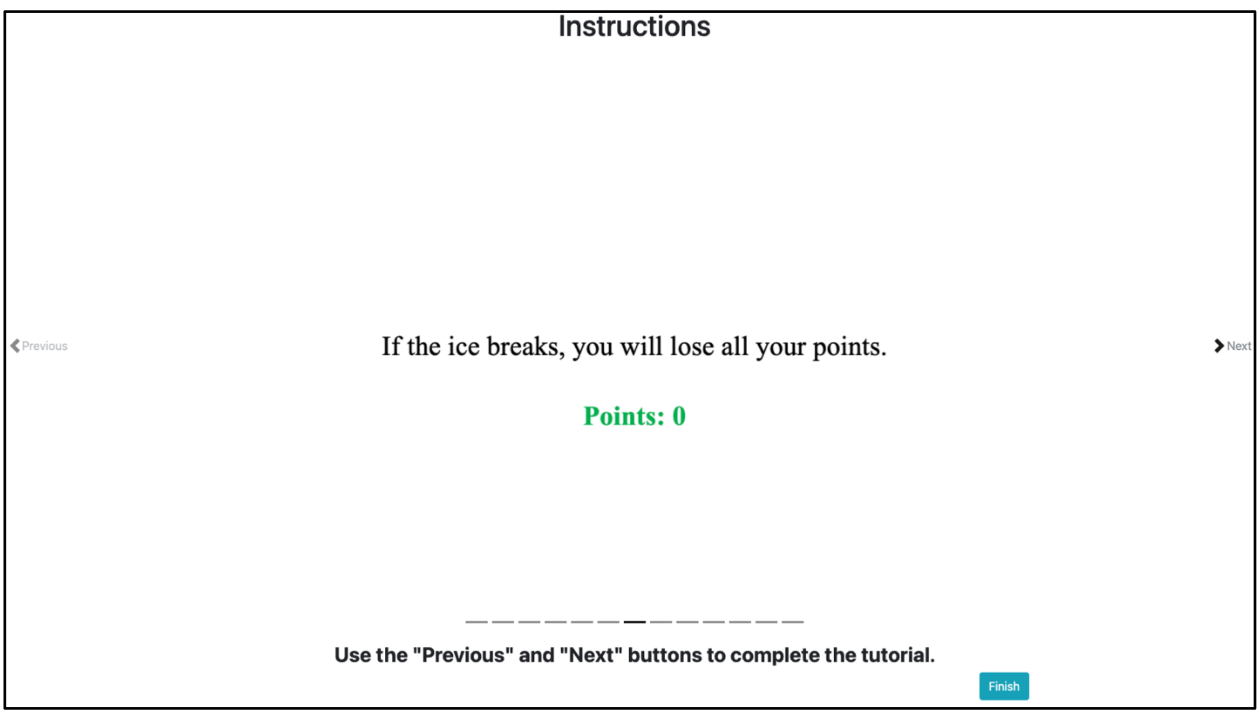


Figure A20

Study 2 Tutorial Page 9, Narrow Bracketing Condition

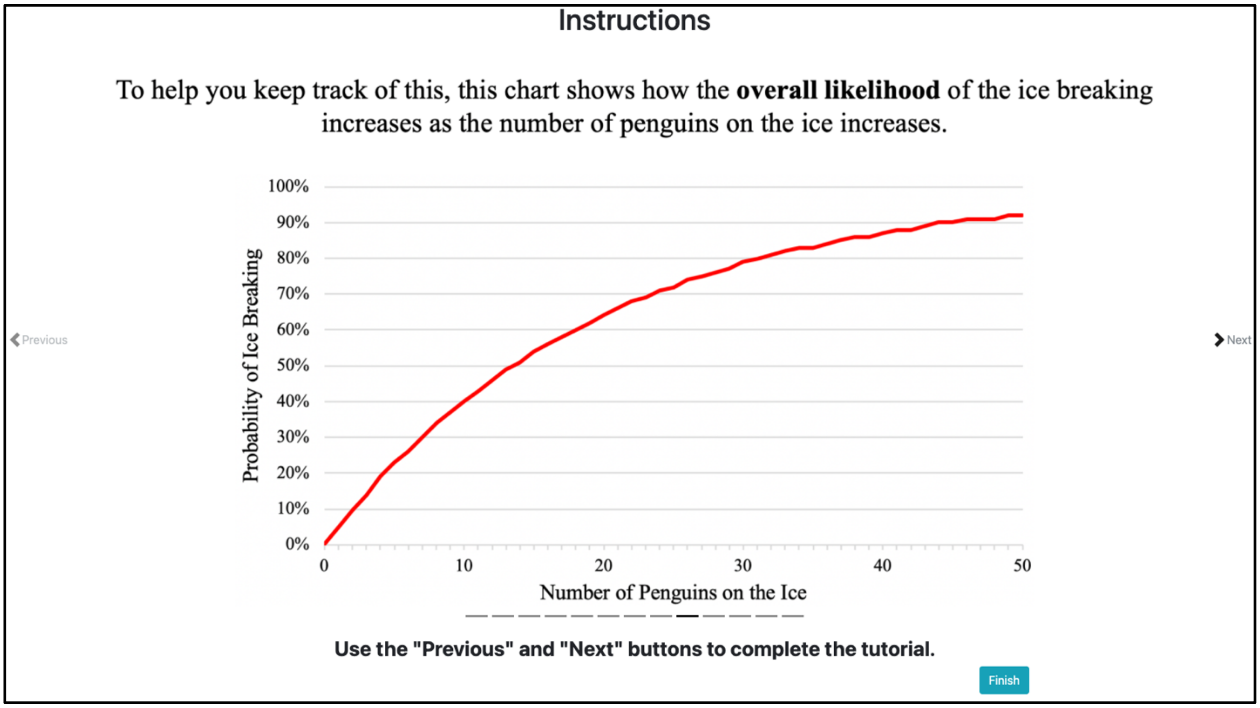


Figure A21

Study 2 Tutorial Page 10, Narrow Bracketing Condition

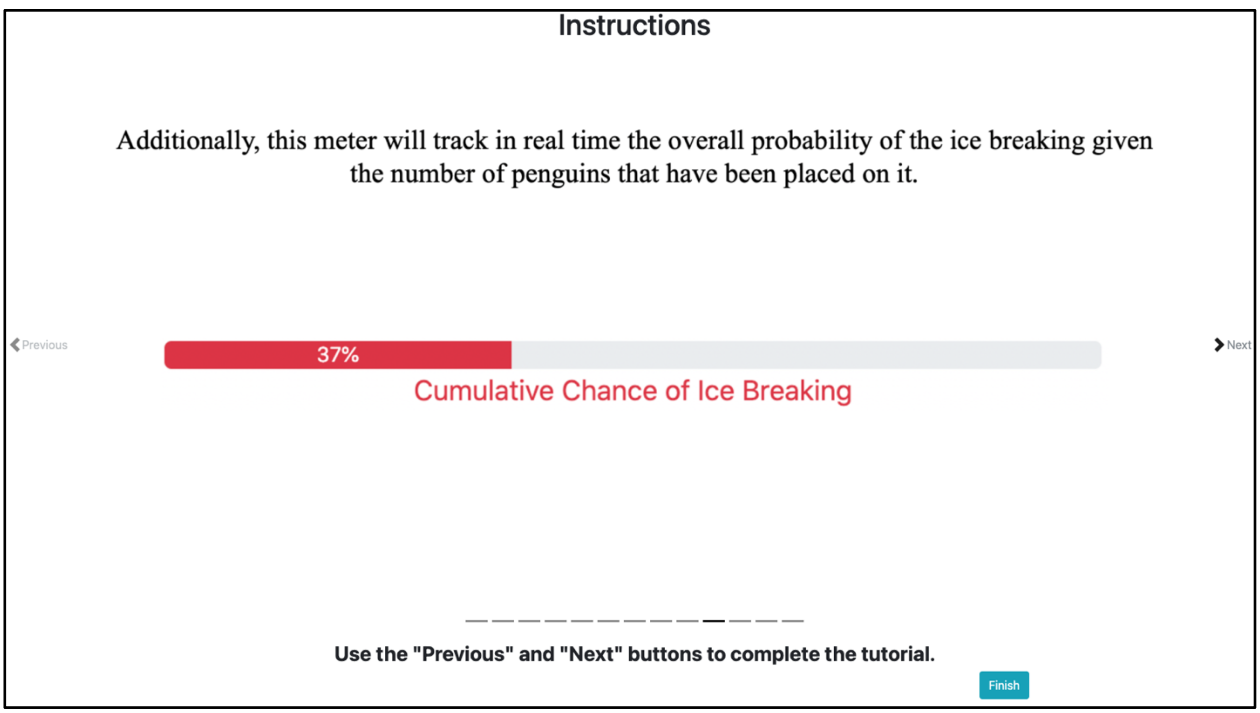


Figure A22

Study 2 Tutorial Page 11, Narrow Bracketing Condition

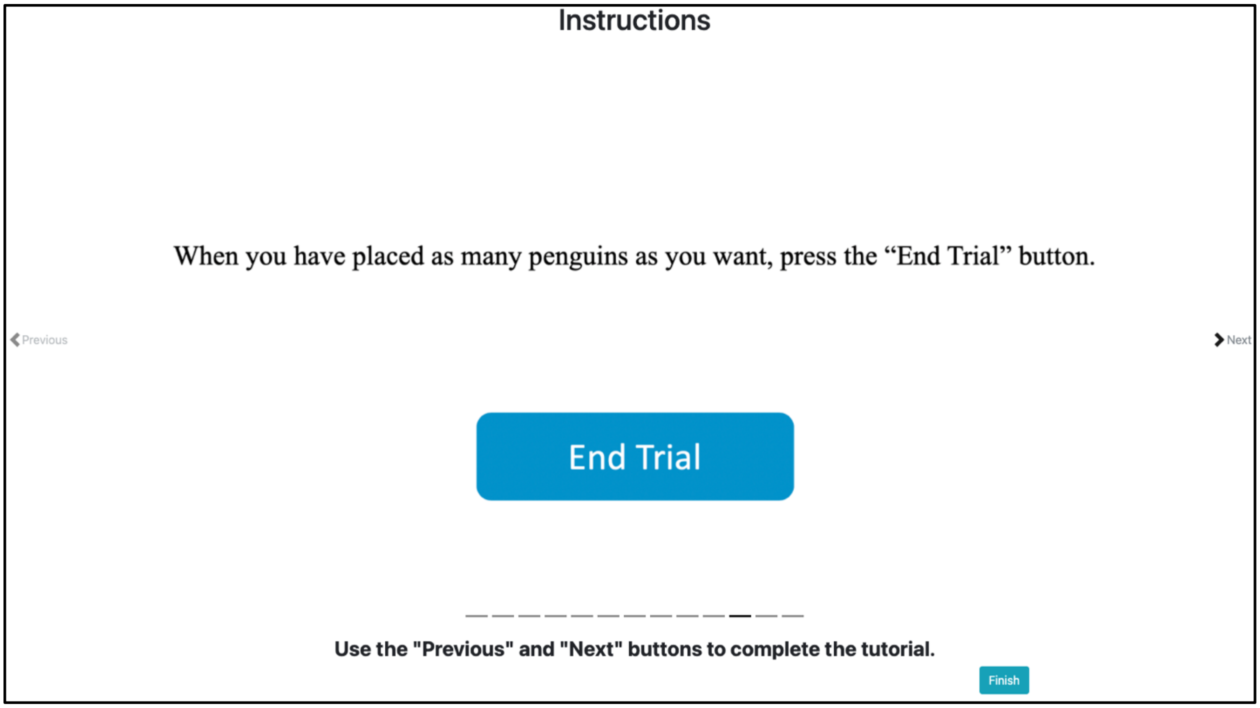


Figure A23

Study 2 Tutorial Page 12, Narrow Bracketing Condition

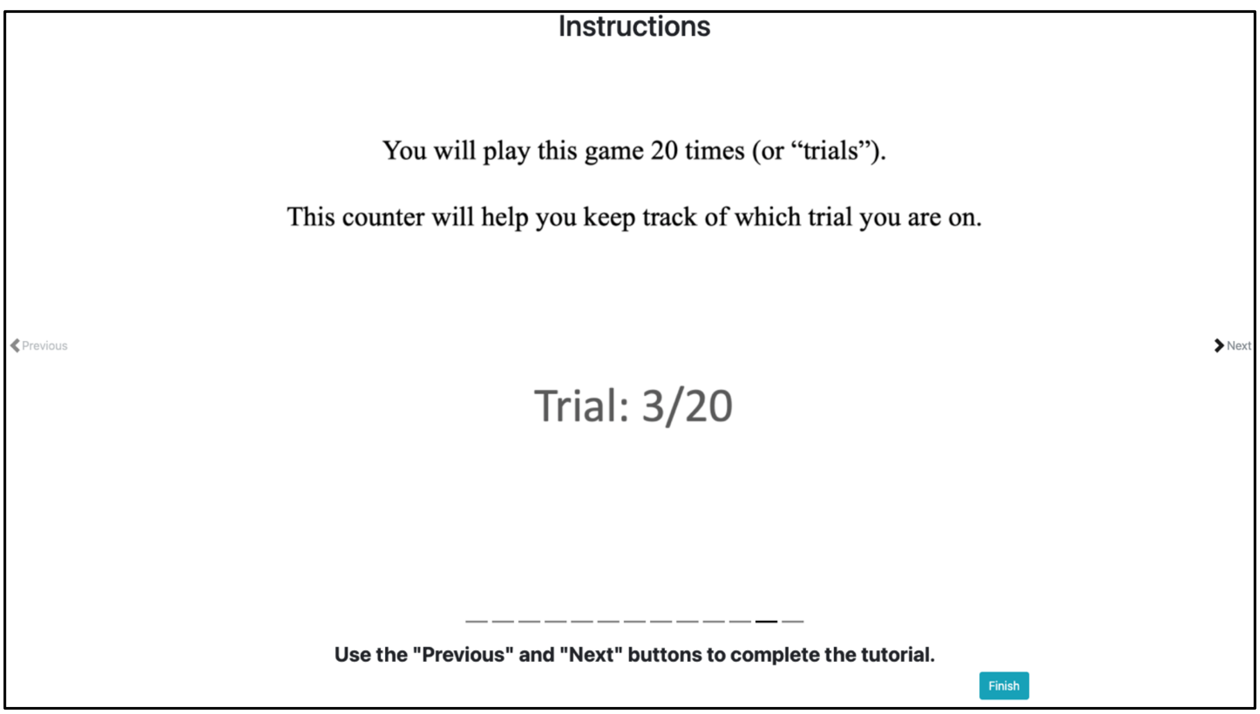


Figure A24

Study 2 Tutorial Page 13, Narrow Bracketing Condition

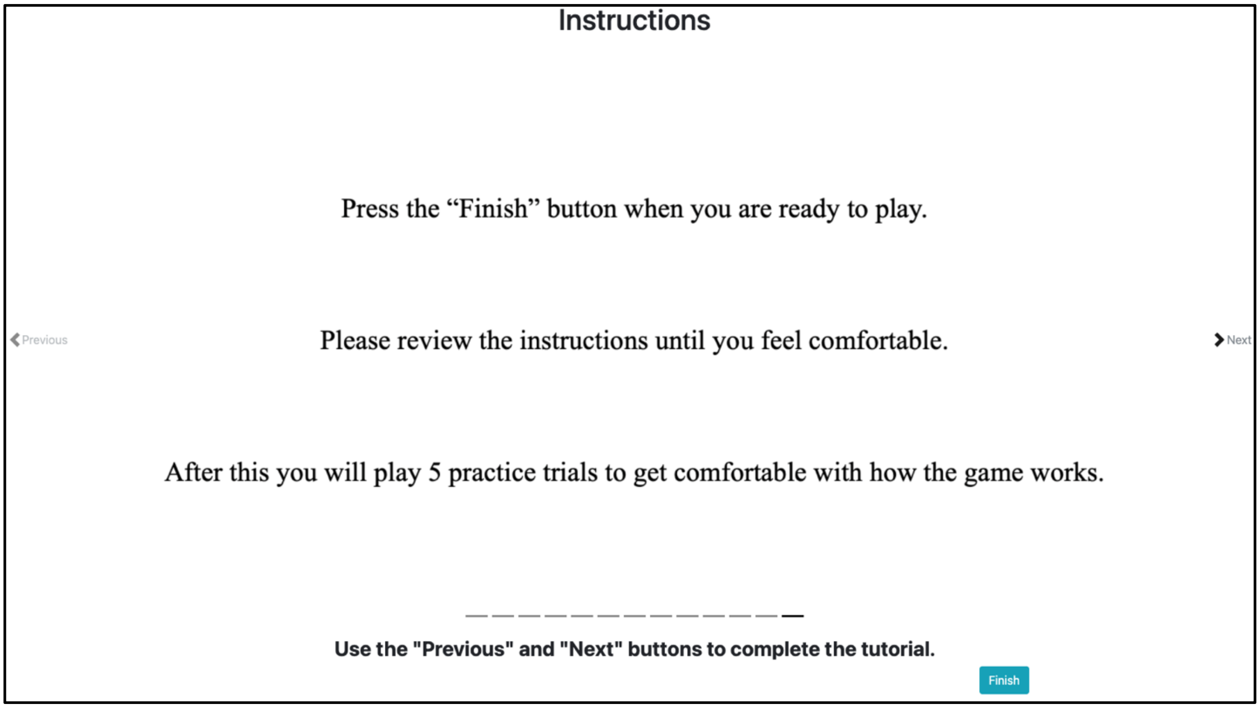


Figure A25

Study 2 Tutorial Page 1, Broad Bracketing Condition

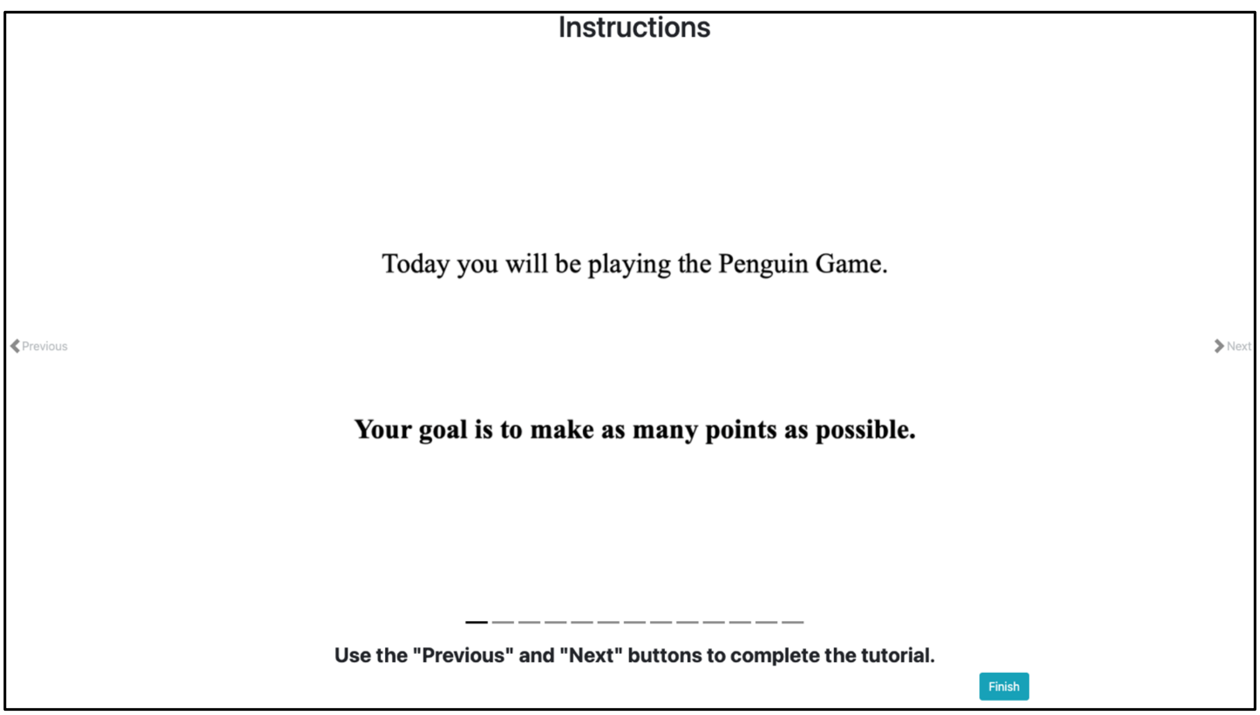


Figure A26

Study 2 Tutorial Page 2, Broad Bracketing Condition

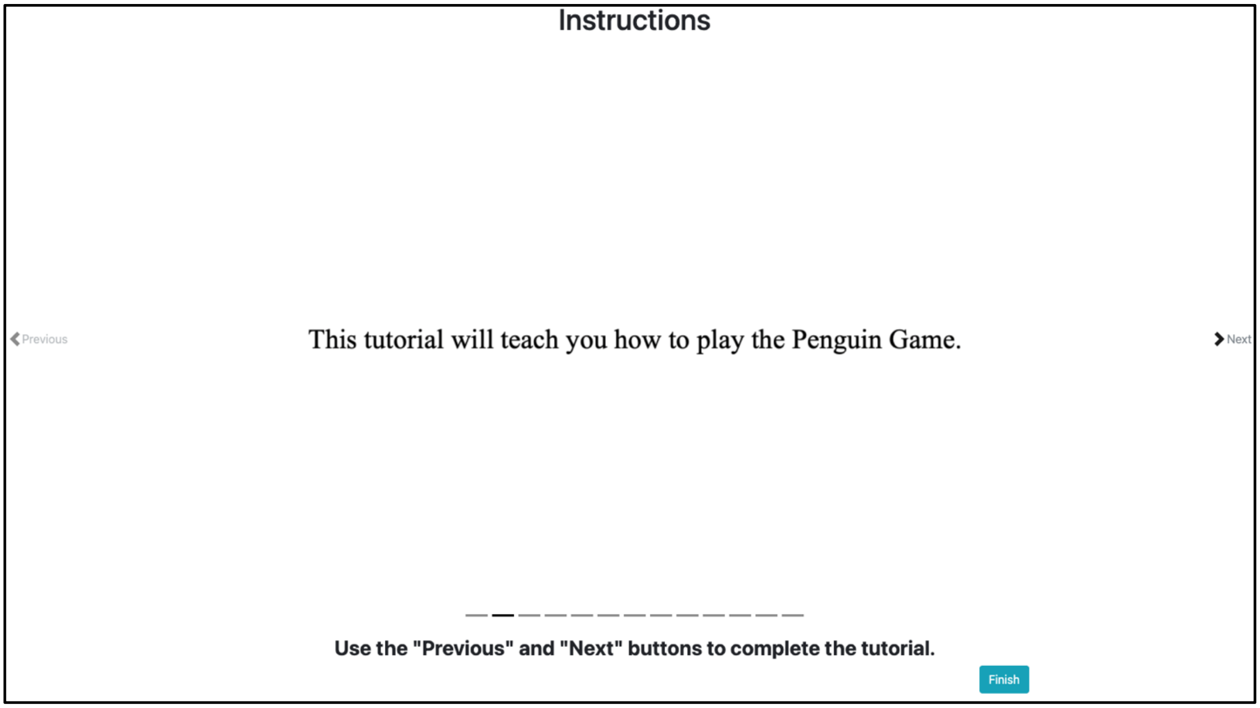


Figure A27

Study 2 Tutorial Page 3, Broad Bracketing Condition

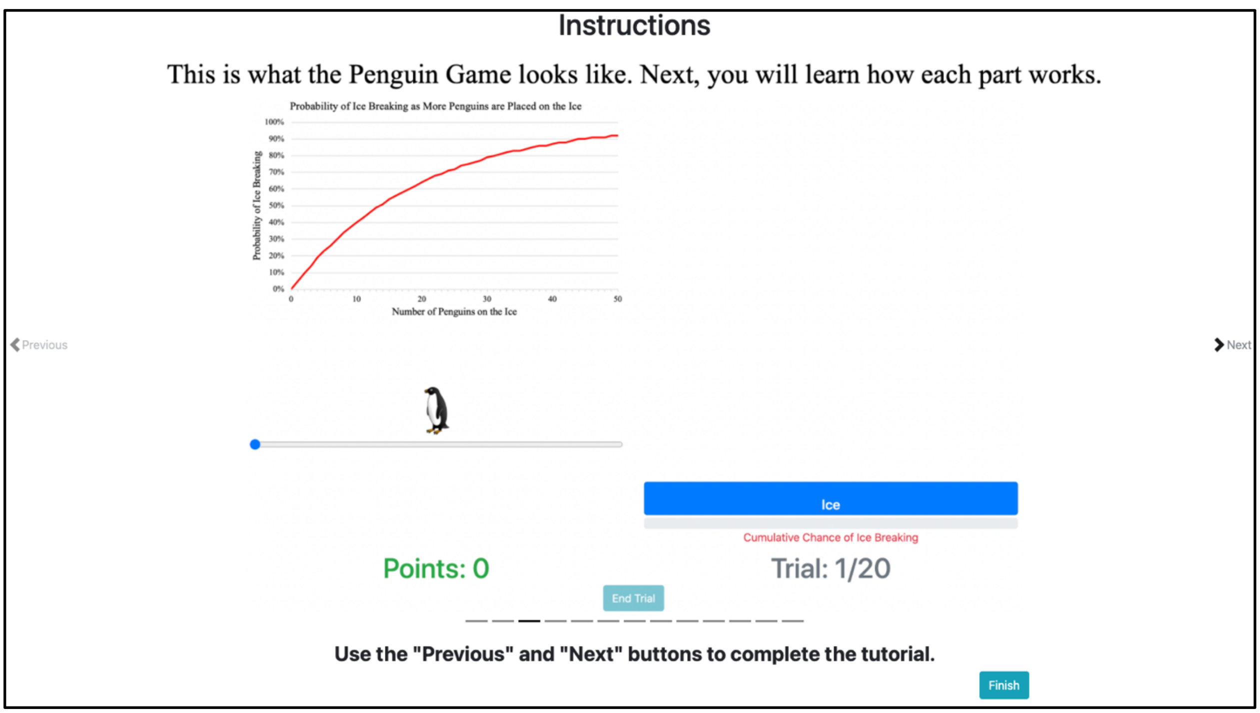


Figure A28

Study 2 Tutorial Page 4, Broad Bracketing Condition

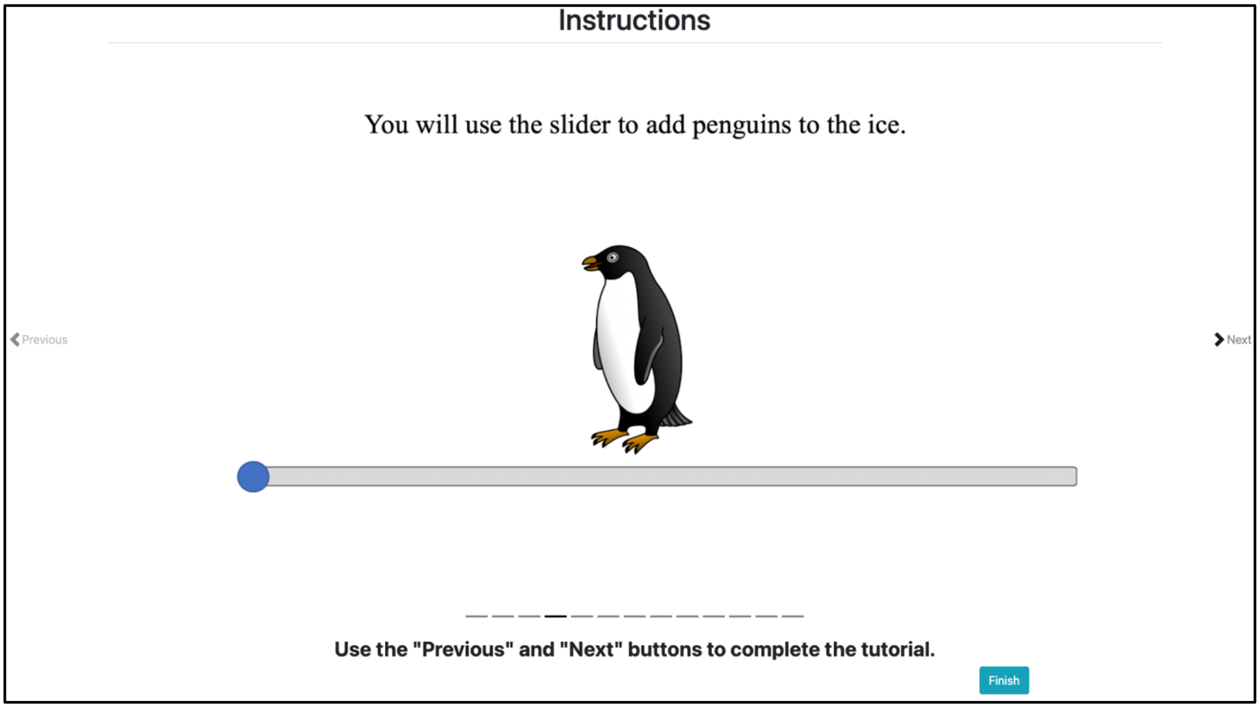


Figure A29

Study 2 Tutorial Page 5, Broad Bracketing Condition

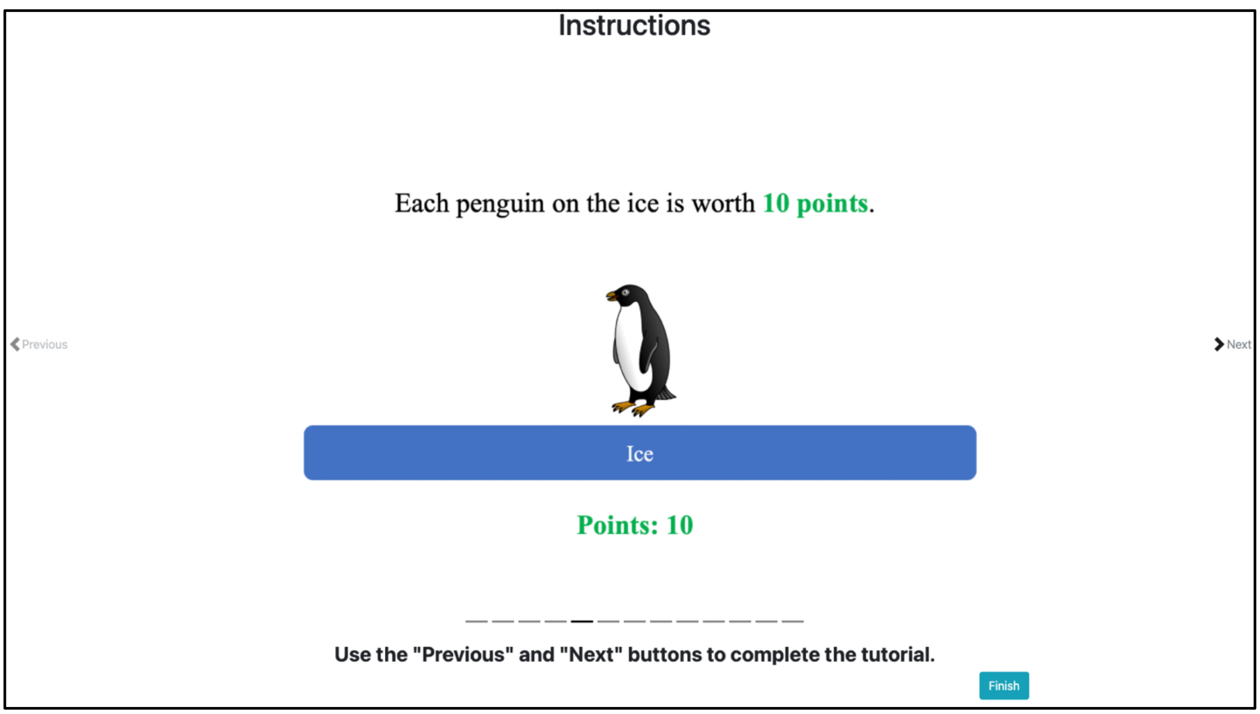


Figure A30

Study 2 Tutorial Page 6, Broad Bracketing Condition

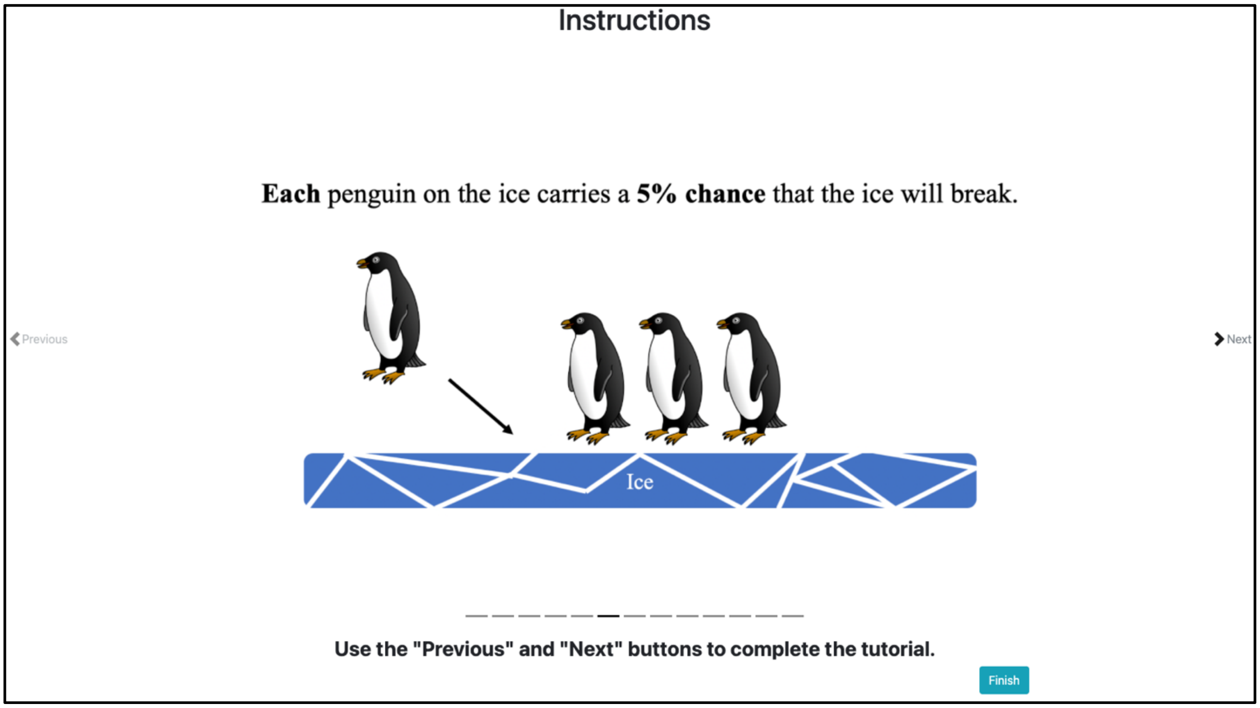


Figure A31

Study 2 Tutorial Page 7, Broad Bracketing Condition

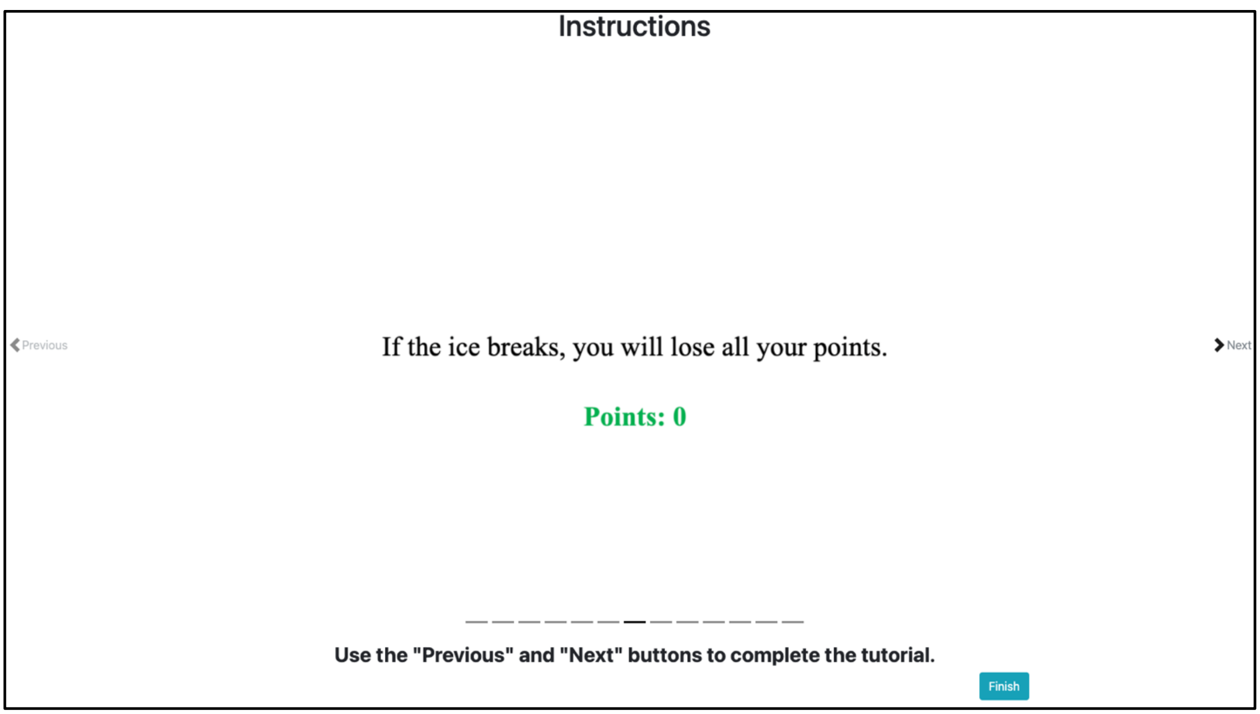


Figure A32

Study 2 Tutorial Page 8, Broad Bracketing Condition

Instructions

Each penguin you add carries only a **5% chance** that the ice will break.

Previous

Next

However, the more penguins on the ice, the more likely it is overall that the ice will break.

Use the "Previous" and "Next" buttons to complete the tutorial.

Finish

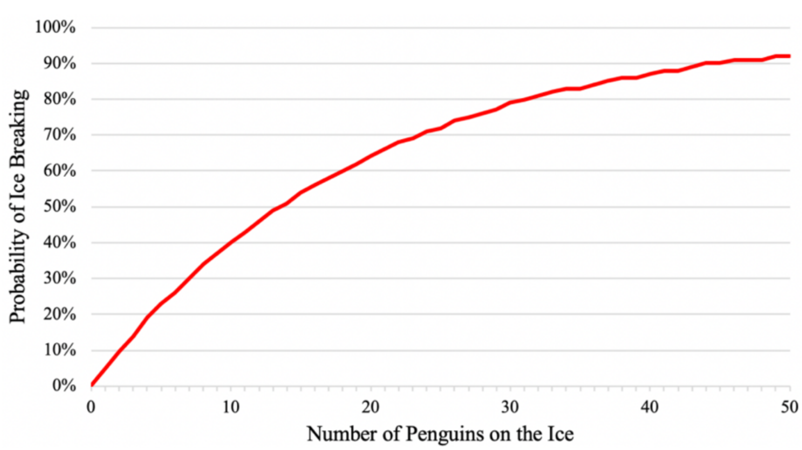
Figure A33

Study 2 Tutorial Page 9, Broad Bracketing Condition

Instructions

To help you keep track of this, this chart shows how the **overall likelihood** of the ice breaking increases as the number of penguins on the ice increases.

Previous



Next

Use the "Previous" and "Next" buttons to complete the tutorial.

Finish

Figure A34

Study 2 Tutorial Page 10, Broad Bracketing Condition

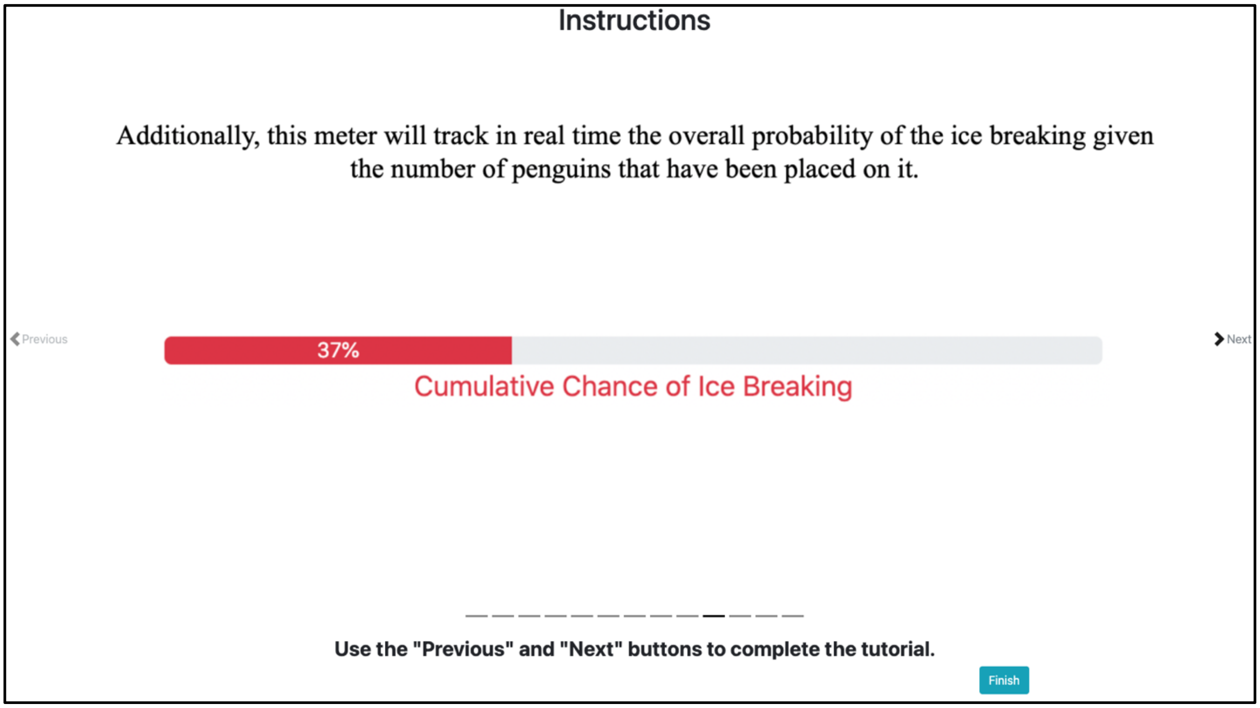


Figure A35

Study 2 Tutorial Page 11, Broad Bracketing Condition

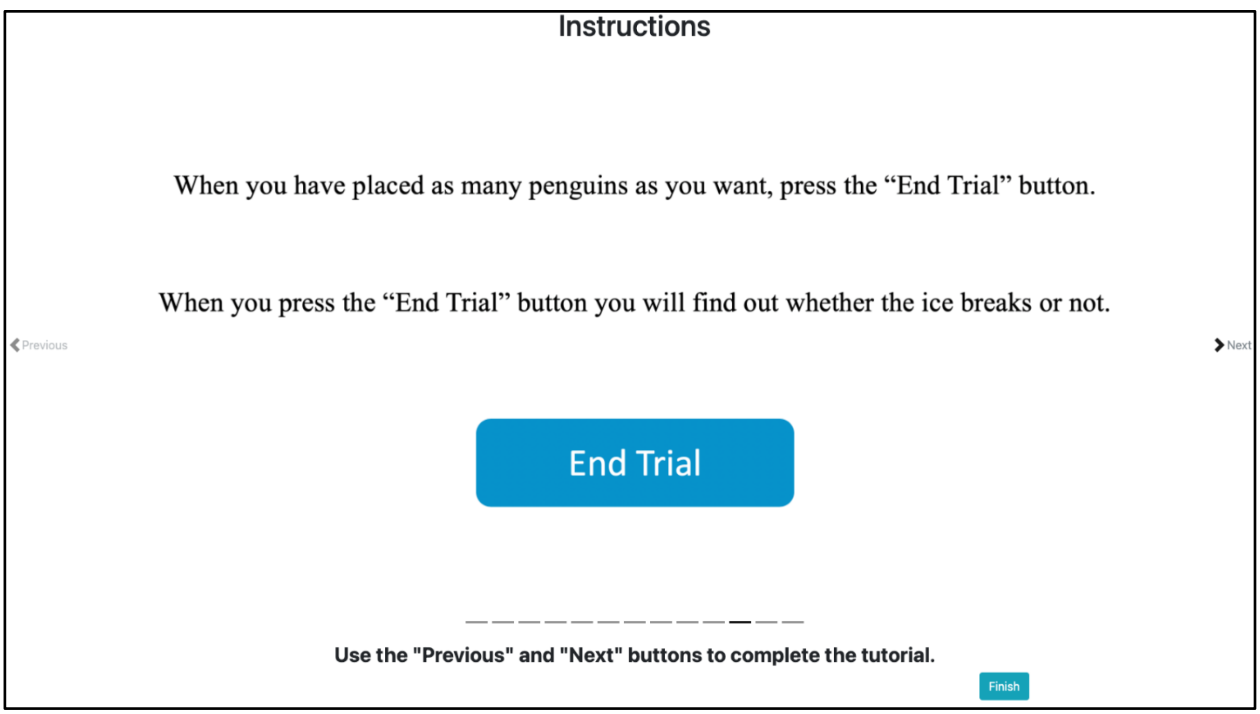


Figure A36

Study 2 Tutorial Page 12, Broad Bracketing Condition

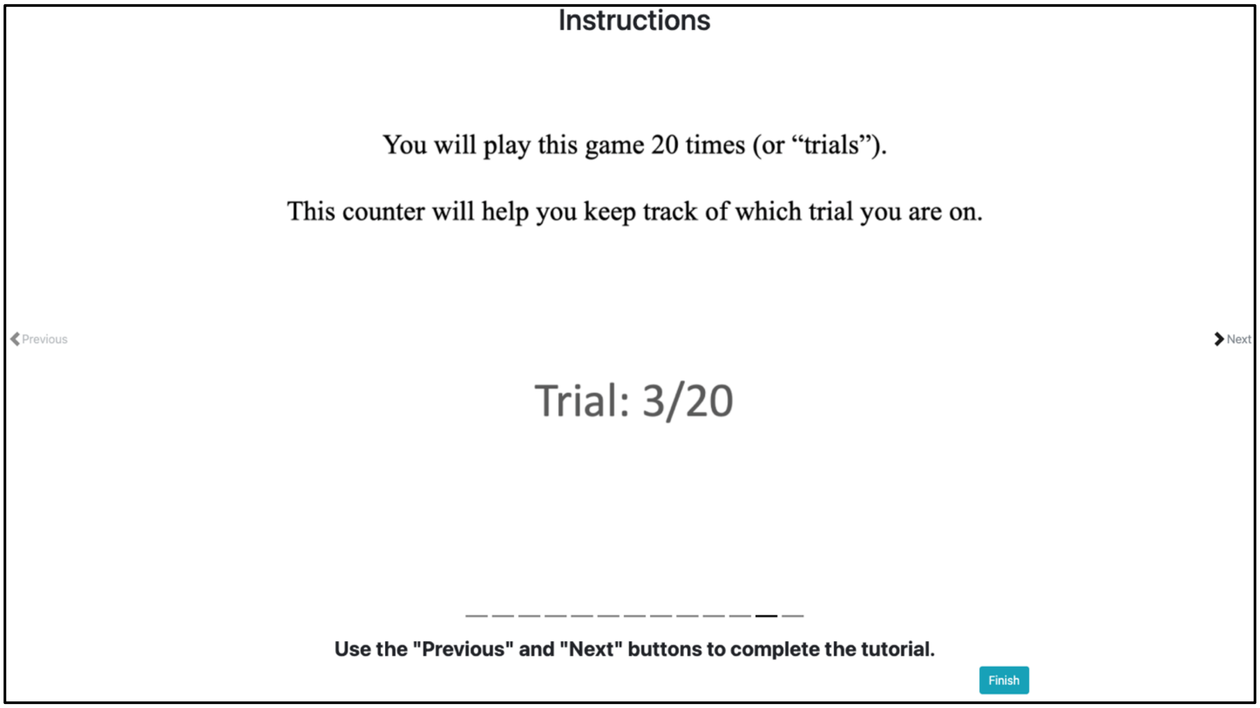


Figure A37

Study 2 Tutorial Page 13, Broad Bracketing Condition