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# Reference Point Effects in Riskless Choice Without Loss Aversion

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Numerous studies have demonstrated that preferences among options in riskless choice are often influenced by reference points. That is, an existing reference level or status quo can bias preferences toward new alternatives. Reference-dependent effects have typically been attributed to loss aversion (Tversky & Kahneman, 1991). The key idea is that when an option is being considered, an individual assesses the advantages and disadvantages of that option along each attribute with respect to the reference point. Disadvantages (losses) are weighted more than advantages (gains) in the decision process. This research provides new experimental evidence that 3 standard reference-dependent effects arise in a low-level perceptual decision task with nonhedonic stimuli. This casts doubt on explanations such as loss aversion, which are limited to high-level decisions with hedonic stimuli, and indicates that reference-dependent effects may be amenable to a general explanation at the level of the basic decision process.

*Keywords:* reference-dependent choice, preference reversals, loss aversion, perceptual decision-making, riskless choice



Loss aversion could arguably be considered one of the most influential ideas in the field of judgment and decision-making. Loss aversion has been used to explain a wide range of phenomena, including framing effects (Tversky & Kahneman, 1981), sunk cost effects (Arkes & Blumer, 1985), and the endowment effect (Knetsch, 1989). It has been incorporated into numerous theories, including prospect theory (Kahneman & Tversky, 1979), reference-dependent preference theories (Tversky & Kahneman, 1991; Bateman et al., 1997), and dynamic models such as the Leaky Competing Accumulator (LCA) model (Usher & McClelland, 2004). However, several researchers have recently demonstrated an absence of loss aversion in experiments of decision-making under risk and uncertainty, thus calling into question the existence of loss aversion in risky choice (Erev, Ert, & Yechiam, 2008; Harinck, Van Dijk, Van Beest, & Mersmann, 2007; Yechiam & Telpaz, 2013). This article provides new evidence casting doubt on loss aversion in riskless choice by showing three reference-dependent effects typically attributed to loss aversion (Tversky & Kahneman, 1991) in a low level perceptual decision-making task where the notion of losses and gains is absent.

Tversky and Kahneman (1991) argued that three reference-dependent effects—the status quo bias, the improvements versus tradeoffs effect, and the small versus large tradeoffs effect – provide "strong support" for loss aversion in riskless choice.[1] To illustrate a reference-dependent effect, consider someone choosing between two new phone plans. One plan offers a phone with a high-quality camera, but expensive monthly rate. The other provides a cheaper monthly rate, but offers a phone with a low-quality camera. Suppose the decision-maker is indifferent between these two options. Now, consider a slightly different scenario in which the decision-maker's current phone plan recently ended and cannot be renewed, but it was similar to the first option—a phone with a good camera and high monthly rate. In this new scenario, the decision-maker will prefer the first

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[1] Tversky and Kahneman (1991) called this effect *advantages and disadvantages*. The name small versus large tradeoffs effect is used instead because it is more descriptive of the phenomenon.

option similar to his or her previous plan over the second option. This is an example of the small versus large tradeoffs effect and demonstrates how a reference point (i.e., the previous plan) can influence preferences between two new alternatives. Figure 1 schematically represents the three reference-dependent effects within a two-dimensional attribute space.

The status quo bias is an enhancement in the choice probability for the status quo or reference point over a new, competitive alternative (Knetsch & Sinden, 1984; Samuelson & Zeckhauser, 1988). In the phone plan example, an individual might prefer to renew a current plan rather than switch to a new plan. More generally, consider a choice between X and Y where in one situation, X is the status quo, denoted $X_R$, and in another situation, Y is the status quo, denoted $Y_R$. The choice sets $\{X_R, Y\}$ and $\{X, Y_R\}$ are identical except for the option designated as the status quo. The status quo bias occurs when the probability of choosing X is greater when X is the status quo compared with when Y is the status quo and vice versa: $\Pr[X \mid \{X_R, Y\}] > \Pr[X \mid \{X, Y_R\}]$ and $\Pr[Y \mid \{X_R, Y\}] < \Pr[Y \mid \{X, Y_R\}]$.

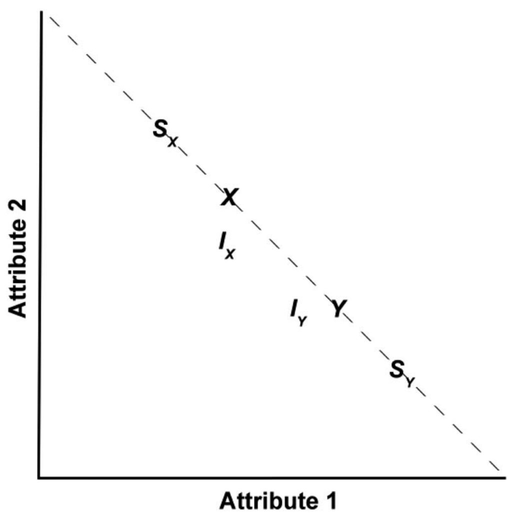


*Figure 1.* The location of options for three reference-dependent effects plotted in a two-dimensional attribute space. Note that in the phone plan example with attributes of camera quality and monthly cost, the cost dimension is decreasing because higher costs are worse than lower costs. The status quo bias is demonstrated in binary choice between options X and Y where one of the options is designated as the reference point. Options denoted I represent reference points for the improvements versus tradeoffs effect. Differences in choice probabilities for sets $\{X, Y, I_X\}$ and $\{X, Y, I_Y\}$ demonstrate the effect. Options denoted S represent reference points for the small versus large tradeoffs effect. Differences in choice probabilities for sets $\{X, Y, S_X\}$ and $\{X, Y, S_Y\}$ demonstrate the effect. Note that in this effect, the reference point S is not available during choice.

The improvements versus tradeoffs effect is an enhancement in the choice probability of one of two new options by a similar, but inferior reference option (Herne, 1998; Tversky & Kahneman, 1991). In the phone plan example, the reference option might be an individual's current plan, which is similar to the plan offering a high-quality camera and expensive monthly rate, but has a slightly inferior camera. More generally, consider a choice set {X, Y} and two reference points, $I_X$ and $I_Y$, where $I_X$ is similar but slightly inferior to X, and $I_Y$ is a similar but inferior to Y (Figure 1). The improvements versus tradeoffs effect occurs when people show a stronger preference for X when the reference point is $I_X$, and similarly for Y. Formally, the effect occurs when the probability of choosing X is greater when the reference point favors X compared with when in favors Y and vice versa: $\Pr[X \mid \{X, Y, I_X\}] > \Pr[X \mid \{X, Y, I_Y\}]$ and $\Pr[Y \mid \{X, Y, I_X\}] < \Pr[Y \mid \{X, Y, I_Y\}]$. This effect is very similar to the attraction effect in multialternative choice (Huber, Payne, & Puto, 1982). In the attraction effect, inferior decoys enhance similar dominating options. However, the inferior option is not a reference point.

The small versus large tradeoffs effect occurs when a reference point, very similar and equally attractive to one of two new options, becomes unavailable and the probability of selecting the similar new option increases (Tversky & Kahneman, 1991; Willemsen, Böckenholt, & Johnson, 2011). Consider a choice set {X, Y} and two reference points, $S_X$ and $S_Y$, where $S_X$ is similar to X, and $S_Y$ is similar to Y (Figure 1). The small versus large tradeoffs effect occurs when the probability of choosing X is greater when the recently unavailable reference point is similar to X compared with when it is similar to Y and vice versa: $\Pr[X \mid \{X, Y, S_X\}] > \Pr[X \mid \{X, Y, S_Y\}]$ and $\Pr[Y \mid \{X, Y, S_X\}] < \Pr[Y \mid \{X, Y, S_Y\}]$.

Tversky and Kahneman (1991) explain the three effects by a reference-dependent model based on the concept of loss aversion. In their model, each option is compared with the reference point along each attribute value. Positive differences in attribute values between the reference point and the other options are treated as gains. Negative differences are treated as losses. The loss aversion assumption weights losses more than equivalent gains. The model also incorporates diminishing sensitivity so that the marginal value of both gains and losses decreases with distance from the reference point.

Applying loss aversion to differences between attribute values seems reasonable when the options are goods and services such as different phone plans. In a choice among consumer goods, personal desirability plays a critical role in how attributes are evaluated. For example, camera quality might be a very important feature for some individuals and a small decrease in quality from one phone to another could be treated as a large loss. However, if the task is changed from selecting the most desirable product to selecting an option along an objective criterion where the attribute values are nonhedonic, it becomes unclear why positive and negative differences should be weighted in an asymmetric manner as dictated by loss aversion. The current experiments use a simple perceptual task where participants are asked to make decisions about the size of rectangles where the attribute values are height and width. These attribute dimensions are nonhedonic and the notion of gains and losses along attributes is absent.

Experiment 1 investigated the three effects using a consumer choice task where participants made decisions about different cell phones. This experiment provides the first evidence that all three effects can be obtained under the same experimental paradigm. There has been no prior evidence indicating that the three effects can occur in the same paradigm in either consumer choice or perception. The first experiment also provides a point of comparison for the second experiment, which investigates the three effects using the simple perceptual task about rectangle sizes. Both experiments use within-subjects manipulations, thus demonstrating reference-dependent effects occur at the individual level in both consumer choice and perception.

## Experiment 1: Consumer Choice

### Method

Forty-six undergraduate students from the University of California, Irvine, participated for course credit, completing the computer-based experiment online at a time of their choosing. Participants were instructed that they would see a set of phones on each trial and should select the phone they preferred. Phones were described by two attributes—camera resolution in megapixels and the monthly cost. They were told that at the beginning of each trial they would be given a particular phone (this phone served as the reference point for the trial). On some trials, participants were told that they would be given the option to swap their current phone for a new one. These trials were used to test the status quo bias and improvements versus tradeoffs effect. On other trials, participants were told that their phone plan had ended and they would have to choose a new phone. These trials were used to test the small versus large tradeoffs effect. Figure 2 shows an example of a status quo trial. Details about the stimuli are provided in the Appendix.

Each participant completed 105 trials, 20 testing the status quo bias, 20 testing the improvements versus tradeoffs effect, 20 testing the small versus large tradeoffs effect, and 45 filler trials. All of the trials were randomly presented. The option expected to be chosen more frequently is termed the "target" and the remaining option is referred to as the "competitor." The trials testing the three reference-dependent effects were divided so that each alternative served as the target for half of the randomized trials. That is, the reference point was counterbalanced so that options X and Y in Figure 1 both served as targets. This type of counterbalancing helps avoid confounding the effects with biased guessing strategies. It also helps reduce the influence of lag effects, in which a reference point or choice in a previous trial acts as a reference point in the current trial. While lag effects might occur, randomization and counterbalancing help to avoid confounding the desired reference point effects with lag effects. The filler trials were similar in format to the improvements versus tradeoffs trials except that these trials contained one phone that was clearly superior to the rest (i.e., great camera resolution and low monthly cost), providing the participant with an objectively correct option. These trials helped participants maintain engagement with the task throughout the experiment.

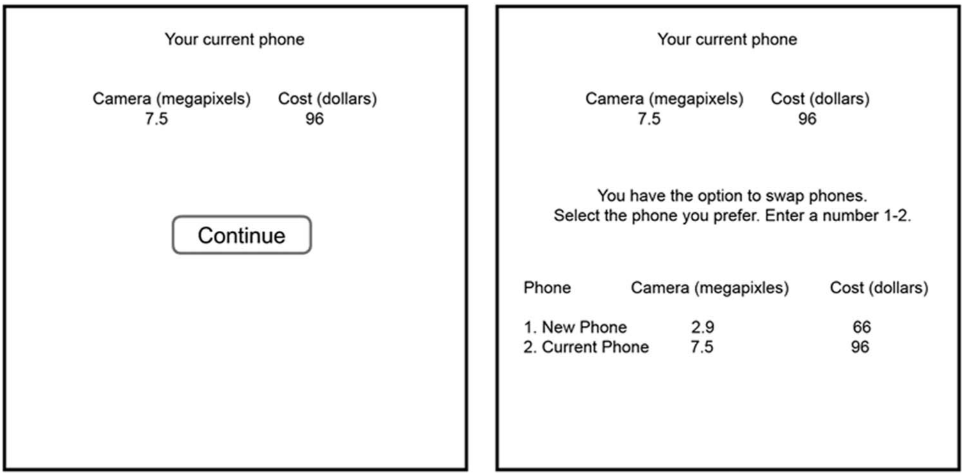


*Figure 2.* Example of a trial from Experiment 1 testing the status quo bias. At the beginning of the trial, the reference point is displayed at the top of the screen as shown in the left panel. After studying the reference point, participants decide when to reveal the options by pressing the "continue" button, which displays the screen shown in the right panel. The options are listed in a table and are labeled as either new or current (i.e., the reference point). The reference point also remains at the top of the screen during the selection process. The positions of the options in the table (i.e., target, competitor, and reference point) are randomized across trials.



## Results

One subject's data were removed from further analysis because he or she selected the inferior reference point options on all of the improvements versus tradeoffs effect trials. Figure 3 shows the mean choice probabilities for the target and competitor for each of the three effects. The figure also shows the mean *relative choice share of the target* (*RST*), which is defined as the number of times a participant chose the target divided by the number of times he or she chose the target plus the competitor (Berkowitsch, Scheibehenne, & Rieskamp, 2014). If the RST value is greater than 0.5, then the target was selected more often than the competitor indicating the presence of a reference-dependent effect. RST values equal to 0.5 imply the target and competitor were selected equally often showing an absence of an effect. For the status quo bias and small versus large tradeoffs effect, the RST value equals the mean choice probability for the target because there were only two choice options for these effects compared with three options for the improvements versus tradeoffs effect.

A hierarchical Bayesian model was used to test whether the RST values were larger than 0.5 across participants for each of the three effects (Kruschke, 2011). A graphical model illustration is provided in Figure 4 (Lee & Wagenmakers, 2014). For each effect, it was assumed that the number of times the target was chosen followed a binomial distribution with parameters $\theta$ and $n$ where $\theta$ is the probability the target was selected and $n$ is the total number of times the target plus the competitor was chosen ($T_{ij} + C_{ij}$ in Figure 4). In a hierarchical model, participants have their own set of parameters, which are sampled from an underlying population. Hierarchical parameters capture information about the distributions of the different populations such as the mean and variance. The person-specific parameters are drawn from the distributions defined by these hierarchical parameters. When defining the person-specific parameters, a different $\theta$ parameter was assumed for each effect so that each individual had three $\theta$ parameters. The population distributions for the $\theta$ parameters were assumed to follow beta distributions with hyperparameters defining the mean ($\mu_j$ in Figure 4) and concentration ($\kappa_j$ in Figure 4). For the beta distribution, when the concentration parameter $\kappa_j$ is large, the distribution of $\theta_{ij}$ is more narrowly dispersed about $\mu_j$.

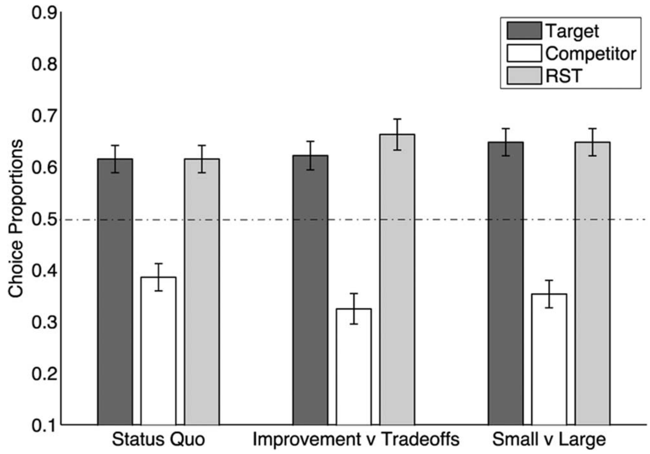


*Figure 3.* Results for Experiment 1. Mean choice proportions for the target and competitor options and relative choice share of the target (RST) values for the status quo bias, improvements versus tradeoffs effect, and small versus large tradeoffs effect. RST values greater than 0.5 imply the target was selected more often than the competitor indicating an effect. The error bars show the standard error of the mean.



The prior for $\mu_j$ was a beta distribution with both shape parameters equal to 2. This prior is considered vague and provides low certainty about the value of $\mu_j$. It also slightly favors the null hypothesis that the RST is equal to 0.5. The prior for $\kappa_j$ was a gamma distribution with shape and rate parameters equal to 0.001. This is also a vague prior and is commonly used on precision parameters such as $\kappa_j$ because it is invariant to changes in the measurement scale (Lee & Wagenmakers, 2014). Three MCMC chains were used to estimate the posterior distributions for the parameters (both person-specific and hierarchal) using JAGS. Chain convergence was assessed by using the $\hat{R}$ statistic, which is similar to the F statistic. Specifically, if $\hat{R}$ is large, then the between-chain variance is larger than the within-chain variance. A $\hat{R}$ value close to 1 is ideal and values lower than 1.1 are considered satisfactory. All parameters had $\hat{R}$ equal to 1.

The 95% highest posterior density intervals (HDIs) for the hyperparameters $\mu_j$ represent the most credible posterior RST values from the Bayesian analysis at the group level. If this region lies above 0.5, then one can infer that the target was on average selected more often than the competitor. For all three effects, $\mu$ was greater than 0.5: the status quo bias (95% HDI = 0.563–0.671), the improvements versus tradeoffs effect (95% HDI = 0.605–0.731), and the small versus large tradeoffs effect (95% HDI = 0.594–0.707). Frequentist statistics provide the same conclusion that the RST is significantly greater than 0.5: the status quo bias, $t(44) = 4.33$, $p < .0001$, the improvements versus tradeoffs effect, $t(44) = 5.41$, $p < .0001$, and the small versus large tradeoffs effect, $t(44) = 5.55$, $p < .0001$. Individual level analyses are provided in a later section.

## Conclusions

The results of Experiment 1 confirm previous evidence for the three reference-dependent effects in consumer choice (Tversky & Kahneman, 1991). More important, they provide the first evidence that the effects can occur both within the same person as well as within the same experimental paradigm.

## Experiment 2: Perception

The second experiment examines the three effects using a simple perceptual task about the size of rectangles. Two versions of the experiment were conducted. In the first (referred to as the motivated version), participants were provided with a motivating cover story in which the rectangles are described as representing plots of farm-

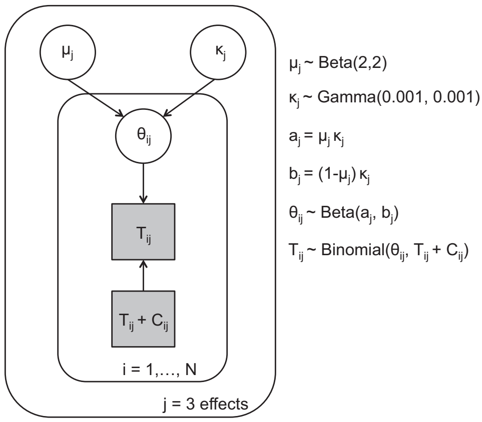


*Figure 4.* Hierarchical Bayesian model used to test whether the relative choice share of the target (RST) was larger than 0.5 for the three effects. Circular nodes indicate continuous values, square nodes indicate discrete values, shaded nodes correspond to known values, and unshaded nodes represent unknown values. The bounding rectangles are called plates and are used to enclose independent replications of a graphical structure. There are two plates in the figure representing replications for the three different effects (outer plate) and replications for different individuals (inner plate). The nodes labeled $\mu_j$ and $\kappa_j$ are the hyperparameters. Each individual has three $\theta$ parameters, which are drawn from beta distributions determined by the hyperparameters.

land. In the second (referred to as the abstract version), participants were given a more abstract version of the task without a motivating cover story.

## Method

A total of 96 undergraduate students from the University of California, Irvine, participated for course credit completing the computer-based experiment in the laboratory. Half of the participants were in the motivated version and the other half completed the abstract version. In the motivated version, participants read a cover story instructing them to imagine that they were a farmer who leases plots of land for growing crops. They were told that the plots of land would be shown to them as black rectangles and their task was to select the plot of land (i.e., rectangle) that has the largest area in order to maximize their growing space. Participants were also told that at the beginning of each trial, they would be shown the plot of land they were currently leasing (this rectangle served as the reference point for the trial). They were further instructed that on some trials they would be given the option to trade the plot for a new one or to retain it. These trials were used to test the status quo bias and improvements versus tradeoffs effect. On other trials, participants were told that the lessor had sold their current plot and that they would be required to select a new one. These trials were used to test the small versus large tradeoffs effect. Participants were also instructed that all plots of land had the same soil quality, irrigation systems, and climate and that they only differed in size.

The abstract version of the experiment was included to eliminate possible confounds in the motivated version. Because of the farmland cover story in the first version, it could be possible that participants were using some other decision criterion besides rectangle size. For example, participants might think it is advantageous to retain a plot of land rather than switch to a new one because they have experience with it. That is, they know the soil, climate, and the best planting configurations. In this version, participants were told that they would see rectangular objects called "gaxs" on each trial and to select the "gax" that had the largest area. Other than this change in the instructions, the two versions of the experiment were identical.

The rectangle stimuli were similar to those used in the experiments discussed in Trueblood, Brown, Heathcote, and Busemeyer (2013) demonstrating the attraction, similarity, and compromise effects in perception. The height and width of the rectangles acted as attribute dimensions analogous to monthly cost and megapixels in Experiment 1. Previous experimental evidence suggests that height and width are perceived separately and then integrated to form area estimates (Anderson & Weiss, 1971). Even if the rectangles are perceived as unidimensional stimuli (e.g., in terms of aspect ratio), that does not change the implications of the outcomes as unidimensional stimuli have previously been used to demonstrate multialternative preference reversals (Choplin & Hummel, 2005).

At the beginning of each trial, one rectangle was presented at the top of the screen as the reference point (i.e., the current plot of land in the motivated version). After studying this rectangle, participants decided when to reveal the options. As in Experiment 1, the reference point remained at the top of the screen during this selection process. The rectangles that participants could select were presented horizontally on the screen below the reference point. All rectangles were solid black and the background screen was white. The vertical positions of the rectangles varied so that they were not all placed on the same horizontal axis. The rectangles were numbered from left to right and labeled as either new or current (i.e., the reference point). The location of different rectangles (i.e., target, competitor, and reference point) was randomized across the trials. Details about the stimuli are provided in the Appendix.

Similar to Experiment 1, each participant completed 105 randomized trials, 20 testing the status quo bias, 20 testing the improvements versus tradeoffs effect, 20 testing the small versus large tradeoffs effect, and 45 filler trials. The reference point effect trials were divided so that each alternative served as the target for half of the randomized trials. The filler trials were similar in format to the improvements versus tradeoffs trials except that these trials contained one rectangle that clearly had a larger area than the rest, providing the participants with an objectively correct option.

## Results

There was no effect of version on choices so the results from the two different versions of the experiment were collapsed, $F(2, 284) = 0.93$, $p = .34$. This implies that the motivating cover story in the first version did not influence choices. Figure 5 shows the mean choice probabilities for the target and competitor and RST for each of the three effects. The 95% HDIs for the hyperparameters $\mu_j$ were calculated using Bayesian statistics as in Experiment 1. For all three effects, $\mu$ was greater than 0.5 suggesting that the target was on average selected more often than the competitor: status quo bias (95% HDI = 0.582–0.637), the improvements versus tradeoffs effect (95% HDI = 0.540–0.595), and the small versus large tradeoffs effect (95% HDI = 0.508–0.556). Frequentist statistics provide the same conclusion that the RST is significantly greater than 0.5: the status quo bias, $t(95) = 7.99$, $p < .0001$, the improvements versus tradeoffs effect, $t(95) = 5.08$, $p < .0001$, and the small versus large tradeoffs effect, $t(95) = 2.56$, $p = .012$.

## Conclusions

The results of Experiment 2 provide the first evidence that reference-dependent effects that are typically associated with choices among consumer goods also arise in simple perceptual tasks. The RST values were greater than 0.5 for all three effects. The effect was smaller for the small versus large tradeoffs effect than the other two effects. This might be because of the similarity between this effect and the compromise effect. Like the extreme decoy in the compromise effect, the reference point is extreme and

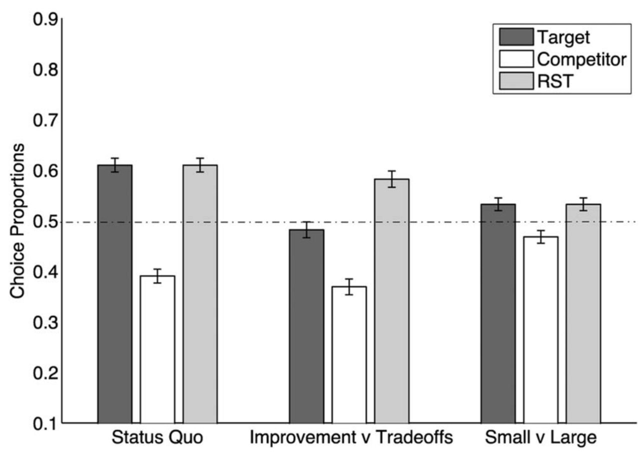


*Figure 5.* Results for Experiment 2. Mean choice proportions for the target and competitor options and relative choice share of the target (RST) values for the status quo bias, improvements versus tradeoffs effect, and small versus large tradeoffs effect. The error bars show the standard error of the mean.

increases the probability of choosing an intermediate option. Some existing research finds that the compromise effect is more vulnerable to time pressure and deferral than other context effects such as the attraction effect, which is similar to the improvement versus tradeoffs effect (Dhar & Simonson, 2003; Pettibone, 2012).

## Individual Level Analyses

While all three effects emerged at the group level for both experiments, individuals might display different levels of susceptibility to the effects. Table 1 lists the percentage of participants that showed none, one, two, or all three effects. From the table, it is clear that about a third of participants are susceptible to all three effects in both paradigms. In the perceptual experiment, the majority of participants (63.5%) were susceptible to one or two of the effects and very few (4.2%) were susceptible to none. In the consumer choice experiment, a larger percentage of participants (17.8%) showed none of the effects.

The individual θ parameters from the hierarchical Bayesian model were used to examine correlations between the three effects. Correlations were calculated using Bayesian methods with the programs provided in Lee and Wagenmakers (2014). Table 2 shows the 95% HDIs for the correlation coefficients for both experiments. The 95% HDIs for the perceptual experiment include the value of zero suggesting there is little to no correlation between effects in this experiment. However, the 95% HDIs for the consumer choice experiment excluded zero suggesting that the effects are positively correlated.

One possible explanation for the high correlations in the consumer choice experiment is heterogeneous participants. The percentages shown in Table 1 suggest that there might be different groups of participants within the experiment because 37.8% showed all three effects but 17.8% showed none. To examine this possibility in more detail, a cluster analysis was performed using k-means. The k-means algorithm was run multiple times using different candidate values for k between 2 and 6. For each candidate value, the Dunn index (Dunn, 1973) was calculated. Higher values of the index indicate better clustering in terms of compactness. The highest Dunn index was achieved with k equal to 2 suggesting there are two groups within the data. Figure 6 plots the θ parameters for each individual in the consumer choice experiment and shows the two groups, one showing strong effects and the other weak effects. The same clustering analysis was applied to the perceptual data, but a single cluster provided the best description of the data. One reason there might be two groups of participants in the consumer choice experiment compared with the perceptual experiment is the presence of loss aversion in the former. It is possible that loss aversion exacerbates the effects in some individuals.

## General Discussion

Tversky and Kahneman (1991) argue that in reference-dependent choice, individuals assess the advantages and disadvantages of options along

Table 1
*Percentage of Participants Showing All Three Effects, Only Two Effects, Only a Single Effect, or None of the Effects*

| | % | |
|---|---|---|
| Effects | Consumer choice | Perceptual |
| All three effects | 37.78 | 32.29 |
| Status quo and improve versus tradeoffs | 6.67 | 21.88 |
| Status quo and small versus large | 4.44 | 9.38 |
| Improve versus tradeoffs and small versus large | 8.89 | 4.17 |
| Status quo | 2.22 | 11.46 |
| Improve versus tradeoffs | 6.67 | 8.33 |
| Small versus large | 15.56 | 8.33 |
| None | 17.78 | 4.17 |

*Note.* The percentages for perceptual choice were calculated by combining the two versions of the task (i.e., motivated and abstract).

Table 2
*Correlations Between Individual θ Parameters From the Hierarchical Bayesian Model for the Three Effects*

| Effects | Consumer choice | Perceptual |
|---|---|---|
| Status quo and improve versus tradeoffs | 0.80 to 0.94 | −0.17 to 0.37 |
| Status quo and small versus large | 0.59 to 0.86 | −0.03 to 0.37 |
| Improve versus tradeoffs and small versus large | 0.56 to 0.85 | −0.15 to 0.26 |

*Note.* Correlations were calculated by using Bayesian Methods, and 95% highest posterior density intervals (HDIs) are provided.



each attribute with respect to the reference point. Disadvantages are treated as loss and are weighted more than equivalent gains in accord with loss aversion. The loss aversion account is not limited to reference-dependent choice, as it has also been applied to context effects in multialternative choice such as the attraction, compromise, and similarity effects (Tversky & Simonson, 1993; Usher & McClelland, 2004). Experiment 2 challenges the loss aversion explanation of reference-dependent effects by demonstrating the effects in a simple perceptual task where there is no notion of gains and losses. This experiment adds to growing evidence that preference reversals in riskless choice are not solely the result of loss aversion. Trueblood et al. (2013) find all three major context effects (attraction, similar, and compromise effects) in a simple perceptual task about the size of rectangles similar to the one presented here. Choplin and Hummel (2005) demonstrate the attraction effect in perceptual judgment tasks about the size of ovals and line segments. Tsetsos, Chater, and Usher (2012) and Tsetsos, Usher, and McClelland (2011) find the attraction and similarity effects with psychophysical stimuli. Trueblood (2012) also demonstrates all three context effects in an inference paradigm where the notion of gains and loses is absent. Taken together, these experiments suggest that a parsimonious account of multialternative choice that generalizes to a number of domains (consumer goods, perception, etc.) cannot be based on loss aversion alone. However, loss aversion could exacerbate the effects in consumer choice paradigms. Yechiam and Hochman (2013) suggest that losses can enhance on-task attention, which could result in increased sensitivity to the effects in consumer choice. The cluster analysis revealed one group of participants with very strong effects. It is possible these subjects are highly sensitive to losses. Future work could examine this issue in more detail.

An alternative to the loss aversion hypothesis is that reference point effects are a type of assimilation effect, in which a judgment involving the target is biased toward the context stimulus (e.g., the reference point). In this case, the reference points make similar options more desirable. Assimilation effects have been shown in a wide range of paradigms including perception (Helson, 1963). Dynamic models provide another alternative to loss aversion. These models assume preference for different options is accumulated over time until a decision criterion is reached and one of the options is selected. Examples of these models include Multialternative Decision Field Theory (MDFT: Roe, Busemeyer, & Townsend, 2001), the Associative Accumulation Model (Bhatia, 2013), and the Multiattribute Linear Ballistic Accumulator (MLBA) model (Trueblood, Brown, & Heathcote, 2014). All three models can account for the attraction, similarity, and compromise effects without using loss aversion. The Associative Accumulation Model can also explain the three reference-dependent effects discussed in this paper. In this model, a reference point increases the accessibility of its attributes, which in turn biases the preferences for the other options.

MDFT and the MLBA model have not yet been applied to reference-dependent effects. However, the models could be extended to account for these effects. One possibility, following the Associative Accumulation Model, could use increased weight on the most salient attributes of the reference point to bias preferences for the other alternatives. Another possibility would be an initial bias created by the reference point before the accumulation process begins, similar to an assimilation effect. In the MLBA model, this type of initial bias would occur in the mapping of physical stimuli values to psychological magnitudes. The MLBA model allows an individual's perception of an option to

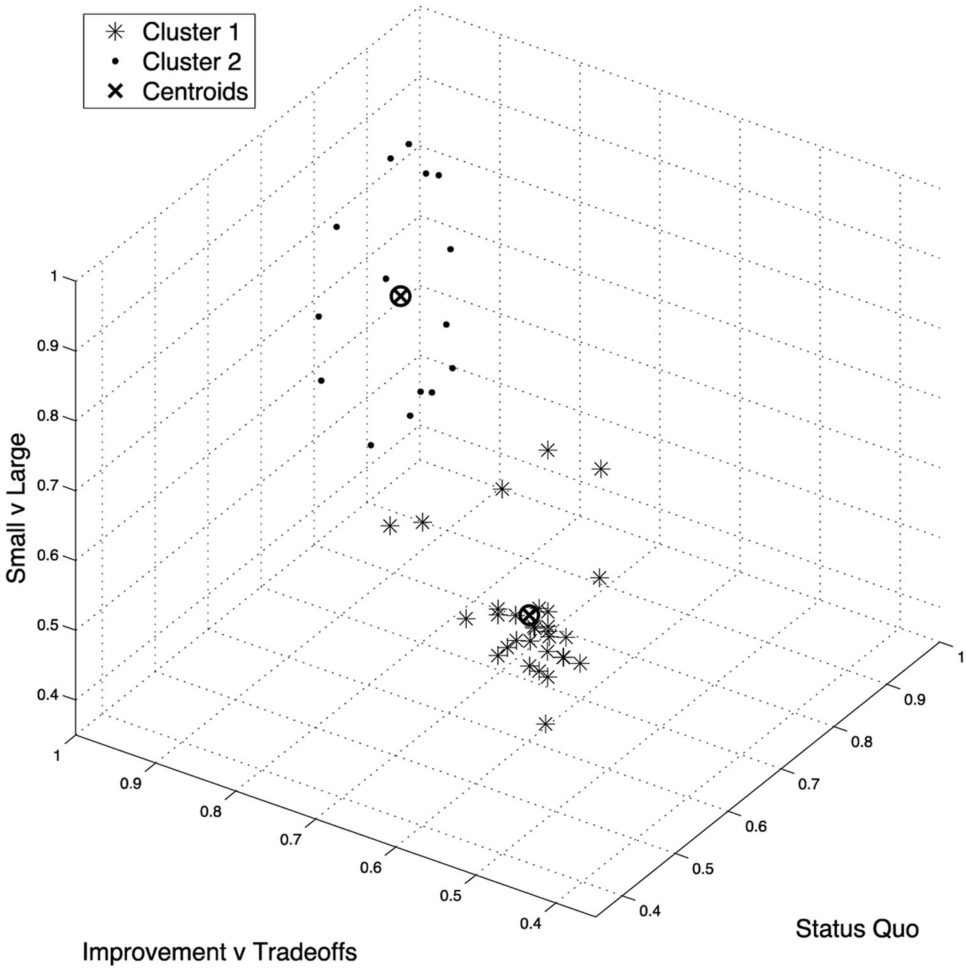


*Figure 6.* Results from the cluster analysis for the consumer choice experiment using the individual θ parameters for each effect. Two clusters emerged—one corresponding to participants with strong effects and another corresponding to participants with weak effects.



differ from the way the option was defined experimentally. Mathematically, this is done with a simple one-parameter function that introduces curvature to the attribute space (i.e., the space were the options are plotted by attributes as shown in Figure 1). This function could be extended so that the mapping is skewed to favor options similar to reference points. Psychologically, this suggests that reference points make similar options appear more desirable as suggested by an assimilation effect.

In general, the experiments presented in this paper in combination with the experiments discussed in Trueblood et al. (2013) present a challenge to cognitive modelers to provide a unified framework for six multialternative effects (three reference-dependent effects and three context effects). These experiments showed all six effects in the same perceptual paradigm and provide support for the hypothesis that there exists a common set of cognitive mechanisms that produce the effects.

The value-based decision (e.g., consumer choice) and perceptual choice literatures have mostly been independent. However, Dhar and Glazer (1996) and Gold and Shadlen (2007) have argued that researchers should study the similarities and differences between decisions in these domains because principles of perceptual choice might be able to account for phenomena in value-based decisions. The experiments presented in this paper show that three reference-dependent effects from the consumer choice literature occur in perception suggesting that these effects are a fundamental part of decision-making processes and thus a general feature of human choice behavior.

Even though the three reference-dependent effects occur in perception, there is one important difference between the effects in consumer choice and perception. The effects are smaller in perception than in consumer choice. A similar pattern of results was found in Trueblood (2012) and Trueblood et al. (2013) where context effects were larger in a high-level inference paradigm compared with a perceptual task. A possible explanation for these differences is that the effects become smaller with faster response times. This hypothesis is consistent with experiments by Pettibone (2012) and Trueblood et al. (2014) showing that the attraction, similarity, and compromise effects decrease with time pressure. Another possibility is the influence of loss aversion in high-level domains, which could strengthen the effects. Even within the same paradigm, some reference points will result in stronger effects than others. Herne (1998) examined asymmetrically dominated reference points (similar to those in the improvements vs. tradeoffs effect) in a consumer choice experiment and found that changing the location of the reference point resulted in different choice proportions. Future research is needed to fully understand the strength of the effects both within and across domains.

Using perceptual domains to study multialternative choice behavior offers the possibility of collecting response time data because choices are made quickly and response times are easy to measure. Dynamic models such as MDFT, MLBA, and the Associative Accumulation Model are difficult to discriminate on the basis of choice data alone. However, it might be possible to distinguish these models using response time data as discussed in Tsetsos, Usher, and Chater (2010). Future experiments building upon the ones presented here and in Trueblood et al. (2013) could examine these issues.

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# Appendix

## Stimuli for Consumer Choice and Perceptual Experiments

In Experiment 1, the X and Y options (as shown in Figure 1) were each associated with a bivariate normal distribution with the two dimensions being the two attribute values – megapixels and monthly cost. The mean values of these distributions are given in Table A1. The megapixel dimension had variance equal to 0.5 and the cost dimension had variance equal to 1. The covariance was zero. Using distributions for X and Y instead of a single option for each location introduced variation in the task and allowed for more trials.

The reference points for the improvements versus tradeoffs effect were calculated by adding a random number in the interval [3,5] to the cost dimension of X and subtracting a random number in the interval [1,2] from the megapixel dimension of Y. The reference points associated with X for the small versus large tradeoffs effect were calculated by subtracting a random number in the interval [0,1] from the megapixel dimension and subtracting a random number in the interval [3,5] from the cost dimension. The reference points associated with Y for the small versus large tradeoffs effect were calculated by adding a random number in the interval [0,1] to the megapixel dimension and adding a random number in the interval [3,5] to the cost dimension.

In Experiments 2 and 3, option X was associated with a bivariate normal distribution with dimensions being the height and width of rectangles in pixels. The distribution had mean (50, 80) and variance 2 on each dimension with no

Table A1
*Mean Stimuli Values for Experiment 1 Given in Megapixels and Monthly Cost*

| Effect | X | Y | Reference point for X | Reference point for Y |
|---|---|---|---|---|
| Status quo bias | (3.0, 65) | (7.0, 95) | NA | NA |
| Improve versus tradeoff | (3.0, 65) | (7.0, 95) | (3.0, 69) | (5.5, 95) |
| Small versus large | (3.0, 65) | (7.0, 95) | (2.5, 61) | (7.5, 99) |

*Note.* NA = not applicable.

(*Appendix continues*)

Table A2
*Mean Stimuli Values for Experiments 2 and 3 Given in Pixels for the Height and Width of the Rectangles*

| Effect | X | Y | Reference point for X | Reference point for Y |
|---|---|---|---|---|
| Status quo bias | (50, 80) | (80, 50) | NA | NA |
| Improve versus tradeoff | (50, 80) | (80, 50) | (50, 72) | (72, 50) |
| Small versus large | (50, 80) | (80, 50) | (39.5, 101.3) | (101.3, 39.5) |

*Note.* NA = not applicable.

correlation as shown in Table A2. The height of option Y was determined from X by adding a random number from the interval [−2,2] to the width of X. The width of option Y was selected so that X and Y had equal area.

The reference points for the improvements versus tradeoffs effect were calculated by subtracting a random number from the interval [7,9] from the width dimension of X and the height dimension of Y. The reference points for the small versus large tradeoffs effect were calculated by subtracting a random number from the interval [9,12] from the height dimension of X and width dimension of Y. The remaining dimension of the reference points for the small versus large tradeoffs effect were selected so that the reference points had area equal to that of X and Y.

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