Antecedents and Consequences of Loss Aversion:

Mental Accounting and Allocation of Attention

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Submitted in partial fulfillment of the requirements for
the degree of Doctor of Philosophy
under the Executive Committee of the Graduate School of
Arts and Sciences

COLUMBIA UNIVERSITY

2012

ABSTRACT

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This dissertation consists of three essays. The first examines analytically as well as empirically the mental accounting principle that Thaler (1985) termed the "silver lining principle." The second and third essays investigate the link between attention and preferences. In the first essay, loss aversion is an important antecedent and moderator of the principle's effect on preferences, and in the latter two we hypothesize both antecedent (Essay Two) and consequent (Essay Three) roles for loss aversion with respect to attention.

The silver lining effect predicts that segregating a small gain from a larger loss results in greater psychological value than does integrating the gain(s) into a smaller loss. Using a generic prospect theory value function, we formalize this effect and derive conditions under which it should occur. We show analytically that if the gain is smaller than a certain threshold, segregation is optimal. This threshold increases with the size of the loss and decreases with the degree of loss aversion on the part of the decision maker. Our formal analysis results in a set of predictions suggesting that the silver lining effect is more likely to occur when (i) the gain is smaller (for a given loss), (ii) the loss is larger (for a given gain), and (iii) the decision maker is less loss-averse. We test and confirm these predictions in three studies of preferences, in both monetary and non-monetary settings, analyzing the data in a hierarchical Bayesian framework.

The second and third essays together examine the relation between allocation of attention and choice behavior—in particular the sensitivity of choices to gains and losses (and thus loss aversion). An initial empirical study suggests an association between decision makers' increased attention to losses and decreased attention to gains, and increased degrees of loss aversion. We then examine this association in two further empirical studies in order to test a potential causal relationship. The first of these manipulates loss aversion and measures attention, while the second manipulates attention and measures loss aversion.

We find no systematic evidence for a causal link between attention and loss aversion; our findings rather suggest a common influence accounting for their initially observed association. Some of the results point to a potential role of perceptual fluency, though this possibility awaits further research. We propose an additional empirical study using an alternative manipulation of attention previously utilized by Shimojo et al. (2003), among others.

We find evidence for a direct influence of attention on preferences, however, such that increased attention to positive attributes is associated with greater preference for an alternative, and vice versa for negative attributes. This result supports and extends previous work on the link between preferences and attention (e.g. Rangel 2008).

In addition, we observe a novel phenomenon that we term *attentional* loss aversion, by which the direct influence of attention on preference for an alternative is stronger for negative attributes than for positive attributes.

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ACKNOWLEDGMENTS

I gratefully acknowledge the work of the members of my dissertation committee, Leonard Lee, Vicki Morwitz, Olivier Toubia, Elke Weber, and in particular my advisor, Eric Johnson.

DEDICATION

To my friends and family, and in particular my parents, for their support and encouragement before, during, and after the efforts resulting in this dissertation.

1. Introduction and Overview.

At its very broadest, the research reported in this dissertation addresses the question of how decision makers interact with information in the choice environment, and in particular, how they react when the way that information is presented changes. To be concrete, on a very basic level changes to information presentation may be of two kinds: the information itself may change (a retailer may, for instance, decide to promote a product by modifying its price), or the information may stay the same while the way it is displayed changes (continuing with the example, the retailer may decide to promote a product by modifying only the size and color of the price information in order to draw the customer's attention towards it, while keeping the price itself constant). The series of studies reported here may then be arranged around these two themes; the first part addresses changes to the information itself, while the second part focuses on changes in the presentation of information.

In the first essay, we focus on a particular kind of information change: how we present a negative outcome to the decision maker. Specifically, we contrast presenting a loss of some amount on its own (a "pure loss") versus presenting a small gain together with the correspondingly larger loss. While presented in two components (a "mixed loss"), the net outcome is kept constant.

In the context of the retailer, the price promotion could be presented either as a simple price reduction ("used to sell for $100, buy now for $95!"), or it could be presented as money given back to the customer upon purchase, with the base price kept constant ("buy now for $100, get $5 back at the register!"). The latter is often referred to as an *instant rebate*.

The two modes of presentation are thus identical in terms of net monetary outcome: the sum of the old price and the discount in the price reduction case is exactly the same as the new price in the instant rebate case. The product is also unchanged between the two formats. Why then would we expect a different decision by the potential customer? Thaler (1985) made an intuitive prediction based on Kahneman and Tversky's (1979) prospect theory, which he called the "silver lining principle." This principle states that for outcomes simultaneously involving both losses and gains (i.e., "mixed outcomes"), the outcome holds greater (subjective) value for the decision maker if the two components are kept separately in mind ("segregated") than if they are collapsed together ("integrated") into one net outcome.

Though this principle has received little empirical attention in the literature, we have incorporated it in our thinking here. We start from the first principles of prospect theory, derive a richer set of predictions to extend Thaler's original work, and test these empirically. We find that rather than segregation always being optimal (as the strict silver lining principle prescribes), the size of the gains and losses involved, as well as characteristics of the decision maker, are going to moderate which of the two formats (segregation or integration) is optimal in a given situation.

In contrast to the studies reported in the first essay of this dissertation, where the decision environment is manipulated only by modifying the attribute levels (relative amounts) involved while keeping the decision situation itself and the display format of the alternatives constant, the studies featured in the second and third essays hold the amounts constant. Instead, they manipulate the type of decision scenario (Essay Two) and the visual environment (Essay Three) in which the choices are embedded.

In the studies of the second essay we introduce changes to the situation (such as whether a participant is deciding for oneself or acting as an agent for someone else) intended to produce changes in preferences. The preferences that we focus on are the degrees of sensitivity to changes in the alternatives' attributes; in particular, we seek to manipulate participants' loss aversion. Following this manipulation, we monitor the decision makers' allocation of attention for evidence of preference-driven changes in what types of information they focus on.

The third essay focuses on visual changes in information display. While the default way of presenting information about a particular option may be to show the various attributes in a consistent visual style, what happens when one of the attributes radically departs from the others in its presentation? In particular, we examine how the decision maker reacts when one of the features of an option is made to stand out by being unusual, and when extra attention is required to acquire the information about that feature. Here we are particularly interested in the consequences of the sensitivity of the decision maker's choice behavior to changes in an attribute, and the degree of attention paid to that attribute.

The reactions of the decision maker may vary in relation to changing decision environments, of both types mentioned above. These reactions include changes to the decision maker's attitudes (including specifically targeted attitudes towards the choice object, as well as more general attitudes such as risk preferences) and behavior (which may include both behavior during the decision process, such as search behavior, and the direct outcome of the decision process, such as choice behavior). When the retailer changes his prices or the way in which they are presented, the most obvious reaction in the potential customer is of course purchase behavior, a type of choice behavior: when you see prices falling, you become more likely to purchase. However, there may also be changes to the decision process, which may in turn change the choice behavior. For instance, making the price more visible than the other attributes of a product may increase the impact of price in the purchase decision. In our case, changing the legibility of the features may alter the search pattern, which in turn may change the outcome of the process.

Thus, in the second essay, we ask whether attention is allocated in different ways when choice behavior changes. In the third essay, we investigate the reverse relationship: how does re-allocation of attention following changes in the visual presentation of attribute information affect a decision maker's choices? The second and third essays of this dissertation thus examine two potential causal directions of the relationship between attention and preferences.

1.1 Methodologies.

We use a wide variety of analytic and empirical methodologies. As described in the first essay, we begin by using analytical methods that derive predictions for when the silver lining effect will and will not occur. We then test these predictions in three experimental studies. We capture these effects with a hierarchical Bayesian model, estimated using Markov Chain Monte Carlo methods.

In the second and third essays, we use MouseLabWEB (Willemsen and Johnson 2008), a software tool that lets us track the pattern by which the decision maker allocates attention to the information in the choice environment. We deploy these studies to the home computer of the participant over the Internet, displaying the task and the available information while tracking which pieces of information she looks at; we can thus remotely log her allocation of attention during the decision process.

1.2 Stimuli and Manipulations.

Many of the stimuli we employ in the empirical studies of this dissertation are gambles. The gambles are generally two-outcome mixed gambles; each has a potential loss and a potential gain (monetary as well as non-monetary), with respectively associated probabilities. The task for the decision makers is then to accept or reject the gamble.

Using gambles in choice tasks lets us isolate the choice behavior and attention allocation pattern from many of the factors that would be present in real-life choice situations. In the retail setting, for example, one encounters choice options with a variety of different attributes and presentation styles. Removing these factors helps to eliminate noise from the decision process and increases our power to detect the hypothesized effects: the price of this is diminished realism, and in particular the lessened ability to predict whether the effects would be significant in settings where those factors are present. Since the main goal here is establishment of the hypothesized effects' presence, rather than their relative sizes, we consider this trade-off acceptable. Further, it would be straightforward to replicate the research in other settings in order to examine the effects' relative strength in the presence of the elements eliminated as nuisance factors here.

Gambles also carry the advantage of having been previously used as the canonical way of testing decision-making hypotheses experimentally (e.g. Kahneman and Tversky 1979).

Some of our experiments feature increased realism over gambles; examples include using concrete prices and discounts rather than abstract losses and gains, and using vacation days as the currency of gambles. In addition, we manipulate attention by altering the readability and salience of the text of certain attributes, which is, while not identical, similar to what a retailer might do to attract the gaze of potential customers.

2. Essay One: The Silver Lining Effect.

2.1 Introduction.

Decision makers are often faced with mixed outcomes, famously captured by the saying "I have good news and I have bad news." In this paper we look at the case where the bad news is larger in magnitude than the good, and ask: Does the decision maker want these events combined or presented separately? Thaler, in his seminal paper (Thaler 1985), showed that a decision maker faced with such a mixed outcome consisting of a loss and a smaller gain should generally prefer to separate the loss and the gain. That is, evaluating the gain separately from the larger loss is seen more positively than reducing the loss by the same amount. The small gain becomes a "silver lining" to the dark cloud of the loss, and, pushing the analogy further, adding a silver lining to the cloud has a more beneficial impact than making the cloud slightly smaller. The separate evaluation is referred to as *segregation* and the joint evaluation as *integration*.

The silver lining effect has broad application, since equivalent information may often be framed to decision makers in either integrated or segregated form. Consider for example a retailer who decides to decrease the price of a product: he or she could simply lower the price, reducing the loss to the consumer, and announce the new discounted price. Another option would be to keep charging the same amount but then give some of it back to the consumer in the form of a rebate (Thaler 1985). Similarly, a vacation resort could lower its average daily rates for stays of one week or more, or offer a free night for every six nights spent in the resort. The two methods, of course, can translate to the exact same dollar saving, differing only in framing. Consider an investor receiving a brokerage statement containing a net loss: Would he or she want to see only the smaller total loss or to see the winners separated from the losers, even though the balance would be identical?

Despite the relevance of the silver lining effect to both academics and practitioners, we are not aware of any formal study of when it should occur, beyond Thaler's (1985) intuitive argument that the silver lining effect is more likely when the gain is smaller relative to the loss. The primary contribution of the current paper is to fill this gap. We assume a generic prospect theory value function and formally show that if the gain is smaller than a certain threshold, segregation is optimal. Next, we show how the value of this threshold is affected by both the magnitude of the loss and by the loss-aversion parameter of the value function. Our formal analysis provides a set of predictions suggesting that the silver lining effect is more likely to occur when: (i) the gain is smaller (for a given loss), (ii) the loss is larger (for a given gain), (iii) the decision maker is less loss-averse. We test and confirm these predictions in three experiments. Finally, we provide a methodological contribution to the literature on the measurement of loss aversion by replacing the deterministic, individual-level approach traditionally used by behavioral economists with a hierarchical Bayes framework that accounts for measurement errors and similarities across decision makers.

This first part of this dissertation is structured as follows: In Section 3, we briefly review the silver lining effect and the prospect theory framework. In Section 4, we report our theoretical analysis of the silver lining effect. The context and results of our first empirical study, which is conducted in a non-monetary setting, are reported in Section 5. In Section 6 we present the second empirical study, which extends the findings from the first study to monetary decisions. A third empirical study is reported in Section 7, which tests one of our hypotheses using a different manipulation than that used in the second study. Section 8 concludes and provides directions for future research.

3. The Silver Lining Effect and Prospect Theory.

3.1 The Silver Lining Effect.

When faced with a decision that involves several pieces of information, decision makers don't always integrate them into a whole but instead may use them in the form presented by the decision context; Slovic (1972) calls this the *concreteness principle*. Thus, an individual may treat two amounts of money, for instance, as separate entities instead of simply summing them. Thaler and Johnson (1990) provide evidence that these effects occur for monetary gambles, and Linville and Fischer (1991) demonstrate this phenomenon for life effects. Thaler's (1985) theory of mental accounting addresses what this phenomenon implies for subjective value and thus for decision making. The silver lining principle focuses on outcomes that consist of a loss and a smaller gain, known as *mixed losses*. When faced with such outcomes, Thaler's prescription—which he dubbed the *"silver lining principle"*—is to keep them separate in mind (i.e., segregate the gain from the loss), so that the small gain can provide a *silver lining* to the larger loss, rather than disappear if used to diminish the loss (i.e., if the gain were integrated with the loss). An important implication of concreteness is that decisions can be materially affected by the presentation of the outcomes as either integrated or segregated, because decision makers do not spontaneously combine them (Thaler and Johnson 1990).

Read, Loewenstein, and Rabin (1999) introduce the related concept of *choice bracketing*. In broad bracketing, several decisions are considered jointly, whereas in narrow bracketing each individual choice is considered separately. Bracketing is distinguished from segregation and integration—which refer to *outcome editing* (Kahneman and Tversky 1979; Thaler 1985), the consideration of outcomes within a single choice—because bracketing addresses whether a group of choices is evaluated jointly or separately.

3.2 Prospect Theory.

Prospect theory (Kahneman and Tversky 1979; Tversky and Kahneman 1992) proposes a value function $v(\cdot)$ as an alternative to the utility functions assumed by expected utility theory. The value function is characterized by three key features: *reference dependence,* meaning that the arguments of the value function are positive and negative deviations from some reference level, defined as gains and losses, respectively; *loss aversion,* reflecting the fact that losses loom larger than gains of the same magnitude; and *diminishing sensitivity,* indicating that the marginal impact of both gains and losses decreases as they become larger. These three characteristics result in a value function shaped as seen in Figures 1, 2, and 3. The origin denotes the reference point relative to which outcomes are categorized as gains and losses. Loss aversion results in a "kink" in the function at the origin: for all $x > 0$, $-v(-x) > v(x)$. Moreover, diminishing sensitivity in both domains implies that the value function is concave for gains and convex for losses, that is, $v''(x) < 0$ for $x > 0$, and $v''(x) > 0$ for $x < 0$. A large amount of evidence supporting this function, both from field studies and experimental work, can be found in Tversky and Kahneman (2000).

In this paper, we assume the following generic specification of the value function:

$$v(x) = \begin{cases} g(x) & x \geq 0 \\ l(x) = -\lambda g(-x) & x < 0 \end{cases} \quad (1)$$

where $\lambda > 1$ and g is a function from $[0,\infty[$ to $[0,\infty[$ which is strictly concave, strictly increasing, twice differentiable, and such that $g(0)=0$. Note that we assume here a "reflective" value function (as in Kahneman and Tversky 1979), i.e., the value function for losses is the mirror image of the value function for gains. This assumption has received mixed empirical support (see, e.g., Abdellaoui, Bleichrodt, and Paraschiv 2007). We leave to future research the extension of our results to non-reflective value functions. Such extension would be trivial under a power function specification.

4. Theoretical Analysis.

In this section we derive theoretical predictions for the silver lining effect. In particular, we characterize regions where segregation of gains and losses is preferable to integration, and identify how the trade-off between integration and segregation is influenced by the magnitude of the gain, the magnitude of the loss, and the degree of loss aversion of the decision maker.

The proofs to all the results are provided in Appendix 1. Our analysis starts with the following proposition:

PROPOSITION 1**:** *For any fixed loss L > 0 there exists a gain* $G^* \in]0, L[$ *such that the value derived from segregation is greater than that derived from integration for any gain G < G*, and the reverse is true for any gain G > G*.*

- *If* $\lim_{x \to 0^+} g'(x) = \infty$ *or if* $\lim_{x \to 0^+} g'(x) \neq \infty$ *and* $\lambda < \lambda^* = \frac{g'(0)}{g'(L)}$ *, then* $G^* > 0$*, that is, there exists a region in which the value derived from segregation is greater than that derived from integration.*
- *If* $\lim_{x \to 0^+} g'(x) \neq \infty$ *and* $\lambda > \lambda^* = \frac{g'(0)}{g'(L)}$*, then* $G^* = 0$*, that is, the value derived from integration is greater than that derived from segregation for any gain G ≤ L.*

Proposition 1 shows the existence of a threshold *G** such that segregation is optimal for all gains smaller than this threshold, and integration is optimal for all gains larger than this threshold. The intuition behind the existence of a gain threshold is best explained graphically. Figure 1 gives an example of a mixed loss (*L*, *G**) for which the decision maker is indifferent between integration and segregation, i.e., $g(G^*)=l(-L+G^*)-l(-L)$. Let us consider a smaller gain G'. Both the corresponding gain $g(G')$ and the corresponding loss reduction $l(-L+G')-l(-L)$ are smaller under G' than under G^*. Whether integration or segregation is optimal thus depends upon which of the two quantities is decreased the least. Because of the concavity of the gain function *g,* the difference between the initial gain $g(G^*)$ and the smaller gain $g(G')$ corresponds to the flattest part of the gain function between 0 and G^*. In other words, the decrease in gain between G^* and G' is relatively *small* compared to the initial gain $g(G^*)$. On the other hand, the difference between the initial loss reduction and the smaller loss reduction corresponds to the steepest part of the loss function between $(-L+G^*)$ and $-L$. Therefore the decrease in loss reduction $l(-L+G')-l(-L)$ is relatively *large* compared to the initial loss reduction $l(-L+G^*)-l(-L)$, and thus compared to the initial gain $g(G^*)$—recall that $g(G^*)=l(-L+G^*)-l(-L)$. Therefore, the new gain from segregation is larger than the new gain from integration, and segregation becomes optimal for G'. The same argument holds for G'' larger than G^*. In this case both the gain and loss reduction are *increased*. Because of the concavity of the gain function, the increase in gain is smaller than the increase in loss reduction, and integration becomes optimal for G''.

Proposition 1 also states that for some specifications of the value function, there may exist situations in which a decision maker who is very loss-averse will always prefer integration over segregation, i.e., $G^* = 0$.[1] Note, however, that such situations do not arise in the common specification in which *g* is a power function (of the form $g(x)=x^{\theta}$).

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[1] Because *g* is strictly concave, $\lim_{x \to 0^+} g'(x) \neq \infty$ implies that $\lim_{x \to 0^+} g'(x)$ exists and is finite.

Indeed, in that case $\lim_{x \to 0^+} g'(x) = \infty$ and there always exists a range of gains for which it is optimal to segregate, no matter how loss-averse the decision maker is.

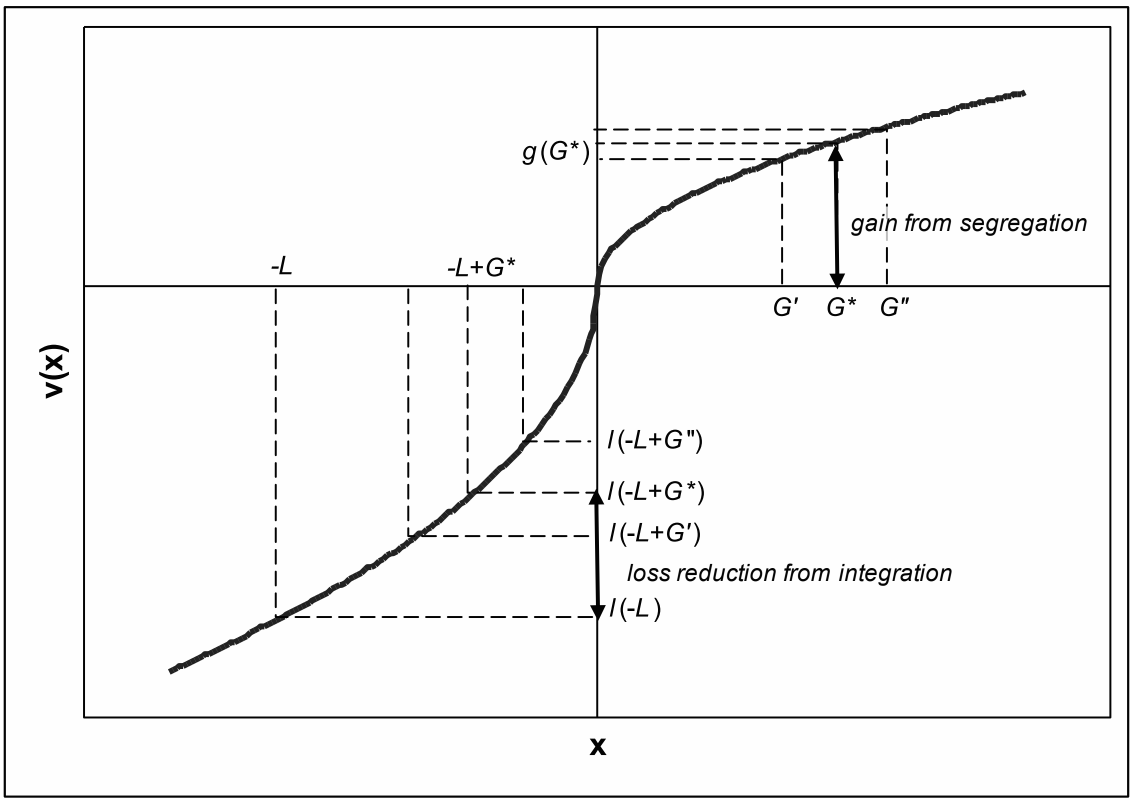

Figure 1. Illustration of Proposition 1.

Proposition 1 has the following testable implication:

HYPOTHESIS 1 ("GAIN SIZE HYPOTHESIS"). *For a given mixed loss (L, G) with L > G, the smaller the gain G, the greater the value derived from segregation relative to* *integration; and conversely, the greater the gain, the greater the value derived from integration relative to segregation.*

Proposition 1 introduced a threshold gain, G^*, such that segregation is optimal for gains smaller than G^*, and integration is optimal for gains larger than G^*. G^* is a function of L and λ, as well as of any parameter of the value function. In the region in which $G^*>0$, G^* is defined by: $g(G^*)=l(-L+G^*)-l(-L)=-\lambda g(L-G^*)+\lambda g(L)$. Setting $F(G,L,\lambda)=g(G)+\lambda g(L-G)-\lambda g(L)$, G^* is defined by $F(G^*, L, \lambda) = 0$.

The following proposition uses the envelope theorem to evaluate the influence of L and λ on G^*.[2]

PROPOSITION 2: *In the region in which $G^*>0$, the following comparative statics hold:*

a) G^* is monotonically increasing in the amount of the loss L ($\frac{dG^*}{dL} > 0$)

b) G^* is monotonically decreasing in the loss aversion parameter λ ($\frac{dG^*}{d\lambda} < 0$)

Like Proposition 1, these results may be illustrated graphically. Let us first consider Proposition 2a, illustrated by Figure 2. The gain G_0^* is such that for a loss L_0 a decision maker is indifferent between integration and segregation, i.e.,

[2] The implications of Proposition 2, captured by Hypotheses 2 and 3, extend to the domain in which $G^*=0$. The more loss-averse the decision maker, the more likely $\lambda > \lambda^* = \frac{g'(0)}{g'(L)}$ is to hold, and therefore the more likely is G^* to be 0 and integration to be always preferred over segregation. Because of the concavity of the function g, $\lambda^* = \frac{g'(0)}{g'(L)}$ is increasing in L, and for a fixed λ, the larger the loss L, the less likely $\lambda > \lambda^*$ is to hold and therefore the less likely is integration to be always preferred to segregation.

$g(G_0^*) = l(-L_0 + G_0^*) - l(-L_0)$. Let us consider a change from L_0 to L_1<L_0. The gain function being unaffected by L, the gain from segregation $g(G_0^*)$ is unaffected as well. However, because of the concavity of the loss function, reducing the loss by a fixed amount G_0* leads to a greater increase in value when the loss being reduced is smaller, i.e., $l(-L_1+G_0^*)-l(-L_1) > l(-L_0+G_0^*)-l(-L_0)$. As a result, while the decision maker is indifferent between segregation and integration for G=G_0* under L_0, he or she would prefer integration for G=G_0* under L_1, i.e., $g(G_0^*) < l(-L_1 + G_0^*) - l_1(-L_1)$, and therefore $G^*(L_1, \lambda) < G^*(L_0, \lambda)$.

Second, let us consider Proposition 2b. Figure 3 represents two value functions that differ only on the value of the loss aversion parameter λ. The gain function is unaffected by the parameter λ, and the two loss functions l_0 and l_1 on Figure 3 correspond respectively to $\lambda = \lambda_0$ and $\lambda = \lambda_1 > \lambda_0$. The gain G_0* is such that a decision maker with a loss aversion parameter λ_0 is indifferent between integration and segregation, i.e., $g(G_0^*) = l_o(-L + G_0^*) - l_0(-L)$. Let us consider a change from λ_0 to λ_1. The gain function being unaffected by λ, the gain from segregation $g(G_0^*)$ is unaffected as well. However, the loss reduction from integration $l(-L + G_0^*) - l(-L)$ being proportional to λ is greater when λ is greater. As a result, while a decision maker with loss aversion λ_0 would be indifferent between segregation and integration for $G = G_0$*, a decision maker with loss aversion λ_1 would prefer integration, i.e., $g(G_0^*) < l_1(-L + G_0^*) - l_1(-L)$, and therefore $G^*(L, \lambda_1) < G^*(L, \lambda_0)$.

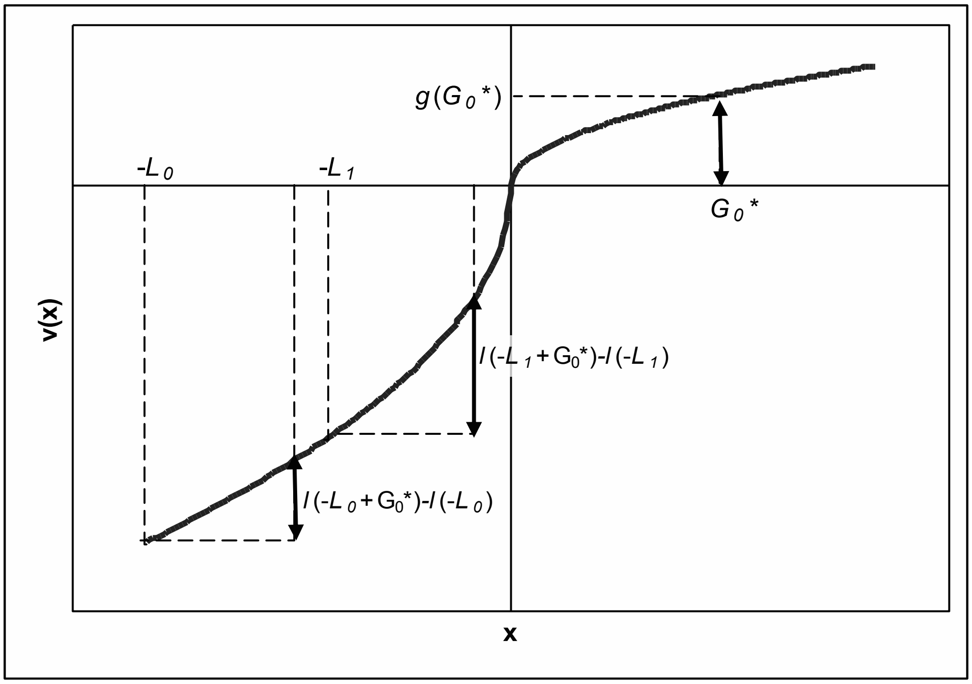

Figure 2. Varying the magnitude of the loss.

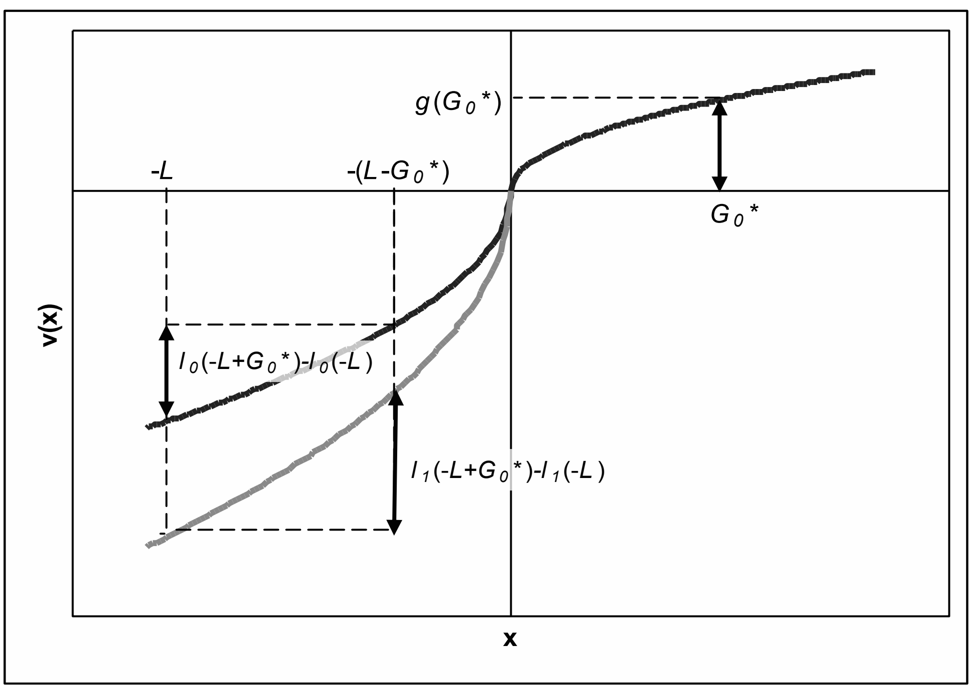

Figure 3. Varying the degree of loss aversion.

Like Proposition 1, Proposition 2 has the following testable implications.

HYPOTHESIS 2 (“LOSS SIZE HYPOTHESIS”): *For a given mixed loss (L, G) with L > G, the larger the loss L, the greater the value derived from segregation relative to integration, and conversely, the smaller the loss L, the greater the value derived from integration relative to segregation.*

HYPOTHESIS 3 (“LOSS AVERSION HYPOTHESIS”): *For a given mixed loss (L, G) with L > G, the more loss-averse a decision maker, the greater the value derived from integration relative to segregation, and conversely, the less loss-averse a decision maker, the greater the value derived from segregation relative to integration.*

The remainder of this essay focuses on testing the above hypotheses experimentally.

5. Study 1.1 (Vacation Days).

Our analysis led to a set of hypotheses that together suggest that the segregation of a small gain from a larger loss is more appealing when: (i) the gain is smaller (for a given loss), (ii) the loss is larger (for a given gain), (iii) the decision maker is less loss-averse. Our first study tests these hypotheses in the context of choices between different numbers of vacation days.

5.1 Method.

The experiment was conducted using a large online panel of pre-registered individuals who were offered the opportunity to participate on their own time and compensated $2 for their assistance. A total of 53 participants completed the survey. We employed three methods to ensure that only participants who paid proper attention were kept for analysis. First, completion times were recorded and screened for participants who were outside two standard deviations from the mean; this led to the exclusion of one subject. Second, one subject was excluded for answering “yes” to all 16 of our gamble items (presented below); this response does not provide usable data, and also suggests inattention. The third screening method was a “trick” item inserted in the middle of our survey. This item consisted of a block of text apparently containing the instructions for how to answer the following questions; however, in the middle of the block participants were told that this was an attention-check, and given instructions to ignore the surrounding text and instead answer the questions in a particular way to show that they were indeed paying attention. The “real” instructions were positioned so that briefly skimming or ignoring the text altogether would lead to an identifiable response to the question; this method eliminated as inattentive a further 15 participants. The analyzed sample thus consisted of 36 individuals, with a median age of 37 and a median income of $42,500. Our sample goes well beyond the student populations often used in experimental studies: only 14% of our subjects described themselves as students, 11% as unemployed, and 64% as employed outside the household.

We tested our three hypotheses using a rating task in which each participant read four scenarios. Each scenario involved a change of jobs necessitated by the current employer going out of business, and an associated change in the allocation of vacation days. In each of the four scenarios, the decision maker faced two job offers, both of which involved a net loss of vacation days but which differed in their distribution (see Table 1 for details of each scenario).

	Pair 1		Pair 2		Pair 3		Pair 4	
	A	*B*	*C*	*D*	*E*	*F*	*G*	*H*
Change in number of summer vacation days	−4	−1	−4	−3	−7	−4	−7	−6
Change in number of winter vacation days	3	0	1	0	3	0	1	0
Net change	−1	−1	−3	−3	−4	−4	−6	−6

Table 1. The four pairs of job offers and their outcomes.

For instance, in scenario 1, offer A would mean a loss of four summer vacation days and a gain of three winter vacation days, while offer B would mean a loss of only one summer vacation day. Both offers thus resulted in a net loss of one vacation day. In one case, this was presented as a larger loss (−4 days) and a separate (segregated) smaller gain (3 days), and in the other case only as a smaller loss (−4+3=−1 day). After reading the scenario, the participant rated her preference for one offer over the other on a five-point scale from −2 (strongly prefer the integrated offer) to 2 (strongly prefer the segregated offer).

The design of the experiment was a 2 (loss: small (4 days) vs. large (7 days)) × 2 (gain: small (1 day) vs. large (3 days)) factorial design, with all manipulations within-subject, and the order of presentation of the pairs of job offers varying between-subjects in a Latin square pattern.

In addition to the main preference measure, we collected two additional individual-level measures: relative preference for summer vacations over winter vacations, and loss aversion. Since each choice was between a loss in summer vacation days and a gain in winter vacation days (segregated option) vs. a smaller loss in summer vacation days (integrated option), it is important to control for a general preference for summer vacation days. To do this, we asked participants to allocate 20 vacation days among summer, winter, and the rest of the year. Our measure of participant *i*'s relative preference for summer vacation days, $summer_i$, was then defined as the ratio of days allocated to summer divided by the total days allocated to summer and winter. (Days allocated to the rest of the year were ignored as they do not appear in our scenarios.)

The other additional measure was loss aversion for vacation days (the currency used in this experiment). To estimate this parameter, we used two sequences of gambles, with participants asked to accept or reject each (see Goette, Huffman, and Fehr 2004 and Tom et al. 2007 for similar measures of loss aversion). The gambles were introduced by a scenario in which the decision maker had the option of joining a new project at work, which if successful would result in extra vacation days (5 days in one sequence, 12 in the other), and if unsuccessful would result in a loss of vacation days. The project's probability of success was estimated at .5, and because it depended on competitors and clients, the decision maker herself would not be able to influence it. The gambles varied on the amount of lost vacation days resulting from the project's failure; see Table 2 for the complete sequences of gambles used.

	Sequence 1		Sequence 2	
Gamble	*Gain*	*Loss*	*Gain*	*Loss*
1	5	0.5	12	1
2	5	1	12	2
3	5	1.5	12	2.5
4	5	2.5	12	3
5	5	3	12	3.5
6			12	4.5
7			12	5
8			12	6
9			12	8
10			12	10

Table 2. The gambles used to measure loss aversion, and their outcomes (all probabilities are 1/2 and all amounts are in number of vacation days).

For each subject, each sequence of gambles provided the number of vacation days lost equivalent to 5 and 12 days gained. For instance, if a subject accepted Gamble 3 but rejected Gamble 4 in the first sequence, and accepted Gamble 7 but rejected Gamble 8 in the second sequence, we coded these responses as if a gain of 5 days was equivalent to a loss of 2 (the average of 1.5 and 2.5) days, setting x_{5days}=2, and as if a gain of 12 days was equivalent to a loss of 9 (the average of 8 and 10) days, setting x_{12days}=9. This provided us with two measures of the parameter λ: $\hat{\lambda}_5 = \frac{5}{x_{5days}}$ and $\hat{\lambda}_{12} = \frac{12}{x_{12days}}$. In the analysis below, we use both of these measures and take into account the existence of measurement error. The two measures correlated at Kendall's τ=.45 across subjects. Responses were screened for monotonicity; that is, the analysis included only subjects with at most one switch from acceptance to rejection as the size of the loss increased. This eliminated one participant. Six participants indicated that they would accept all gambles in the first sequence; in those cases, only the 12-day measure was used in the analysis.

Note that the expressions for $\hat{\lambda}_5$ and $\hat{\lambda}_{12}$ assume that the value function is approximately linear for small amounts, and that the probability weighting function is similar for gains and losses. These estimates are biased upwards if the true value function exhibits diminishing sensitivity. Indeed, if $v(x) \propto x^{\theta}$, then the correct estimates of λ would be $(\frac{5}{x_{5days}})^{\theta}$ and $(\frac{12}{x_{12days}})^{\theta}$, which are smaller than $\hat{\lambda}_5$ and $\hat{\lambda}_{12}$, respectively, assuming θ<1 (diminishing sensitivity) and x_{5days}<5 and x_{12days}<12 (loss aversion).[3] If different probability weighing functions are applied for gains and losses, then our estimates are off by a factor of $\frac{w^-(0.5)}{w^+(0.5)}$, where w^- and w^+ are the weighing functions for losses and gains, respectively. These effects would increase the noise and decrease the fit of our model and would work against our hypotheses, making our analyses conservative.

5.2 Results and Discussion.

There was an overall preference for integration in our sample (M=−.49 on our scale from −2 to 2; t=−4.72, p<.0001), as well as an overall preference for summer over winter vacations (M=.62 on our scale from 0 to 1, with 0.5 being the indifference point; t=−7.95, p<.0001). As predicted by our hypotheses, the relative preference for segregation was greater for pairs involving small versus large gains (M_{small_gain} =−0.38, M_{large_gain} =−0.60) and large versus small losses (M_{large_loss}=−0.39, M_{small_loss}=−0.58), and was negatively correlated with loss aversion as measured by the average of $\hat{\lambda}_5$ and $\hat{\lambda}_{12}$ (ρ=-0.19).

We now test these hypotheses formally and assess the level of statistical significance of our results. This requires modeling the impact of loss aversion, loss size, and gain size on the relative preference for segregation over integration. We have two noisy measures of loss aversion for each subject. Our individual-level estimate of λ should reflect these two measures and weigh them appropriately based on their respective precisions. Moreover, previous research has shown that extreme values of λ are unusual and that this parameter tends to follow a unimodal distribution across decision makers (Gaechter, Johnson, and Herrmann 2007). We use a Bayesian framework in order to

[3] The magnitude of this effect would be modest. For example, given the commonly cited value of θ=.88, an estimated value of 2 would correspond to a true value of $2^{.88}\approx1.84$.

capture these aspects of our data (Gelman et al. 1995; Rossi and Allenby 2003). This framework allows the production of individual-level estimates of λ that appropriately weigh each measure while capturing similarities across individuals by allowing λ to be shrunk towards a population mean. Our individual-level estimates of λ may be thought of as a weighted average between the two measures of loss aversion and the population mean, where the weights are determined from the data according to the variance of each component. The effect of shrinkage is primarily limited to outliers, correcting any unreasonably extreme value of λ towards the population mean while effectively "leaving alone" the other subjects (Rossi and Allenby 2003). Additional benefits of using a Bayesian framework include flexibility in model formulation and the direct quantification of uncertainty on the parameters. Such a framework is particularly well suited for situations such as ours in which limited data are available from a moderately large sample of subjects. The details of the model and its estimation can be found in Appendix 2.[4]

At the subject level, we modeled the preference of subject *i* on gamble pair *j*, $pref_{ij}$, as a function of the size of the gain, the size of the loss (both coded orthogonally, with small=−1 and large=1), their interaction, a subject-specific intercept a_i, and a normally distributed error term, ε_i. We also included indicator variables for the position (within the Latin square design) at which pair *j* was presented:

$$pref_{ij} = a_i+\beta_1 gain_{ij}+\beta_2 loss_{ij}+\beta_3 gain_{ij}\times loss_{ij}+\beta_4\times 1(\text{position}_{ij}=1)+\beta_5\times 1(\text{position}_{ij}=2)+\beta_6\times 1(\text{position}_{ij}=3)+\varepsilon_{ij} \quad \text{with } \varepsilon_{ij} \sim N(0,\sigma^2)$$

[4] Similar results were obtained with a simpler non-Bayesian linear model.

Our two measures of individual *i*'s loss aversion, $\hat{\lambda}_{5,i}$ and $\hat{\lambda}_{12,i}$, are modeled as functions of a true underlying value, λ_i, plus normally distributed errors δ_i and ζ_i:

$$\hat{\lambda}_{5,i} = \lambda_i + \delta_i$$

$$\hat{\lambda}_{12,i} = \lambda_i + \varsigma_i$$

with $\delta_i \sim N(0,\nu_5^2), \zeta_i \sim N(0,\nu_{12}^2)$

We captured the effect of loss aversion and relative preference for summer vacations on the preference for segregation versus integration by allowing λ_i and $summer_i$ to impact the subject-specific intercept a_i. In particular, we used the following Bayesian prior for a_i:

$$a_i \sim N(a_0 + \lambda_i a_1 + summer_i a_2, \eta^2)$$

Finally, we specified a prior on λ_i that captures similarities across subjects and allows shrinking towards a population mean:

$$\lambda_i \sim N(\lambda_0, \tau^2)$$

We estimated this model using Markov Chain Monte Carlo, with 100,000 iterations, the first 50,000 being used as burn-in. Convergence was assessed informally from the time-series plots of the parameters. The mean estimate of λ_i, the individual-level degree of loss aversion for vacation days, was 4.34.

The results are shown in Table 3. The estimates shown are the means of the posterior distributions of each parameter; the reported *p*-values are posterior *p*-values, based on the draws from the posterior distribution (one-tailed where our hypotheses make directional predictions). The results generally support our hypotheses: greater gains predict increased preference for integration (Hypothesis 1), greater losses (marginally) predict increased preference for segregation (Hypothesis 2), and greater loss aversion predicts increased preference for integration (Hypothesis 3). As expected, we also see a significant impact of a general preference for summer over winter vacations.

Parameter	Estimate	*p*-value
a_1 (loss aversion)	−.402	.022
a_2 (summer preference)	−4.82	<.0002
β_1 (gain: large=1, small=−1)	−.113	.032
β_2 (loss: large=1, small=−1)	.088	.071
β_3 (gain x loss interaction)	.034	.558
β_4 (position=1)	.339	.052
β_5 (position=2)	.027	.876
β_6 (position=3)	.074	.664

Table 3. Estimates from the hierarchical Bayes model.

Study 1 provides initial support for our three hypotheses in a non-monetary setting and also introduces our modeling framework. We conducted an additional experiment to look for stronger support for Hypothesis 2 (loss size) in a larger sample size and a more canonical context. The second experiment also extends the initial findings to a monetary setting.

6. Study 1.2 (Gambles).

The three hypotheses were tested here in the context of mixed monetary gambles.

6.1 Method.

The study was conducted in the virtual lab of a large East Coast university, with participants accessing the experiment over the Internet. The present stimuli and measures were embedded in a longer series of surveys. Invitations to participate were sent out to a group of pre-registered individuals who had not previously participated in surveys from the lab and were offered $8 for completing the series of surveys.

The sample consisted of 163 individuals, with a median age of 35.5; the reported median income range was between $50,000 and $100,000. Again the sample was composed of individuals of varied occupations: 13% of our subjects were students, 13% were unemployed, and 57% were employed outside the household.

We tested our hypotheses using four pairs of gambles, all of which had three possible outcomes, each with probability 1/3. Each of the four pairs corresponded to one cell in a 2 (loss: small ($30) vs. large ($60)) × 2 (gain: small ($5) vs. large ($20)) factorial design. See Table 4 for a complete description of the gambles. Within each pair, one gamble presented the gain and the loss separately (as outcomes 1 and 2), while the other combined them in a single outcome (outcome 2). In each pair, a third outcome was added to both gambles in order to equate the expected value of all gambles to $20; this ensured that differences across pairs were not due to differences in the expected values of the gambles.

	Pair 1		Pair 2		Pair 3		Pair 4	
	A	*B*	*C*	*D*	*E*	*F*	*G*	*H*
Outcome 1 (gain)	5	0	20	0	5	0	20	0
Outcome 2 (loss)	−30	−25	−30	−10	−60	−55	−60	−40
Outcome 3 (equalizer)	85	85	70	70	115	115	100	100
Expected value	20	20	20	20	20	20	20	20

Table 4. The four pairs of gambles and their outcomes (all probabilities are 1/3 and all amounts are in dollars).

For each pair of gambles, subjects were asked to rate their preference for one of the gambles versus the other on a five-point scale from −2 (strongly prefer the integrated gamble) to 2 (strongly prefer the segregated gamble), with zero indicating indifference. The order of presentation of the gambles was counterbalanced between subjects using a Latin square design.

The loss aversion parameter was measured using gambles in a similar way to Study 1.1, the main difference being the use of gambles for money rather than for vacation days. Subjects were shown two sequences of ten gambles each and for each gamble were asked to indicate whether they would accept the offer to play it. Again, all gambles were binary, with one loss and one gain, and probabilities were held constant at .5. Each of the two sequences held the gain amount constant, at $6 and $20, respectively, while the loss amounts increased as the sequence progressed. See Table 5 for the complete set of gambles.

Gamble	Sequence 1		Sequence 2	
	Gain	*Loss*	*Gain*	*Loss*
1	6	0.5	20	2
2	6	1	20	4
3	6	2	20	6
4	6	2.5	20	8
5	6	3	20	10
6	6	3.5	20	12
7	6	4	20	14
8	6	5	20	16
9	6	6	20	18
10	6	7	20	20

Table 5. The two sequences of gambles used to measure loss aversion (all amounts in dollars).

For each subject, each sequence of gambles then provided an amount of loss equivalent to a gain of \$6 and \$20, respectively. This provided us with two (noisy) measures of the parameter λ: $\hat{\lambda}_6 = \frac{6}{x_6}$ and $\hat{\lambda}_{20} = \frac{20}{x_{20}}$. The two measures correlated at Kendall's τ=.60 across subjects. Responses were screened for monotonicity; that is, the analysis includes only subjects with at most one switch from acceptance to rejection of the gambles as the size of the loss increased. This led to the elimination of seven subjects.

6.2 Results and Discussion.

There was a slight overall preference for segregation over integration (*M*=0.09 on our scale from −2 to 2; *t*=1.60, *p*=.11). As predicted by our hypotheses, the relative preference for segregation was greater for pairs involving small versus large gains (M_{small_gain} = +0.20, M_{large_gain} = -0.03) and large versus small losses (M_{large_loss}=+0.18, M_{small_loss}=−0.01), and was negatively correlated with loss aversion as measured by the average of $\hat{\lambda}_5$ and $\hat{\lambda}_{20}$ (ρ=-0.15).

As in Study 1.1, we used a hierarchical linear model to test our hypotheses formally. The only difference was in the specification of the prior distribution for the subject-specific intercepts a_i, where we eliminated the term that captured a preference for summer over winter vacations, leaving only the intercept and the effect of loss aversion:

$$a_i \sim N(a_0 + \lambda_i\, a_1, \eta^2)$$

We again estimated this model using Markov Chain Monte Carlo, with 100,000 iterations, the first 50,000 being used as burn-in. Convergence was assessed informally from the time-series plots of the parameters. Our estimate of the individual-level degree of loss aversion for money, λ_i, had a mean of 2.88, which is consistent with previous findings (see e.g. Camerer 2005), and somewhat smaller than what we observed for vacation days in Study 1.1.

The results are shown in Table 6.[5] The estimates support all three hypotheses, including the loss size hypothesis. As before, a large gain predicts greater preference for

[5] It is important to note that according to Cumulative Prospect Theory (Tversky and Kahneman 1992), the difference between the value of the "integrated" and "segregated" gamble is only approximately proportional to $l(-L+G) - l(-L) - g(G)$. We also note that Wu and Markle (2008) have recently documented

integration compared to a small gain (Hypothesis 1), and greater loss aversion predicts greater preference for integration (Hypothesis 3). Our loss size hypothesis now also receives significant support, as an increase in loss size predicts greater preference for integration (Hypothesis 2).[6]

Parameter	**Estimate**	***p*-value**
a_1 (loss aversion)	−0.400	.0050
β_1 (gain: large=1, small=−1)	−0.115	.0024
β_2 (loss: large=1, small=−1)	0.099	.0042
β_3 (gain x loss interaction)	0.105	.0074
β_4 (position=1)	0.257	.017
β_5 (position=2)	−.006	.96
β_6 (position=3)	0.155	.16

Table 6. Estimates from the full hierarchical Bayes model.

In conclusion, our second experiment strongly supports all three of our hypotheses, as well as demonstrates the usefulness of prospect theory as a predictive theory for these kinds of decisions. Next, we test the magnitude hypothesis in an empirical study using a different manipulation to provide additional support for our findings.

that the assumption of gain-loss separability in mixed gambles is questionable. These caveats do not apply to Study 1.1.

[6] The interaction between gain size and loss size is significant in this experiment. This interaction term was included in the model for completeness and was not motivated by our theory. Moreover, it was not significant in the first experiment. Therefore we do not elaborate on it.

7. Study 1.3 (Price Expectations).

7.1 Introduction.

A third study now tests the magnitude hypothesis using a different manipulation of the loss facing the participants. Instead of directly changing the price offered by the retailer, the reference price of the participants was manipulated.

Novemsky and Kahneman (2005) argue that loss aversion in "ordinary transactions" is present only to the degree that the money exchanged for products was not already intended to be given up; that is, there is only a *loss* involved if the price encountered is greater than the intended expenditure. This builds on Kahneman and Tversky (1979), who state that the coding of losses and gains relative to a reference point can be affected by the expectations of the decision maker.

Thus, we predict that with a high reference price (although still below the actual price), the loss faced will be smaller, and so a segregated rebate will result in a higher propensity to purchase than will an integrated discount when compared to a low reference price.

7.2 Method.

The study was conducted in a virtual lab in a manner similar to that of the first study (Study 1.1), but using a DVD player as stimulus. The design of the experiment was a 2 (reference price: high vs. low) × 2 (frame: reduction vs. rebate) factorial with both factors varied between-subjects, which were again randomly assigned to one of the four conditions. Participants were recruited using electronic invitations posted to an online message board, resulting in 406 respondents. Participants were paid $5 for their efforts.

The main dependent variable was again a choice measure, this time whether or not the decision maker wanted to buy a particular DVD player presented to them with certain attributes. Participants were asked to read and imagine themselves in the hypothetical scenario in which their old machine had become unable to play all their discs, and they had decided to buy a new one. They were told they had decided to buy online, and that quality, picture, sound quality, and the menu system were important attributes.

We manipulated the reference price by giving participants an expectation of the amount they were going to spend as they entered the purchase scenario. We told participants to imagine that they had set aside an amount of money specifically for the purchase of a new DVD player, and that they expected to spend the entire amount on it. In the low reference price condition, the decision maker had set aside $45, while in the high reference price condition the designated amount was $60.

We then presented a model from their "favorite internet shop" together with information on the attributes listed above, in addition to a base price and a price reduction. All conditions involved the same attribute levels; the only difference was the reference price and how the price reduction was framed. The base price of $84.95 was equal in all conditions to prevent possible quality inferences based on price differences; this price was reduced to $68.99 in the discount condition, and it came with an instant rebate of $15.96 in the rebate condition. Thus, considering the losses faced by the participant to be the base price less the reference price (i.e., $54.95 or $39.95), the gain of the discount or rebate was either 29% or 40%, respectively.

Following presentation of the attributes, subjects were asked to choose either to purchase this model or to keep looking. After this choice, subjects answered some further questions, including the importance of this choice to them.

Of the 406 responses, 105 were not complete, and 17 more were excluded as outliers (defined as further than three standard deviations removed from the mean) in the manipulation checks, resulting in a sample size of 284 in the analysis.

7.3 Manipulation Check.

At the end of the survey we probed our participants' manipulated expectations by asking them what amount they remember having set aside for the purchase of the player. A regression of these answers on the frame and size manipulations (as well as their interaction) ($F = 11.12$, $p < .0001$, $R^2 = .11$) indicates that the only significant effect was our manipulation of size ($t = 5.75$, $p < .0001$); neither frame nor the frame × size interaction had significant effects ($|t| < 1$).

In addition, participants were asked what the price offered for the player had been ("the amount of money that you remember being the price of the player"), in order to ascertain how they themselves framed price in their minds. Regressing these answers on the same factors as above ($F = 25.73$, $p < .0001$, $R^2 = .22$) indicates as expected that the only significant effect was our manipulation of frame ($t = -8.75$, $p < .0001$); neither size nor the frame × size interaction had significant effects ($|t| < 1$).

7.4 Results and Discussion.

Figure 4 shows the proportions of participants indicating that they would purchase the DVD player in each of the four conditions. We see that the proportion of buyers is marginally greater in the rebate frame ($M = .44$) than in the discount frame ($M = .37$) for the small price reduction (Fisher's exact $p = .096$), but significantly smaller for the rebate ($M = .47$) than the discount ($M = .71$) when the price decrease is large (Fisher's exact $p < .0001$). While the proportion of buyers is significantly larger for the larger price decrease under the discount frame (Fisher's exact $p < .0001$), the proportion of buyers under the rebate frame is not significantly different (Fisher's exact $p = .32$). There is, as expected, a main effect of price, such that more participants chose to buy in the large price-decrease condition ($M = .58$) than in the small price-decrease condition ($M = .41$) ($p < .0001$).

Table 7 displays the results of a logistic regression including dummy variables for frame, size, and their interaction, and perceived quality as a continuous predictor of the purchase decision. The overall model fit is good ($\chi^2 = 17.53$, $p = .0006$, $R^2 = .04$), and as predicted by Hypothesis 1 and confirmed in Study 1.1, the interaction between frame and size is significant. That is, we find support for the greater psychological value when segregating a small gain from a larger loss when that loss is relatively small, but greater value from integrating the gain with the loss when the gain is relatively large.

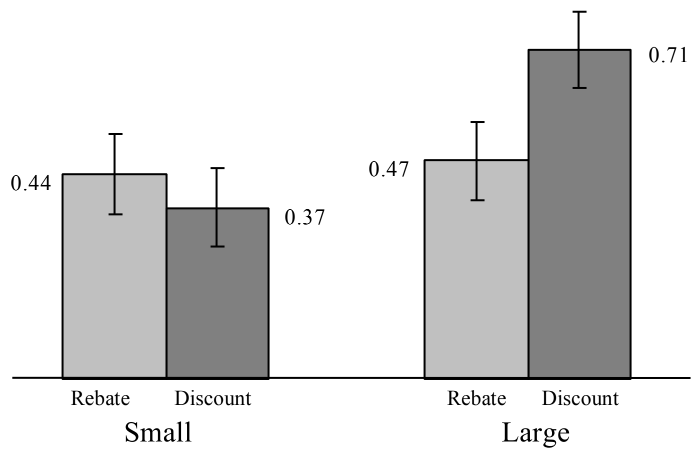

Figure 4. Study 1.3 results: Purchase shares.

Term	Estimate	χ^2	$p > \chi^2$
Frame	−.18	2.06	.15
Size	−.38	9.64	.002
Frame × Size	−.32	6.63	.01

Table 7. Logistic regression results.

8. Conclusion and General Discussion of Essay One.

In this essay we have formalized the silver lining effect identified by Thaler in 1985, using the basic assumptions of prospect theory. We have identified analytically and tested experimentally a set of conditions under which decision makers are more likely to segregate gains from losses. We have shown that segregating a gain from a larger loss is more appealing when (i) the gain is smaller (for a given loss), (ii) the loss is larger (for a given gain), and (iii) the decision maker is less loss-averse.

Our first empirical study tested the analytic predictions in a non-monetary setting, in the context of vacation days, and found initial support for our hypotheses. The second study extended and generalized the results to monetary decisions, and a third study provided additional support using a different manipulation. Together, the three studies suggest that the basic phenomenon of the silver lining effect, and the moderators we have documented here, are likely to be quite general.

Our predictions are highly relevant to researchers, practitioners, and policy-makers in a variety of domains where different frames of presentation of the same underlying information may provide different subjective values. Our analysis could, for instance, provide guidance to marketers wishing to design promotion schemes (where a rebate could provide a silver lining to a base price) or bureaucrats attempting to inform economic policy ("stimulus checks" or tax refunds may be silver linings to overall tax payments). We hope that future research will test our predictions in such decision environments.

A final contribution of our current work is the use of a small set of choices to estimate, at the individual level, the degree to which a decision maker is loss-averse. Our results show that loss aversion is an important individual difference in predicting the reactions of decision makers to integration and segregation as predicted by our model. Recent work shows that individual differences in loss aversion are related to demographic variables (Gaechter, Johnson, and Herrmann 2007), reactions to changes in wages (Goette, Huffman, and Fehr 2004), and underlying neural signals in the striatum (Tom et al. 2007). Our method provides a framework for estimating these differences and modeling this source of heterogeneity.

9. Essay Two: Does Loss Aversion Drive Attention?

9.1 Introduction.

The analytical and empirical results in the first essay of this dissertation contribute to the body of findings demonstrating that loss aversion can be an important influence on choice behavior. This phenomenon—that losses, as defined relative to some reference point, can carry greater weight in decisions than gains of equal size—is well established in the literature on economic behavior (see, e.g., Camerer 2005 and Ho, Lim, and Camerer 2006 for a summary of the marketing literature), having been observed in a wide range of domains and contexts. In addition to its moderating role in the silver lining effect (Jarnebrant, Toubia, and Johnson 2009), loss aversion has been shown to influence a wide range of economic behavior. Examples include Genesove and Mayer's (2001) finding of an effect of loss aversion on the price of real estate in Boston; Hardie, Johnson, and Fader's (1993) research showing that consumers exhibit loss aversion both for quality and price in their purchase behavior for orange juice; and the "disposition effect" (Shefrin and Statman 1985), that is, the tendency for investors to hold on to stocks that have declined in value and sell stocks that have increased in value.

Less common than demonstrations of the appearance and influence of loss aversion, however, are investigations of the associated psychological processes; indeed, "[surprisingly] little is known about the psychology" of loss aversion (Ariely, Huber, and Wertenbroch 2005). To approach the psychology of loss aversion and to go beyond thinking of loss aversion simply as a descriptor of certain choice patterns, or as a pre-stored preference summarized by the parameter λ_i, we take the perspective that loss aversion may be an integral component of the decision process. By an "integral component," we mean that loss aversion may be both an antecedent and a consequence of the decision process. That is, in addition to influencing the decision process and its outcome, it may be a product of that process. If we think of choice as a constructive process rather than as a retrieval of pre-formed preferences, loss aversion in choice may thus be an emergent property of the decision process rather than exclusively a property of the decision maker with respect to a certain attribute. So loss aversion may, for instance, arise from some feature of how information is perceived, acquired, or processed by the decision maker rather than being a pre-determined relation between the decision maker and the attribute. If loss aversion is thus a property of the decision process, it could arise via *how* the decision is made rather than *what* the decision concerns. We begin our exploration of the psychology of loss aversion in this essay by examining loss aversion as an influence on the decision process itself—in particular on how attention is allocated. The discussion then moves to investigating how the allocation of attention during the decision process may influence loss aversion.

We would like to note that loss aversion comes about from an asymmetry between two underlying entities, namely different sensitivities of decision value (i.e., $v(\bullet)$ in prospect theory parlance) to losses and gains. In what follows in this essay and the next, we examine loss aversion not simply as one aggregate phenomenon of asymmetric sensitivity to gains and losses; we also disaggregate it into its components by looking separately at sensitivity to gains and losses. We will of course be able to draw conclusions about the aggregate phenomenon by recombining the components, while gaining a more detailed view of the psychological underpinnings from the disaggregate analysis. Differences in loss aversion—between individuals, attributes, or decision contexts—may emerge from variations in either or both of the underlying sensitivities to gains and losses: Consider an example where the decision maker becomes more sensitive to losses because something in the situation makes him especially vigilant against potential loss. This would have the same appearance in terms of loss aversion (i.e., in terms of *relative* sensitivity to losses versus gains) if he became less sensitive to gains, perhaps due to satiation or other change in tastes; thus examining loss aversion only in the aggregate masks the underlying drivers of behavior. Or consider the case where a decision maker becomes simultaneously more sensitive to losses and (proportionately) more sensitive to gains; in the aggregate nothing may then have changed, while breaking loss aversion down into its components would reveal two interesting and opposed phenomena. In each of these two pairs of cases, the two situations look superficially similar but are quite different beneath the surface. We think the underlying components of loss aversion deserve separate examination, and we attempt to disentangle them whenever possible.

In the second and third essays, then, we examine the interplay between the impact of *attention* to gains and losses on choice behavior, and the potentially separate impact of gain and loss *amounts* on choice. In particular, we ask if attention to an attribute value has any relationship to the impact of that value upon choice. We distinguish between a *decision weight* (the impact of an attribute value upon choice) and an *attention weight* (the impact of the amount of attention received by this attribute upon choice).

If loss aversion is indeed a phenomenon integral to the decision process, and not simply a pre-stored "preference parameter," we would expect to find a relationship between attention and the underlying sensitivities to gains and losses that can be manipulated by changing the way an alternative is presented to the decision maker. For information to enter the decision process it first needs to receive attention; with limited cognitive resources available, attention is not unlimited but must be allocated among the information available in the choice environment. We expect that preferences (whether pre-stored, formed prior to the current situation, or constructed in the immediate decision process) will contribute to that allocation.

Since we know that losses and gains ultimately do have asymmetric impacts on a wide range of choice behavior, we expect that when the choice environment contains both losses and gains, there will also be analogous asymmetries in the relationships between attention and choice. That is, we expect that attention weights will follow the same well-documented pattern that decision weights do.

We will look at two types of relationships between attention and choice behavior. One is a direct association of attention and choice behavior—in other words, a direct link between the amount of time spent processing an attribute and the outcome of the decision process. The other relationship is an indirect link between attention and choice behavior, linking attention and decision weights. The first (direct) link could arise because spending more time looking at a loss, for instance, may make a person less willing to accept the alternative in which that loss is an attribute. The link may, however, also come about if a person who is unwilling to accept a certain alternative, for whatever reason, also spends more time looking at losses (say, in order to provide justification for his choice, or simply because he is vigilant against high values of negative attributes for the same reasons that he is unwilling to accept the alternative). This is the attentional analog of the direct link between attribute values and choice behavior (which we termed decision weight above; this link is then the origin of what we termed attention weights).

The other type of link also connects attention and choice but indirectly, by linking attention to an attribute and the sensitivity of choice behavior to values of that attribute, that is, by linking attention and decision weights. While the first relationship above was a direct link between a property of the decision process (viz. attention) and the outcome of that process (viz. choice behavior), we are now looking at an indirect (or interaction) effect: we expect to see a link between, for example, the amount of attention allocated to a loss attribute and the sensitivity of choices to the level of that attribute. That is, the impact of an attribute on choice may depend on the attention devoted to that attribute. For instance, the marginal value of an increase in the level of a positive attribute may increase if more attention is paid to it. We can think of this as an interaction of attribute values and attention in a regression predicting choice behavior. For instance, if a shopper consistently pays more attention to price than to quantity information on a store shelf, she may be more sensitive to changes in price than in quantity; or, conversely, a particularly (ex ante) price-sensitive customer may direct more attention to price information when shopping.

A close analog to this effect has been examined in the visual perception literature, where sensitivity to stimuli has been found to be greater when the stimuli are in a location to which attention has been allocated (see, e.g., Bashinski and Bacharach 1980; Downing 1988; Reynolds, Pasternak, and Desimone 2000).

Assuming that there are indeed direct and indirect relationships between allocation of attention and choice behavior, the direction of causality of the links involved also needs to be examined. Three different scenarios of causal relations are possible:

(i) **Attention as consequence:** Allocation of attention may be a product of choice behavior, so that when behavior is manipulated, so is attention—the behavior then has its origin elsewhere than in the allocation of attention between gains and losses (this need not necessarily imply the existence of fixed, pre-stored preferences; it shows only that the choice behavior does not emerge from this particular feature of the decision process).

(ii) **Attention as antecedent:** Here the causality is the reverse from (i), with attention driving choice behavior;.

(iii) **Attention and choice behavior as common consequences:** In this scenario a third underlying construct is the common origin of both phenomena, correlated without causation.

In this essay we report our efforts to test the hypothesized associations of attention and choice under the working assumption of the first scenario; that is, we study the impact of changes in choice behavior on the allocation of attention. In the next essay we then examine the associations from the perspective of the second causal scenario; there, we investigate the impact of changes in attention allocation on choice behavior.

It should also be noted that the first two scenarios are not necessarily mutually exclusive. A combination of these two causal scenarios is possible; in this case one could expect a positive feedback loop, such that loss aversion guides attention which then further drives loss aversion, and so on.

This essay now proceeds as follows: we next review relevant research on the relation between visual attention and preferences. We also review some extant models for how loss aversion in choice arises, including research on preferences and attention. The statement of our hypotheses is then presented. Following this, we report the results of two empirical studies. In an initial study (2.1) we first establish a correlation between allocation of attention and loss aversion. In the second study (2.2) we look closer at the relation between the separate sensitivities to losses and gains, and the allocation of attention. We test one of the scenarios of causality in Study 2.2 by manipulating loss aversion (and thus the sensitivity to losses and gains) and observing the consequences for allocation of attention. The second study improves on the first by using a better measure of loss aversion.

9.2 Models of Loss Aversion.

Models for how choice behavior comes to exhibit loss aversion can be categorized into two main types depending on how they view the evaluation of a choice option by the decision maker (Willemsen, Böckenholt, and Johnson 2008). *Value encoding* models see the evaluation as an application of an already extant encoding scheme, or preference, whereas *value construction* models view the value of an option to the decision maker as arising through the process by which the decision is made. According to the latter model, preferences are constructed *in* the choice process rather than pre-stored, retrieved, and applied *to* the choice process. Under the heading of value construction models, we also include accounts of loss aversion that rely on asymmetric experiences of affect or emotion, and reactions of the autonomous nervous system taken as inputs in the choice process.

9.2.1 Value Encoding Models.

A value encoding view sees loss aversion as a preference governing the trade-off of gains and losses, which is then applied to a given choice. To make a choice, the options involved are examined, and after gains and losses have been encoded relative to some reference point, the application of the preference establishes the relatively greater weight of losses over gains (as captured by the λ_i parameter) in the decision. Prospect theory (Kahneman and Tversky 1979) is an example of a value encoding model. The options, such as the outcomes of a gamble, are entered into the value function $v(x)$, and losses (i.e., outcomes that lie below the relevant reference point) receive an extra weight relative to gains by an already determined coefficient $\lambda > 1$ (i.e., $l(x) = \lambda g(x)$, using the formulation of the value function from the first essay). In this account then, there is no room for the decision process itself to influence the relative valuation of losses and gains; thus, evidence for scenario (ii), above, would speak against a value encoding account of loss aversion. If loss aversion is a consequence of some feature of the decision process, and an exogenous manipulation of this feature affects the degree of loss aversion, then considering loss aversion to be a predetermined preference is clearly inadequate. Note also that by the formulation of the prospect theory model used in the first essay, separating the sensitivity of value to losses from that of gains is not possible, since the loss function $l(x)$ is simply a multiple of the gain function $g(x)$, and thus the relation between their slopes is fixed: the sensitivity of value to losses will be the same multiple of the sensitivity to gains: $l'(x) = \lambda g'(x)$. The empirical studies in this essay are consistent with this account; we here treat loss aversion as exogenously given (although varying among different scenarios, etc.) and examine its impact on a variable of the decision process, allocation of attention. By contrast, the studies presented in the next essay are consistent with a value construction account, to which we will return below.

9.2.2 Attention and Preference.

Evidence linking thinking about an object, forming opinions about, and looking at that object comes from several areas of psychology. Research in the cognitive psychology of speech and language comprehension has shown that people tend to direct their vision at what they are currently talking and thinking about (Tanenhaus, Spivey-Knowlton, Eberhard, and Sedivy 1995; Griffin and Bock 2000). It has also been found that not only do individuals think about the object that they are looking at, they place greater weight on the feature of the object that they are currently directing their attention to. Findings in category learning research, using eye-tracking methods, show that features of an object that more strongly predict category membership receive greater allocation of attention than do features that less strongly predict category membership (Rehder and Hoffman 2005).

Research on (sub-clinical) anxiety has found that when attention is fixed on an object, it takes longer to disengage attention from the object if it is related to threatening stimuli compared to objects of neutral or positive valence (Fox, Russo, Bowles, and Dutton 2001); this was found to hold for participants with both high and low levels of state-anxiety. However, those participants that were in a high-anxiety state had an increased disengagement time compared to low-anxiety participants. Thus, if potential losses are seen as threatening stimuli we should observe increased attention allocated to them compared to gains. If an individual higher in loss aversion perceives those losses as more threatening, she would then allocate a greater amount of additional attention to them. These findings would suggest then that the causal direction runs from degree of sensitivity to losses to allocation of attention, rather than the reverse; that is, the direction of our scenario (i), and the working assumption in this essay.

A similar phenomenon is the *gaze cascade effect* (Shimojo, Simion, Shimojo, and Scheier 2003), in which the formation of preferences concerning some stimulus object is intimately related to the acquisition of information about that object. The theory posits a positive feedback loop through two mechanisms: a *mere exposure* effect (Zajonc 1968) such that the more an individual looks at an object, the more she prefers it, and a *preferential looking* effect (Fantz 1964) such that visual attention is allocated towards objects that are preferred.

Recent findings by Glaholt and Reingold (2009) have questioned the specificity of the gaze model of Shimojo and colleagues to decisions involving preferences, suggesting that biased allocation of attention is a feature of more general visual decision-making processes. However, as those more general decision processes would include those based on preferences, which are the relevant ones for the present research, these findings do not seem to prevent the application of gaze theory to our research.

Based on these previous findings, we know that there is a relation between attention and preference, but the research in the domain of preferences and choice has so far not addressed the relation between attention to specific features of an outcome and the preference for that outcome. This relation is necessary to examine in order to gain insight into the relation between attention and preferences (in the sense of sensitivity to the level of an attribute) and thus into the role of attention in sensitivity to gains and losses (and thus loss aversion). That is, we would like to form and test predictions regarding an individual's preferences for or against a specific item—preferences stemming from the allocation of attention among the item's attributes, in addition to the levels of those attributes. This is in contrast to the relation between the relative allocation of visual attention between two alternatives and the probability of choosing one over the other.

In particular, the attributes we are interested in are losses and gains. In the gamble paradigm the item is the entire gamble, and its two attributes are its levels of potential gain and loss (and associated probabilities), with the choice being whether or not to accept the gamble.

From the results in the cognitive, learning, and anxiety literatures reviewed above, we may make a number of predictions. First, we hypothesize that the greater the liking (that is, preference) for an alternative, the greater will be the attention devoted to it. In the case of a gamble, for example, the more likely the decision maker is to accept it, the less attention she will allocate towards negative attributes, that is, losses (Hypothesis 2.1a), and the more attention she will allocate to positive attributes, that is, gains (Hypothesis 2.1b). These associations are what we term *direct* links between attention and preference.

Analogous with the "normal" or "monetary" loss aversion observed for the levels of losses and gains (that is, an asymmetry in decision weights), we posit an "attentional loss aversion" whereby the association of attention to losses and preferences is hypothesized to be stronger than the association of attention to gains and preferences; that is, attention weights are hypothesized to be asymmetric (Hypothesis 2.2).

Explicitly addressing the two sub-components of loss aversion, we expect that greater sensitivity to losses (Hypothesis 2.3a) and gains (Hypothesis 2.3b) is associated with additional attention to that attribute.

Additionally, we expect that choice situations where "regular" loss aversion (that is, for the amounts involved) is high are also situations in which *attentional* loss aversion is elevated (Hypothesis 2.4).

Further, when the stakes involved in a decision are high, that is, when the outcomes involved are large, we predict that choice behavior will be especially strongly associated with attention (Hypothesis 2.5).

The true direction of causality of the relationships involved in the above hypotheses is not entirely clear from the existing literature. Based on the gaze cascade effect of Shimojo et al. (2003) it is bi-directional with the mere exposure effect in the direction of our scenario (ii), where attention drives preference, and the preferential looking effect in the direction of our scenario (i), in which otherwise determined preferences drive attention. The research on anxiety of Fox et al. (2001), however, is consistent with the opposite causal direction. Additionally, in the model of Rangel and his coauthors, to which we return in the following essay (e.g. Rangel 2008), attention plays a causal role in choice. Due to this lack of causal clarity in the extant literature, we would prefer to refrain from making too strong a prediction of causality and instead experimentally attempt to discern the dominant direction by first manipulating preferences (in this essay) and then attention (in the next essay).

We next summarize more formally the hypotheses arrived at above.

9.3 Hypotheses Examined in the Essay Two.

H2.1 (*Attention and preference*):

(a) Greater attention to an alternative's loss attribute is associated with lesser preference for that alternative.

(b) Greater attention to an alternative's gain attribute is associated with greater preference for that alternative.

H2.2 (*Attentional loss aversion*):

Greater attention to a loss attribute has a stronger association with preference for an alternative than does greater attention to a gain attribute. (That is, the relationship in H2.1a is stronger than that in H2.1b.)

H2.3 (*Attention and loss aversion through preference sensitivity*):

(a) Greater attention to an alternative's loss attribute is associated with greater loss aversion, through greater sensitivity to losses.

(b) Greater attention to an alternative's gain attribute is associated with smaller loss aversion, through greater sensitivity to gains.

H2.4 (*Loss aversion and attentional loss aversion*):

Increased loss aversion for the *attributes* of an alternative will be associated with increased *attentional* loss aversion with respect to those attributes.

H2.5 (*Stakes and attentional loss aversion*):

(a) The larger the loss attribute of an alternative, the larger will be the association between choice behavior and attention to that attribute.

(b) The larger the gain attribute of an alternative, the larger will be the association between choice behavior and attention to that attribute.

9.4 Empirical Studies.

The hypotheses presented above were tested in two empirical studies: the first, a correlational study, tests (somewhat modified) versions of Hypotheses 2.3a and b concerning attention and loss aversion, while the second study examines the direct-effect Hypotheses 2.1a and b (and, following, Hypothesis 2.2 regarding attentional loss aversion), as well as the full versions of Hypotheses 2.3a and b, 2.4, and 2.5.

10. Study 2.1 (Linking Loss Aversion and Attention).

This first empirical study tests slightly modified versions of Hypotheses 2.3a and b. Due to the nature of the loss-aversion measure used in this study, we cannot test whether the hypothesized association of attention and loss aversion is due to associations between attention and the separate gain and loss sensitivities; instead we can determine only if the associations are between attention and loss aversion in the aggregate.

In order to test the hypotheses that greater loss aversion is associated with more attention to losses, and that smaller loss aversion is associated with more attention to gains, we empirically measure loss aversion as well as attention during the decision process. Like the previous studies, Study 2.1 was conducted over the Internet by inviting individuals who had previously signed up to participate in online surveys. Of 50 invited participants 32 completed the survey and were compensated $5 for their participation; the average time spent on our task was 22 minutes.

10.1 Method.

To capture the decision process of our participants we used the computer program MouseLabWEB (Willemsen and Johnson 2008), which enables the recording of process data in choice tasks. The program is accessed through the participants' web browsers and displays a grid of boxes—in this case four boxes, one each for the amounts and probabilities for gains and losses (see Figures 5a and b for examples). The four boxes initially display only the label of the attribute, for instance "Probability to win." When the decision maker moves her mouse cursor into the box, the value of this attribute is revealed, for instance ".47", until the cursor is moved out of the box. Thus, in order to see each piece of information, the participant must actively direct the cursor to that box, which in turn lets us record what information is being paid attention to at a given moment.

The gambles used in this study to measure loss aversion (and simultaneously to monitor the decision process) were similar to the ones used in the previous experiments, with two main differences: the order of presentation of the gambles was varied randomly (previously losses increased sequentially), and the probabilities were “jittered” around (versus held constant at .5), from .47 to .53 in steps of .01. The purpose of these changes was to increase the engagement of the participants with each gamble.

Further, rather than finding the “switching point” where a certain gain is just outweighed by a loss, as we did in the studies of the first essay, here we wanted to observe the decision process for each gamble considered on its own. By only slightly varying the probabilities, we left the expected value largely unchanged, while still encouraging the decision makers to reexamine all the information for each new gamble. These methodological variations let us treat each of the 20 presented gambles as independent observations of decisions and decision processes, rather than collapsing the data into two points, as we did in the previous studies.

Because the gambles were presented in a random order, the data contained somewhat more non-monotonic responses than previously observed; that is, participants were not always internally consistent across the 20 gambles. This may have been due to response error or perhaps inattention on the part of our subjects. This feature of the data prevented the establishment of a switching point from acceptance to rejection of the gambles as losses grew in size, and thus disqualified the measure of loss aversion we used previously. However, rather than exclude this data from analysis, we utilized an alternative measure of loss aversion. Since the higher (theoretical) switching point a decision maker has, the more gambles she will accept (for both levels of gain), the proportion of gambles accepted will be highly correlated with the loss-aversion parameters as previously calculated. Indeed, across the 18 response levels (from 1 acceptance per sequence to 9 per sequence), the correlation with proportion of accepted gambles is −.85 (note that this holds in the case of monotonic choices), letting us satisfactorily measure loss aversion while preserving as much data as possible.

Two subjects rejected every gamble presented and were thus excluded, as this prevents logistic regression analysis of their choices.

10.2 Results.

The median of our measure of loss aversion was .40 (*M*=.41, s.e.=.04); that is, of the 20 gambles, the median respondent accepted 8; for comparison, this corresponds to a lambda coefficient of 2.20, consistent with previous findings. (That is, if we assume monotonicity, this is the median level of loss aversion we would have found using the previous measure.)

In order to screen out accidental box-openings, or those openings that are simply too short for the human eye to register, only those openings lasting more than 200 milliseconds were retained (this is the case for all MouseLabWEB studies reported here, including in the third essay) (Willemsen and Johnson 2010). Excluding these observations, average looking times per gamble for the four cells were 1.07 seconds for the loss-money cell, .90s for loss-probability, 1.02s for gain-money, and .87s for gain-probability. That is, on average participants looked at the money boxes for slightly more than one second per trial, and at the probability boxes slightly less than one second.

To examine the relationship between attention and preferences, we split the respondents into three groups based on the proportion of accepted gambles: low, medium, and high proportions, corresponding to high, medium, and low loss aversion, respectively. The median proportion of accepted gambles of the 10 respondents in the high-loss-aversion group was .175 (3.5 gambles), while in the low-loss-aversion group, the median proportion was .65 (13 gambles), which is significantly greater than in the high-loss-aversion group (t=13.02, p<.0001).

Looking times for losses were hypothesized to be greater in the high-loss-aversion group, and vice versa for looking times for gains. Participants' average looking time for loss amounts for the twenty gambles was 20.0s (s.e.=2.38) in the low-loss-aversion group and 23.3s (s.e.=1.86) in the high-loss-aversion group. This difference is directionally consistent with our hypothesis, and marginally significant (t=1.77, p=.06). The same analysis for looking times for gain amounts, however, shows no difference between the two groups; the low-loss-aversion group looked at gain amounts for an average of 19.2s (s.e.=2.32), while the high-loss-aversion group looked for 20.7s (s.e.=1.36) (t=1.09, *n.s.*). While the first result indicates initial support for our hypothesis, a more appropriate regression analysis was performed for closer examination of the data.

The main analysis to test our hypotheses was done by regressing the measure of loss aversion, that is, the proportion of accepted gambles, on the looking times for gain and loss amounts. In order to reduce the influence of outliers in the timing data, the values were square-root transformed (Fidell and Tabachnick 2003).

An initial regression also included the times for the gain and loss probability boxes; neither of these was estimated to have a significant relationship (ps>.45) with loss aversion. As they were of no direct interest with respect to our hypotheses, they were excluded from the subsequent model.

The model with two parameters, for loss and gain amounts, had an adjusted R^2 of .15 and the overall fit could not be rejected (F=3.46, p=.046). The estimated parameters provide tests of our hypotheses: looking times for loss amounts are significantly related to loss aversion (B_{loss}=.0082, p=.035) in the predicted direction—greater looking times at loss amounts predict greater loss aversion. The estimate for gain amounts is also directionally consistent with our hypothesis, but the parameter is only weakly negative, merely approaching marginal statistical significance (B_{gain}=-.0054, p=.19).

Thus, as in the psychophysical asymmetry of losses looming larger than gains in their impact on choice behavior, we observe an asymmetrical effect of allocation of attention. The association between looking times for losses and the rejection of gambles is stronger than that between looking times for gains and acceptance of gambles. Examining the size of the estimated parameters for attention, as measured by looking times, we observe a ratio of losses to gains (i.e., *attentional loss aversion*) of .0082 to .0054 = 1.52, which is somewhat smaller than what we usually see for loss aversion to monetary amounts.

In conclusion, the results of this study support the simplified version of Hypothesis 2.3a, showing an association between allocating more attention to loss amounts and being more loss-averse. The results also show directional, though only suggestive, support for the simplified Hypothesis 2.3b, concerning the association of more attention to gain amounts and being less loss-averse. Given previous findings that losses show stronger effects than gains, this may not be surprising.

10.3 Conclusions from Study 2.1.

This work extends previous research on the psychophysical influence of stimulus size (i.e., the magnitude of gains and losses) to allocation of attention, confirming the existence of a gain-loss asymmetry in a previously unexplored domain.

In this study we have established an association between attention and loss aversion, but we are unable to make claims about the direction of causality from these results. That is, we cannot yet say whether loss aversion acts as an intrinsic parameter, guiding the allocation of attention towards losses (causal scenario (i)), or whether it is the allocation of attention to losses that leads to greater loss aversion (scenario (ii)), or both. In fact, since we only measure both constructs rather than manipulate them, the association could also be due to an unintentionally manipulated third factor acting as a common cause of both loss aversion and attention allocation (scenario (iii)).

To shed light on the causal relations, we will now go beyond measurement to manipulation. In the following study we test one of the two causal directions by manipulating loss aversion. A manipulation of loss aversion that consequently affects attention would support scenario (i).

The following study also increases sample size for greater statistical power, as well as utilizes a further improved measure of loss aversion. In addition, we investigate the effects involving loss aversion in greater detail by looking separately at the sensitivity of choice behavior to changes in gain and loss amounts, rather than only in aggregate, by looking at their ratio.

11. Study 2.2 (Manipulation of Loss Aversion).

The present experiment examines causal scenario (i), in which the direction of causality runs from loss aversion to attention, by manipulating participants' loss aversion and observing the effect on their allocation of attention. This means again testing Hypothesis 2.3 (*Attention and loss aversion*):

> (a) Greater attention to an alternative's loss attribute is associated with greater loss aversion, through greater sensitivity to losses.
>
> (b) Greater attention to an alternative's gain attribute is associated with smaller loss aversion, through greater sensitivity to gains.

In doing so, we also test our other previously stated hypotheses. We examine the ("direct-effect") association of attention and choice behavior, testing Hypothesis 2.1 (*Attention and preference*):

> (a) Greater attention to an alternative's loss attribute is associated with lesser preference for that alternative.
>
> (b) Greater attention to an alternative's gain attribute is associated with greater preference for that alternative.

We also examine the hypothesized greater impact on choice behavior of attention to losses than to gains, stated in Hypothesis 2.2 (*Attentional loss aversion*):

> Greater attention to a loss attribute has a stronger association with preference for an alternative than does greater attention to a gain attribute.

Additionally, we test Hypothesis 2.4 (*Loss aversion and attentional loss aversion*):

> Increased loss aversion for the attributes of an alternative will be associated with increased attentional loss aversion with respect to those attributes.

Also tested again is Hypothesis 2.5 (*Stakes and attentional loss aversion*):

(a) The greater the gain attribute of an alternative, the stronger will be the association between choice behavior and attention to that attribute.

(b) The greater the loss attribute of an alternative, the stronger will be the association between choice behavior and attention to that attribute.

11.1 Method.

In this experiment we again used a gamble paradigm—the key difference from Study 2.1 is that we now manipulate loss aversion rather than just measuring it. While manipulating loss aversion, we again measure attention using the same MouseLabWEB technology as in Study 2.1.

The gambles presented to participants were adapted from those used by Tom et al. (2007); 9 gambles formed a 3 (gains) × 3 (losses) design, with all three levels of gains crossed with all three levels of losses. Gains ranged from 3 to 9 days (see below for details of the currency of days used in the gambles), and losses from 1 to 3 days. Probabilities were again jittered around .5 (ranging from .48 to .52 in .01 steps) to reduce participant monotony.

To create variation in loss aversion, we manipulated the gambles along two within-participant factors, each with two levels. Thus, each participant decided to accept or reject a total of 36 gambles, 9 for each of the four cells of the experiment.

Previous literature suggests that loss aversion is heightened when a decision involves outcomes in which the decision maker herself will gain “ownership rights” or “ownership experience,” rather than when the outcome involved is hypothetical (Sayman and Öncüler 2004). Since an outcome that only affects someone else is even further removed from actual ownership and experience, we predict that between two hypothetical outcomes, one concerning yourself will give rise to greater loss aversion than one concerning another individual only. We also expect loss aversion to be enhanced when a decision involves a health-related outcome (Chapman and Johnson 1995).

Based on these findings, we constructed a *scenario* factor, which manipulated whether or not the outcome was health-related, and a *target* factor, which manipulated whether or not the decision was being made for the decision maker herself or for someone else.

The scenario factor was varied between expressing the gains and losses of the gamble outcomes in terms of the duration of a flu disease that the participant might hypothetically contract, and the duration of the vacation time that the participant gets from his work. As the former is a health-related outcome, we hypothesized that participants would demonstrate greater loss aversion for the flu duration than for the vacation duration.

In the flu condition, participants were told that they had the opportunity to try a new flu treatment that would shorten or lengthen the duration of the flu, in the case that they contracted it. With a probability jittered around .5 the treatment would be successful, which would result in the reduction of a certain number of flu-diseased days, and with an equal probability, save for the jittering, the treatment would fail and they would have to endure an additional number of sick days.

The vacation condition posed an analogous question, except that the currency of the gamble was days not of a flu disease, but of vacation. Participants were told that they could choose to join a new project at work, and that with equal probabilities (again save for jittering), the project would succeed and they would gain vacation days, or it would fail and they would lose vacation days. The number of days and the probabilities were the same as in the flu-days scenario. In contrast to the previous scenario, however, an increase in the number of days is now a positive outcome (i.e., a gain), while a decrease in duration is now a negative outcome (i.e., a loss) (see also Jarnebrant et al. 2009).

Crossed (within-subjects) with the scenario factor, the target factor varied whether the decision maker decided for herself whether to get the flu treatment (or to join the work project) and thus experience the potential outcomes herself, or whether she decided for a friend, who would then experience the outcome.

The dependent measure in both scenarios and for both targets was the participants' choices of accepting or rejecting the offered gambles. Each participant thus provided 36 dependent variable data points. Note that, as described above, across both scenarios and targets the number of days to win or lose was kept constant; gains of 3, 6, and 9 days were crossed with losses of 1, 2, or 3 days in all conditions.

We again employed the MouseLabWEB software to present participants with gambles and to capture the pattern of information acquisition during the decision to accept or reject them. Figures 5.1 and 5.2 show examples of the presentation of the vacation and flu duration gambles, respectively. The former shows the appearance of the flu duration gamble as if the participant had positioned the mouse cursor in the upper left box and so revealed the information about the potential decrease in flu duration, while the latter shows the appearance of the vacation gamble as if the participant had positioned the mouse cursor in the upper right box to reveal the information about the potential increase in vacation days (i.e., in both cases the decision maker is looking at the information about the potential gains from accepting the gamble).

Figure 5a. A flu duration gamble in the Other-target condition (as presented to participants).

Figure 5b. A vacation duration gamble in the Self-target condition (as presented to participants).

The MouseLabWEB software recorded the duration of participants' information acquisition. Two measures were taken: the amount of time that the two gain boxes and the two loss boxes were opened (in both cases combining the amount box and the probability box). Box-openings shorter than 200ms in duration were again discarded as subliminal.

Respondents were recruited through an online database[7] and accessed the survey using the Internet from their own computers. They were compensated $5 for their participation. Of 101 participants, 60% were female; participants' ages ranged from 18 to 69, with a median of 31 years. It took the average participant 27 minutes to complete the 36 gambles.

11.2 Results.

Initial analyses of the effectiveness of the manipulation examined the differences in loss aversion between the two scenarios, and between the two targets; that is, between the flu and vacation conditions, and the Self and Other conditions, respectively. First, the choices made to accept or reject the gambles were regressed on the sizes of the losses and gains offered by those gambles in two logistic models, one for the scenario manipulation and one for the target manipulation, in each case allowing both an intercept and the parameters that capture the choices' sensitivity to the size of gains and losses, in order to vary between the two levels of the factors. When the choice data (that is, the binomial

[7] Amazon Mechanical Turk, accessed through www.mturk.com.

accept versus reject decisions) are regressed on the size of the gain and loss amounts, the (negative of the) ratio of the loss-amount coefficient to the gain-amount coefficient gives the ratio of the decision maker's sensitivity to losses to her sensitivity to gains and thus provides a measure of loss aversion (Hardie, Fader, and Johnson 1993). The results of interest from these regressions can be found in Tables 8 and 9 below:

Scenario	B_{gain} (s.e.)	B_{loss} (s.e.)	Loss aversion
Flu	.29 (.02)	-.76 (.07)	2.65
Vacation	.36 (.03)	-.68 (.07)	1.91

Table 8. Logistic regression results for the manipulation of scenario.

Target	B_{gain}	B_{loss}	Loss aversion
Self	.33 (.03)	-.67 (.07)	2.01
Other	.29 (.02)	-.75 (.07)	2.61

Table 9. Logistic regression results for the manipulation of target.

We had hypothesized that the flu scenario and the Self target would raise loss aversion above the vacation scenario and the Other target, respectively. The results indicate that in the flu scenario, participants were indeed loss-averse to a greater degree than in the vacation scenario. However, the manipulation of target appears to have had the opposite effect from what we hypothesized: participants were more loss-averse when making choices for someone else than for themselves. While the latter is inconsistent with our prediction from the previous literature, a successful manipulation of loss aversion does seem to have taken place, if to a somewhat smaller extent compared to the scenario manipulation. The magnitude of the estimated loss-aversion values are, however, generally consistent with previous research, which lends support to this method of estimating loss aversion.

Our method of estimating loss aversion by looking individually at the sensitivity of choice behavior to gains and losses lets us look closer at what is driving the changes in loss aversion. We observe that the differences between the loss parameters are quite small in both cases, −.68 vs. −.76 between scenarios and −.67 vs. −.75 between targets—in other words, slightly more than one standard error in each case. The differences in gain parameters are, however, significantly larger: .29 vs. .36 between scenarios and .29 vs. .33 between targets—that is, approximately two standard errors. Thus, the scenario manipulation of loss aversion was effective mainly through an influence on the sensitivity of choices to gain amounts.

We next ran a logistic regression in which we allowed both the intercepts and the sensitivity parameters to vary, depending on whether the currency of the gamble was vacation days or flu days, and whether the choice was being made for the participant self or for someone else. Again, to examine the effectiveness of the two treatments in producing differences in loss aversion, we calculated the ratio of the parameter estimates for the loss size parameters to the gain size parameters for the four cases (Hardie, Johnson, and Fader 1993). The resulting estimates can be found in Table 10 below, and the resulting logistic models can be seen in Figure 6, where flu–Self is drawn in blue, flu–Other in green, vacation–Self in red, and vacation–Other in yellow.

Scenario	Target	B_{gain} (s.e.)	B_{loss} (s.e.)	Loss aversion
Flu	Self	.30 (.03)	-.77 (.10)	2.53
Flu	Other	.27 (.03)	-.76 (.10)	2.78
Vacation	Self	.45 (.04)	-.62 (.10)	1.38
Vacation	Other	.31 (.03)	-.75 (.10)	2.44

Table 10. Logistic regression results for the manipulations of scenario and target.

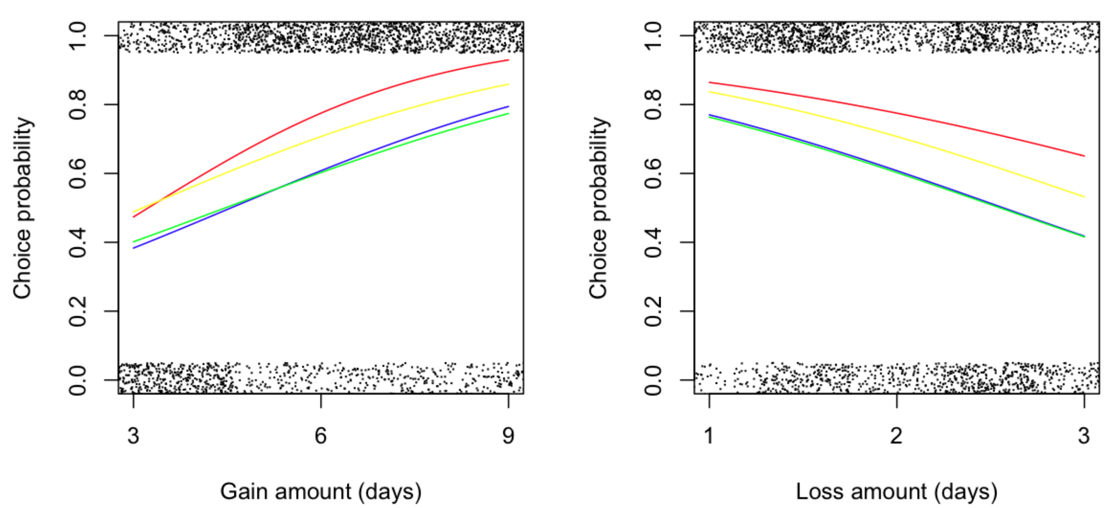

Figure 6. Logistic models for the manipulations of scenario and target.

The four cell-level estimates of loss aversion afford us a closer look at what is driving the observed differences in loss aversion. It appears that the bulk of the attenuation of loss aversion in the vacation and Self cells previously observed is due to an interaction of the two treatments whereby loss aversion is depressed in the case of the vacation scenario in combination with the Self target.

We have thus established differences in loss aversion between the scenarios and the targets, and now move on to examining whether those differences in loss aversion affected the allocation of attention between gains and losses. This analysis tests Hypotheses 2.3a and b. We first centered and log-transformed the looking times for losses and gains and then regressed these on three categorical variables, which coded for whether attention was directed towards a gain or a loss (i.e., valence), whether the scenario was a vacation or a flu, and whether the target was Self or Other. We also included all interactions among the categorical variables.

This analysis revealed a significant main effect of scenario (p=.03), and a significant interaction of scenario and valence (p=.01). The main effect indicates that participants spent slightly more time looking at the gain and loss information in the vacation scenario, with a mean time per gamble of 1.74 seconds, than in the flu scenario, where mean time per gamble was 1.73 seconds. The significant interaction indicates that in the vacation scenario, participants paid more attention to gains than to losses, and in the flu scenario they paid more attention to gains. Transformed back to seconds, we observed means for time spent looking at gains of 1.84 seconds per gamble in the flu condition and 1.75 seconds per gamble in the vacation condition, whereas the mean times spent looking at losses were 1.63 seconds in the flu condition and 1.74 seconds in the vacation condition. No other main effects or interactions were significant in this analysis.

We thus observe that one of the manipulations that produced greater loss aversion (the flu scenario versus the vacation scenario) also diminished the attention paid to losses, as compared to gains. The other manipulation (i.e., Self target versus Other target) does not appear to have had an effect on the relative allocation of attention between losses and gains. Taken together these findings are inconsistent with the hypothesized relation between loss aversion and attention for this study.

The data were then analyzed for evidence of a direct effect of attention on preferences (Hypothesis 2.1); that is, does additional attention to gains and losses influence the propensity to accept and reject gambles? In the first study, this direct link and the link between attention and loss aversion were confounded due to the proportion of accepted gambles being used as the measure of loss aversion. Here, we performed a logistic regression, regressing participants' choices to reject or accept gambles on the time they spent looking at gain and loss information.

This showed significant effects of attention to both gains and losses on choice behavior, in the expected directions: the estimates for attention to gains and losses, respectively, are .16 (s.e.=.07, p=.018) and -.45 (s.e.=.07, p<.0001). See Figure 7 below for illustration of these results: the green and red lines indicate the effect of attention to gains and losses, respectively, on choice probability (n.b., negative values on the horizontal axis indicate looking times smaller than one second on a seconds-scale). These estimates, then, support our predicted association of attention and preference (Hypothesis 2.1).

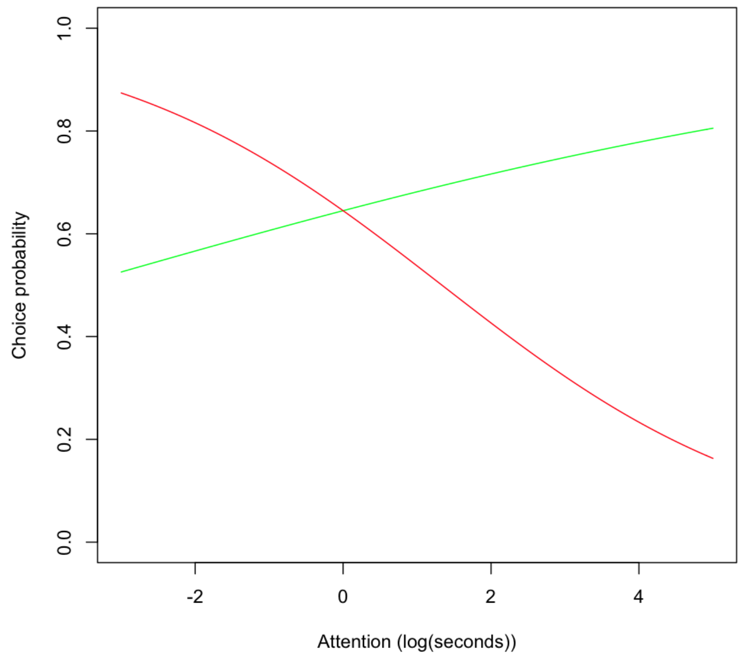

Figure 7. The effects of attention to gains (in green) and losses (in red) on choice behavior.

By analogy to the calculation of a loss-aversion index for amounts of gains and losses performed above, we may now calculate an index of *attentional* loss aversion by taking the ratio of the two parameters, which tests Hypothesis 2.2. This gives a value of (–(–.45)/.16=) 2.81 for attention, compared to the values of 1.89 and 2.62 reported above for amounts. We thus find that attention to losses appears to "loom larger" than attention to gains by a fairly similar degree to that by which the losses themselves loom larger than the gains. Simulation confirmed the significance of the attentional loss aversion, as a 5% confidence interval based on 100,000 simulations did not include unity.

We also ran two additional regressions, letting the intercept as well as parameters for the choice behavior's sensitivity to attention vary between scenarios and targets. This revealed that the attentional effects seem stronger in the flu scenario than in the vacation scenario, and stronger in the Self-target than in the Other-target conditions. In each case, of the four parameters of interest (i.e., the effect of gains and losses in the two scenario and target conditions), three were significant and of the expected signs.

In the flu condition, additional attention to gains has a significantly positive effect on gamble acceptance (B=.33, s.e.=.1, p=.0007) and vice versa for attention to losses (B=-.45, s.e.=.1, p<.0001); while in the vacation condition, we see a significant negative effect for attention to losses (B=-.54, s.e.=.1, p<.0001), but no significant effect of attention to gains (B=.05, s.e.=.1, p=.63). In both cases, however, the directions of the estimates are consistent with our predictions, and the loss parameters are greater than the gain parameters, as hypothesized. See Figure 8a below for an illustration of the model. The green and red lines indicate the effects of attention to gains and losses, respectively, on choice probability; solid lines indicate the flu scenario, and dashed lines the vacation scenario.

In the Self-target condition, allocating more attention to gains also had a significantly positive effect on gamble acceptance (B=.30, s.e.=.10, p=.003) and again the opposite occurred for attention to losses (B=-.67, s.e.=.1, p<.0001); while in the Other-target condition, we observed a significant negative effect for attention to losses (B=-.24, s.e.=.10, p<.01), but no significant effect of attention to gains (B=.05, s.e.=.10, p=.59). This model is illustrated in Figure 8b below; solid lines indicate the Other target, and dashed lines the Self target.

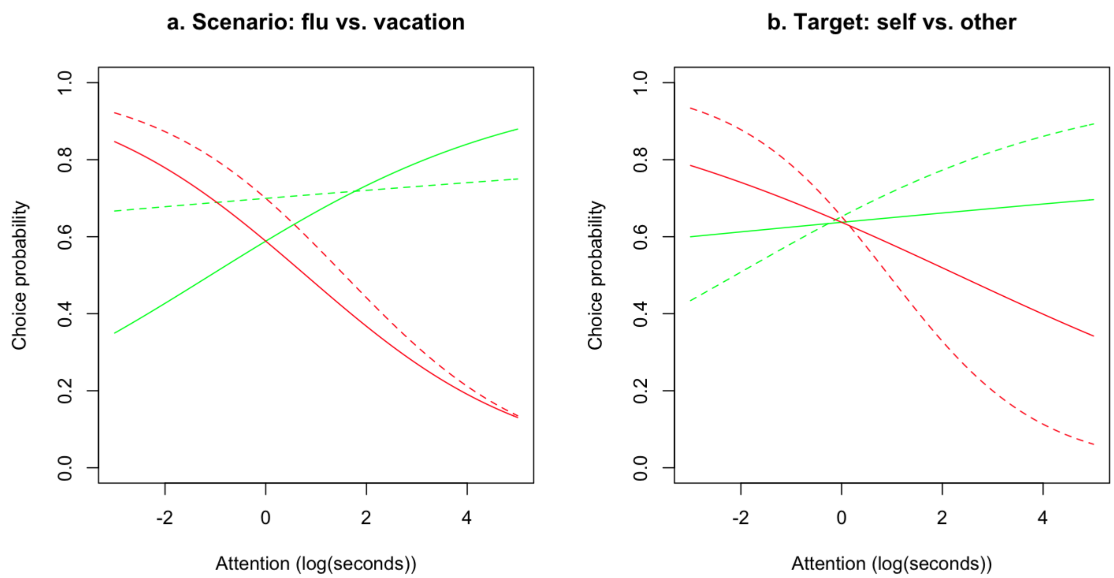

Figure 8ab. The effect of attention to gains and losses on choice probability in the two (a) scenarios and (b) target conditions.

A further, expanded model was run to check for possible interactions between the scenario and target manipulations but did not reveal any such effects (*p*s=.68 for both loss and gain attention).

Thus, our hypotheses regarding attention and preferences are supported by six of eight estimates, with the remaining ones in the consistent direction but not significantly different from zero. Additionally, our hypothesis regarding attentional loss aversion is supported by all four pairs of gain and loss parameter estimates.

We next examined the data for potential support for Hypothesis 2.4, that is, the association of loss aversion for attribute levels and attentional loss aversion with respect to those attributes. Using the estimates from the previous analysis, we note that in one of the high-loss-aversion conditions (the flu scenario) participants exhibit an attentional loss aversion of –(–.45/.33)=1.36, while in the low-loss-aversion (vacation days) scenario, they same calculation gives –(–.54/.05)=10.8. In the other high-loss-aversion condition (the Other target), we observe an attentional loss aversion of –(–.24)/.05=4.8, while in the low-loss-aversion condition (the Self-target), we get a value of –(–.67)/.30=2.23. While not as strong a pattern is exhibited by the scenario manipulation, the direction is clearly the opposite. This is inconsistent with our hypothesized association, pointing towards attentional loss aversion being a separate phenomenon from attribute loss aversion.

A final analysis was done to examine Hypothesis 2.5, which posits a relationship between the sensitivity of choice behavior to attention to gains and losses, and the level of those gains and losses. This was again done using two logistic regressions (one for the two scenarios and one for the two targets), with the effect of interest captured by interactions between gain and loss amounts, and gain and loss attention measures. These interactions were also allowed to vary between the two scenarios and the two targets, as was an intercept. There are thus eight parameters of interest: the interaction of gain amounts and gain attention, and the interaction of loss amounts and loss attention, in the two scenarios and the two targets.

In the scenario manipulation case, we find that three out of four are significant. In the flu scenario, greater gains are associated with increased sensitivity of choices to attention to gain information (B=.061, s.e.=.032, p=.05), and greater loss amounts are associated with increased sensitivity to attention to loss information (B=-.33, s.e.=.10, p=.0008). In the vacation days scenario, only the interaction between gain amounts and attention to gains is significant (B=-.10, s.e.=.037, p=.007). It is, however, in the opposite direction from what we observed in the flu scenario: greater levels of the gain attribute are associated with a weaker influence of attention to that attribute on choice behavior. In the gain domain, the interaction is not significant (*B*=.047, s.e.=.11, *p*=.67). Thus, the results are wholly consistent with our hypothesis in one of the scenarios, while partially null and partially in the opposite direction in the other.

In the target manipulation case, only two of four parameters of interest approach significance. In both the Self and Other conditions, greater losses are directionally associated with increased sensitivity to attention to losses; directionally but not significantly, somewhat more so in the Self-target condition (*B*=-.16, s.e.=.10, *p*=.12) than in the Other-target condition (*B*=-.13, s.e.=.11, *p*=.22). The parameters indicating increased sensitivity to attention to gains when gains are larger are not significantly different from zero in either target condition (*p*s>.65). Thus, for the target manipulation, we observe two estimates consistent with our hypotheses, and two that are null. Whether this weak support is due to our experimental procedure or due to the absence of the underlying phenomenon needs further examination. That the attentional influence on choice behavior does not grow with increasing stakes is, however, consistent with Schmidt and Traub's (2005) failure to find evidence for increasingly loss-averse preferences as stakes grow. Thus, although unanticipated by us, our results for attentional influence could be interpreted as analogous with previous work on the sensitivity of choice behavior with increasing stakes.

11.3 Conclusions from Study 2.2.

This study examined the consequences for the allocation of attention between the attributes of gambles following a manipulation of loss aversion. Using two manipulations that increased loss aversion—health-related versus leisure-related scenarios, and outcomes that affected another person versus oneself—we tested a number of hypotheses relating to the association of attention allocation and preferences. In particular, we wanted to test whether allocation of attention follows the same pattern as loss aversion; that is, when loss aversion is heightened, do losses receive more attention, and does the attention paid to losses become a more powerful influence on choice behavior? In addition, we examined the direct influence of attention to positive and negative attributes on gamble choices, as well as the effect of increasing the level of gains and losses on the power of attention to influence preferences.

The results of this study point to a dissociation of the attentional influence on preferences, and on loss aversion; we could not confirm that the manipulation of loss aversion affected attention in a systematic manner. Thus, it seems that our scenario (i), which this study set out to test, does not accurately describe the underlying association of loss aversion and attention that our first study indicated. Our present findings point towards the truth of either the reverse case (scenario (ii)), with attention driving loss aversion, or scenario (iii), in which a third factor is the common driver.

In addition to the evidence against a causal influence of loss aversion on allocation of attention, however, we found strong support for a phenomenon we termed *attentional loss aversion*. This phenomenon involves the asymmetric influence on choice behavior of attention to negative versus positive attributes of an alternative. Increased attention to negative and positive attributes was found to have direct negative and positive influences (respectively) on decision makers' tendency to accept the gambles we presented them. In addition, and as predicted, the negative influence of attention to losses was considerably stronger than the positive influence of attention to gains; to our knowledge, this phenomenon has not previously been demonstrated. The magnitude of this asymmetry is not unlike that of “regular” loss aversion, but it would be premature to speculate whether or not this indicates a deeper connection between the two phenomena, or reveals something about their potential common cause. That answer awaits further investigation.

12. Conclusion of Essay Two.

The second essay of this dissertation examined the relationship between loss aversion—that is, the asymmetric sensitivities to gain and loss amounts by which "losses loom larger than gains" (Kahneman and Tversky 1979)—and allocation of attention. In particular, we hypothesized that there would be a causal relationship between the degree to which losses exert a stronger influence than gains on choice behavior, and the degree to which attention is allocated asymmetrically between information about a gamble's potential losses and gains. Having observed correlational evidence of an association in a first study, we set out to test one potential causal direction in an additional empirical study. Throughout, our stimuli were gambles, as in the first essay, and the process-tracing software MouseLabWEB (Willemsen and Johnson 2008) was used to monitor the information acquisitions of our participant decision makers.

Our second study tested the causal direction from preferences to attention by manipulating the degree of loss aversion and observing the effect on allocation of attention. We could not, however, confirm a causal influence. Our manipulation successfully influenced loss aversion, but the effects on attention were not as predicted. However, this study also tested the direct-effect hypotheses, and here we found strong influences of attention on preference. Additionally, the negative influence of attention to losses was significantly stronger than the positive influence of attention to gains, a phenomenon we refer to as attentional loss aversion. This phenomenon has to our knowledge not been reported previously, and we consider it a novel contribution of this work.

13. Essay Three: Does Attention Drive Loss Aversion?

13.1 Introduction.

The second essay of this dissertation examined the relationship between attention and loss aversion by manipulating decision makers' loss aversion and measuring their allocation of attention between the attributes of our gamble stimuli. This investigation, however, could not conclusively establish a clear causal influence of loss aversion on attention. In this third essay we proceed to test the other causal direction, by which attention drives loss aversion. By manipulating attention allocation and observing the effects on loss aversion we hope to shed further light on their underlying association, indicated by Study 2.1.

In this essay, we thus test the same hypothesized associations as in Essay Two, this time taking the opposite perspective on the direction of causality by manipulating attention rather than loss aversion. We again test all five of the hypotheses stated above. We proceed to review a few additional findings in the previous literature consistent with this direction of causality.

13.2 Value Construction

In the previous essay, we made the distinction between *encoding* and *construction* accounts of loss aversion (Willemsen, Böckenholt, and Johnson 2008) and took an encoding view by treating attention as the consequence of an already existing preference. By contrast to the encoding view, a value construction account sees the subjective value of an option as being constructed during the decision process (Liechtenstein and Slovic 2006). Earlier research (e.g. Montgomery 1983; Montgomery and Svenson 1983) has found evidence for a bias by which evaluation of the ultimately chosen option increases during the course of the decision process (see Brownstein 2003 for a review). More recently, similar findings have emerged from research based on models of the relation between attention and preference (e.g. Rangel 2008). Influences on valuation that act *during* such a value construction process include affect and emotions, as well as responses of the autonomous nervous system. The next two sections briefly review these latter findings, before moving to the link between attention and preference.

13.2 Affect and Emotions

One suggested source of loss aversion is affect and emotion. If evaluations of alternatives are dependent on (anticipated or actual) emotional reactions to those alternatives, and there are asymmetries between positive and negative emotional reactions, then we would also expect asymmetries in evaluations. Zhang and Fischbach (2005) studied the endowment effect in the presence of emotional manipulations, hypothesizing that it is the anticipation of negative emotional reactions to the loss of an owned object that influences decision makers to express higher valuations for objects in their possession than for the same object when it is not possessed. Consistent with this hypothesis, they found that when factors are introduced that attenuate negative emotional reactions (such as enhancing the current mood), the size of the endowment effect is diminished. In another study, in which participants were explicitly asked to make forecasts of their affective reactions to losses and gains, Kermer, Driver-Linn, Wilson, and Gilbert (2006) observed that decision makers tended to overestimate their negative emotional reactions to losses: they thought losing would have greater emotional impact than winning, whereas in actual experience, this was not generally the case. The authors explain this finding by participants' inability to anticipate the coping strategies they employ once they do experience losses. Thus, even in those cases where loss aversion is present at the point of experience, its degree would be higher in prospect.

13.3 Responses of the Autonomous Nervous System.

Reactions of the autonomous nervous system are other potential contributors to loss aversion. Such reactions, like physiological arousal, may influence loss aversion if they are taken as inputs in the process of constructing preferences. Sokol-Hessner et al. (2009) argue that loss aversion has both a “hedonic” component, caused by our physiological reactions to encounters with losses, and a “judgmental” component, which is more cognitive in nature. (The latter would, for instance, include the affective forecast effect mentioned above.) They find a significant correlation between their measure of physiological arousal (skin conductance response) and behavioral measures of loss aversion (as measured using gamble acceptance), which supports a hedonic component. Additionally, they find that a cognitive strategy for reducing loss aversion (a perspective-taking strategy of “thinking like a trader”) reduces both loss aversion and physiological arousal, supporting the second component while also indicating that the two processes are not independent but may interact.

Using another measure of activation of the autonomous nervous system (pupil dilation), Hochman and Yechiam (2011) find that heightened physiological arousal indeed indicates risk—not through a correlation with losses but rather through association with “global” risk levels of an outcome.

13.4 Attention and Preferences.

As reviewed in Section 9.2.2 above, the gaze cascade model of Shimojo et al. (2003) has two components, working in opposing causal directions: a preferential looking effect

(Fantz 1964) and a mere exposure effect (Zajonc 1968). The direction that we will test in this essay, in which attention drives preferences, is consistent with the latter of these: the more time an individual spends exposed to a stimulus, the more she will prefer it.

Consistent with the gaze cascade model, Rangel and his colleagues (Rangel 2008; Krajbich, Armel, and Rangel 2010) posit a model for the role of visual attention in binary choice. According to their model, when choosing between two options attention is first allocated randomly, but with successive switches of attention (the duration of which is drawn from a random distribution), it becomes increasingly allocated to the option that is ultimately chosen. During the time the decision maker is directing her visual attention towards one of the objects, the probability of choosing that object continuously increases or decreases, depending on whether the object is positively or negatively valenced, while the probability of choosing the other one moves in reverse. This model thus predicts, and research has found, that the more visual attention is allocated to a positive object, the more likely it is to be chosen, and vice versa for negative objects (Armel, Beaumel, and Rangel 2008).

Based on the model of Rangel and his co-authors, which addresses approach and avoidance of whole objects rather than specific features of an object, and the category learning research that does focus on specific features (Rehder and Hoffman 2005), we may make the following predictions, re-framing our earlier hypotheses in a manner consistent with the causal direction of scenario (ii): The more attention that is paid to an alternative's loss attribute, the weaker the preference will be for that alternative (Hypothesis 2.1a). In the case of a gamble, for example, the more attention the decision maker pays to the potential loss, the less likely she will be to accept the gamble.

Conversely, the more attention paid to an alternative's gain attribute, the stronger will be the preference for the alternative (Hypothesis 2.1b).

We again predict that the effect of increased attention on choice behavior is stronger for losses than for gains (Hypothesis 2.2), analogously with loss aversion for attribute levels.

Our Hypotheses 2.3a and b here mean that the decision maker becomes more sensitive to losses and gains, respectively, the more she directs her attention towards those attributes, rather than entering the choice situation with preferences already formed and directing her attention accordingly, as assumed and tested in the previous essay. These hypotheses imply for loss aversion that, all else being equal, a decision maker who looks more at losses is hypothesized to become more loss-averse, while one who increases his attention towards gains is hypothesized to become less loss-averse.

As before, we again expect high loss aversion for attribute levels to be associated with high attentional loss aversion (Hypothesis 2.4), and that the higher the attribute levels, the greater the attentional influence on choice behavior (Hypotheses 2.5a and b)

In terms of the three causal scenarios, to the degree that a successful manipulation of attention also manipulates loss aversion, scenario (ii) will be supported. If such a manipulation has no causal influence on loss aversion, we will have to conclude that the third scenario of a common cause is the more likely explanation for the association found in Study 2.1, assuming that it is not a spurious feature of the particular procedures employed here.

We next proceed to the first empirical study of this essay, in which attention allocation is manipulated while observing the effect on loss aversion.

14. Study 3.1 (Manipulation of Attention).

Study 2.1 established an association between attention to the loss part of an option and the degree of loss aversion exhibited by the decision maker (Hypothesis 2.3b), as well as suggested an association with attention to the gain part (Hypothesis 2.3a). This is consistent with both causal scenarios (i) and (ii) (and the non-causal scenario (iii)); that is, loss aversion may indeed be an emergent property of the decision process, in particular a consequence of asymmetric attention to gain and loss parts of an option, but it may also be a driver of attention and thus an antecedent of asymmetric attention. In addition, it may play both roles, creating a positive feedback loop, as in the gaze cascade model of Shimojo et al. (2003).

To shed further light on the direction of causality, we now manipulate rather than measure the decision maker's allocation of attention during the choice process. If the manipulation is successful in altering attention, it should also alter the degree of loss aversion if causal scenario (ii) is true, exclusively or in combination with one of the other scenarios. If, on the other hand, one of scenarios (i) or (iii) is exclusively true, loss aversion should not be affected by a manipulation of attention.

In addition to loss aversion in the aggregate, we again examine the gain and loss components separately, that is, the sensitivity of choice behavior to gain and loss amounts. This analysis will help us understand the origins of differences in loss aversion, which may be hidden from view when using only an overall loss-aversion measure. In this study we again test all five of our hypotheses.

14.1 Method.

The general procedure of the experiment was similar to that of Study 2.2, with two differences: We introduced a manipulation of the way losses and gains were displayed graphically, and we used a different set of gambles. We manipulated the display of losses and gains across three conditions: a losses-manipulated, a gains-manipulated, and a neutral condition with neither losses nor gains manipulated. In the two manipulated conditions, we altered the contents of the two gain boxes (probability and amount) and the two loss boxes from the previous experiment. Instead of the previously employed black text in an easily readable typeface ("Arial") on a white background, we used green text in an unusual typeface ("Curlz") on a black background in the manipulated conditions. See Figure 9ab for examples of the neutral and altered texts.

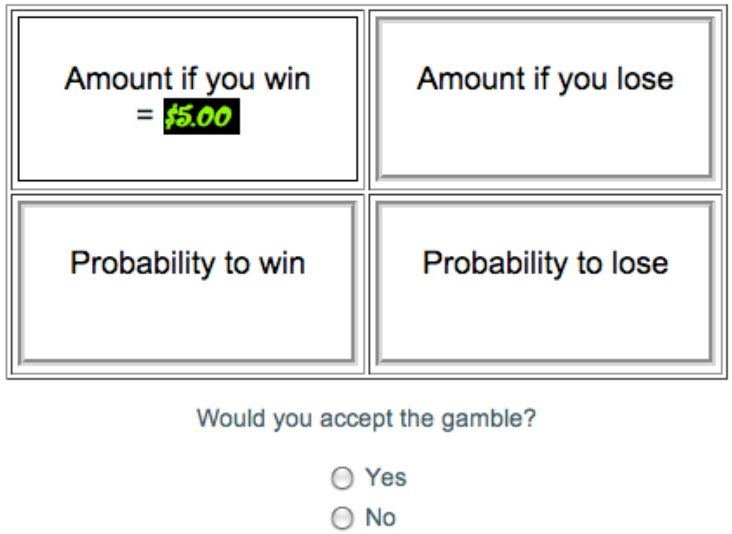

Figure 9ab. The manipulation of attention as seen by participants; the neutral display format (a., top) versus the manipulated (here, gain) format (b., bottom).

Our display format manipulation was intended to affect the ease of reading the information about the gambles. This manipulation may, however, also have affected our participants' experience of cognitive difficulty during their decision-making processes. Previous research has shown that similar manipulations that cause decreases in fluency also can affect judgments and decision-making behavior (see, e.g., Schwarz 2004). For instance, Novemsky et al. (2007) found that decreased fluency was associated with greater deferral of choices; that is, participants elected to not make a decision in favor of any of the presented options. If, in our study, decision makers (erroneously) perceive the rejection of a gamble as a way of deferring choice, we may observe that our manipulation of the display format (of both gain and loss amounts) leads to lower overall acceptance rates, and potentially decreased sensitivity to both gains and losses. Further, Shah and Oppenheimer (2007) found that information that is harder to process (less fluent) is given less weight in judgments. In that study, information cues presented in less clear fonts, out of focus, or hard to pronounce were given less weight in participants' judgments.

To the extent that these findings are applicable to our experimental manipulation, we may observe lower sensitivity to the manipulated attribute, or even to both attributes (i.e., including the non-manipulated one). If the overall alternative (i.e., the gamble) is seen as a cue to whether to accept or reject, and our manipulation decreases our participants' experience of fluency, we may observe a decreased sensitivity of choice behavior to all the information we present. Participants may switch decision strategies and evaluate the gamble differently than by responding to the changes in losses and gains. We will return to this possibility in the discussion of our results.

The gambles used in this study were again adapted from Tom et al. (2007). We used 16 gambles forming a complete 4 (gains: \$5, \$10, \$15, \$20) × 4 (losses: \$2.50, \$5, \$7.50, \$10) factorial design, and respondents were asked whether they would play each gamble or not. Probabilities were again jittered around .5 (ranging from .45 to .55 in .025 increments) in order to make the task less repetitive and monotonous for participants. Each of these gambles was presented in three forms: in a neutral condition in which no text was manipulated, and in two manipulated conditions in which the text in the gain and loss boxes was manipulated. Thus, each of the 16 gambles was presented three different ways per subject, making the total number of gambles seen by each participant 48.

As in the previous experiment, for each gamble participants were asked to make a decision whether or not to accept it. In this experiment we used a different payment scheme, however. All participants started out with \$12 as compensation for taking the survey but were told that one of the gambles would be randomly selected and, if they had accepted it, played out for real money. This procedure thus made the choice task incentive-compatible, with a range of possible final payments between \$2 and \$32.

In this study we again use the full set of choices made by participants and estimate the degree of loss aversion exhibited by these choices using logistic regression. As before, the degree of loss aversion can be found by taking the ratio of the loss-parameter to the gain-parameter.

In the following analyses, looking times below 200ms were again excluded as subliminal (Willemsen and Johnson 2010). Excluding these data points, as well as trials where participants did not examine all the information at least once, left us with 2346 observations from 58 participants.

14.2 Results.

As a manipulation check, we asked participants to rate how difficult to read and how distracting the manipulated text was compared to the neutral one. We found the manipulated display format to be harder to read ($M_{neutral} = 2.66$; $M_{manip} = 1.29$; $p<.0001$) and more distracting ($M_{neutral} = 2.56$; $M_{manip} = 1.27$; $p<.0001$) (both on five-point scales), which we deemed consistent with the manipulation's purpose of attracting increased attention.

We then conducted an initial analysis that showed that the manipulation of display format was successful in attracting the attention of participants. We added the times spent looking at gain and loss probabilities and amounts to form overall gain and loss time variables, which were then log-transformed in order to reduce the influence of outliers and create independent variables more normally distributed.

We regressed the (log of) total time spent looking at gains and losses on a categorical variable for condition. As can be seen in Figure 10, we observed the expected overall effects of condition (F_{gains}=3.54, p_{gains}=.029; F_{losses}=4.95, p_{losses}=.0072). In the first case (gain times), there were expected significant negative effects for both the neutral (*p*=.018) and the loss (*p*=.025) conditions, as compared to the gain condition. For the second case of loss times, there was a significant positive effect of the loss condition over the gain condition (*p*=.022), but no effect of the neutral condition over the gain condition (*p*=.49) These means can be seen plotted in Figure 10, together with the 95% confidence interval (dashed lines).

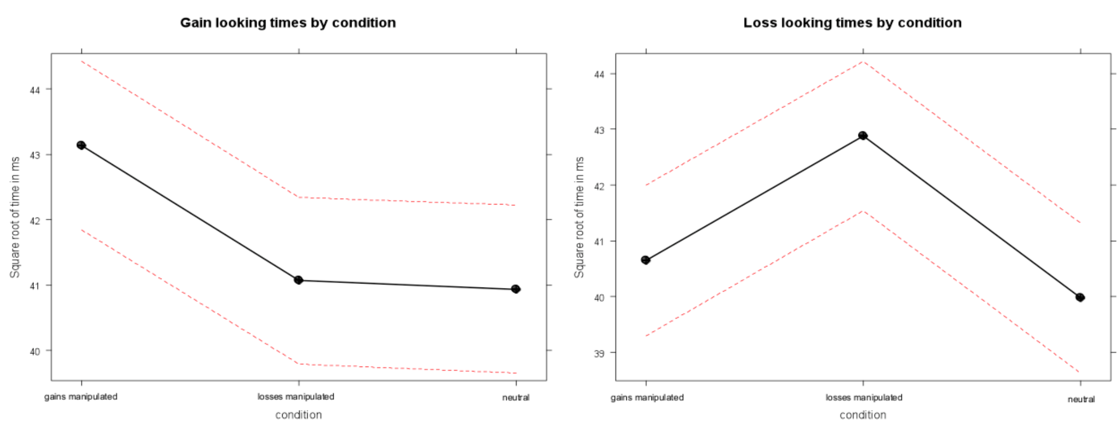

Figure 10. The manipulation of attention to gain and loss information in Study 3.1.

In the left panel, the gain condition shows significantly higher mean looking times at gains over the loss and neutral conditions, which are not different from each other. In the right panel, looking times at losses are similarly significantly above the other two conditions, which are not different from each other. Transforming the means back to seconds, the average time spent looking at the gain boxes per trial (i.e., per gamble) is

1.83s in the gain condition, and 1.66s in the loss and neutral conditions; the gain-condition mean was significantly greater than those of the other conditions (*p*s=.003 and .002, respectively). For the loss boxes, the average looking time was 1.76s in the loss condition, and 1.64s and 1.56s in the gain and neutral conditions, respectively. Here the loss-condition mean was significantly greater than those of the other conditions (*p*s=.04 and .0003, respectively), which did not differ significantly (*p*=.13). Averaging the non-manipulated conditions, we found that the manipulation thus caused an increase of about .16s in the amount of time spent looking at losses, and an increase of about .17s in the amount of time spent looking at gains, per trial.

The significant increases in the times devoted to looking at the boxes with manipulated text indicate that our manipulation of attention was successful. The next step then is to examine the data for corresponding differences in choice behavior between conditions, that is, for differences in sensitivity to gain and loss amounts.

We also perform an analysis related to the hypothesis of a direct link between attention and choice of the risky option, that is, acceptance of the gamble. The manipulation used to influence the allocation of attention may, in addition to the hypothesized effect on loss aversion, have a direct effect on the probability of accepting the gambles.

The hypothesized influence of attention on loss aversion was tested using logistic regression, regressing the binomial choice data on intercepts, gain amounts, and loss amounts, for all of which we varied parameters by condition. The estimated logistic models, together with the data (each grey dot is an accept/reject decision, jittered for visualization purposes), can be seen in Figure 11 below.

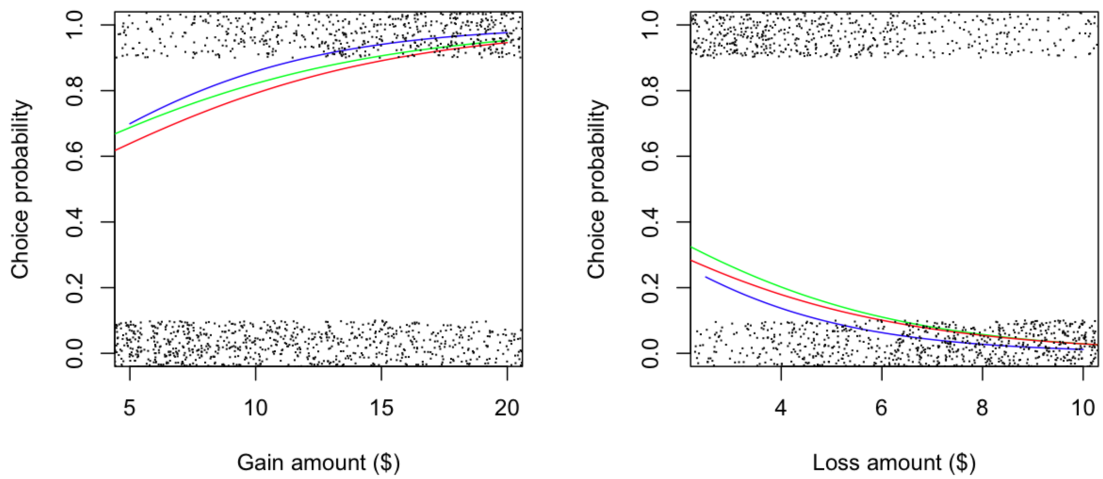

Figure 11. Estimated sensitivities of choice behavior to loss and gain amounts.

In the neutral case (the blue lines in the figure), where none of the displays were manipulated, we estimated a gain-sensitivity parameter of .19 and a loss-sensitivity parameter of -.43 (all gain and loss parameters reported for this analysis were significant at p<.0001), which then results in an estimated loss aversion (i.e., negative ratio of loss sensitivity to gain sensitivity) of 2.24. When the display of gain information was manipulated (the green lines), the gain parameter decreased to .15, and the loss parameter increased to -.36; that is, both sensitivities diminished (simulation[8] confirmed that both these changes were significant at p<.05). Loss aversion was thus estimated by the parameter-ratio to 2.41. Similar changes were observed when the display of loss information was manipulated (red lines)—the gain parameter again decreased to .15, while the loss parameter increased to -.33—thus, again the sensitivities decreased

[8] 100,000 simulations of parameter values were made; reported (pseudo-)p-values are based on proportions of simulated values.

compared to the neutral condition (again confirmed by simulation). The value of loss aversion in the loss-manipulated condition was estimated to be 2.17. Thus directionally, loss aversion increased compared to the neutral condition when attention was diverted towards gains, and diminished when it was diverted towards losses. These changes were, however, not significant—for all three cases, 95% confidence intervals based on the simulations overlap substantially.

The results of this analysis thus do not support our hypothesis of an attentional basis for loss aversion. We did find an effect on preferences when we manipulated attention, but not in the way we had predicted. Indeed, we found a null effect of our manipulation on loss aversion.

The effect we did observe—decreased sensitivity of choice behavior to both gains and losses when any information is made more difficult to acquire—is more consistent with previous findings regarding fluency effects on decision making. As discussed above, our participants may have experienced increased subjective difficulty in forming their choices, and so exhibited something analogous to the choice deferral observed by Novemsky et al. (2007) or the cue-weighting effect of Shah and Oppenheimer (2007) by becoming less sensitive to the attributes of the alternative. It is, however, not simply a case of increased rejection of gambles (as you might expect from Novemsky et al. 2007) when display format is manipulated. The proportion of accepted gambles in the neutral, gain, and loss conditions was .44 in all three cases (a logistic regression of choices on condition dummy variables confirms no differences; ps>.75).

The second analysis we perform examines the hypothesized direct effect of attention on choice. We predict that the more time spent looking at gains, the greater will be the probability of accepting the gamble, and vice versa for losses. We thus ran a logistic regression where choices were regressed on (log-)looking times at both gain and loss information. We estimated a parameter for gain-attention of .14, which was thus directionally (but not significantly, p=.19) positive, as predicted. However, the estimate for the loss-attention parameter was .23 (p=.02), that is, in the opposite direction from what we had predicted. The more attention participants allocated towards loss information, the more likely they became to accept the gamble. This effect may also be due to an unintended (dis-)fluency effect of our attempt to manipulate attention.

14.3 Conclusions from Study 3.1.

This study was designed to test a second potential causal scenario for the association between loss aversion and attention suggested by Study 2.1: that loss aversion with respect to attribute levels of an alternative is a consequence of an asymmetric allocation of attention between loss and gain attributes of that alternative. To test this, we used a change in display format of the information to manipulate the relative allocation of attention to loss and gain information. However, even though we observed significant changes in the allocation of attention, the hypothesized consequential effect on loss aversion did not appear. The causal scenario we set out to test in this essay (running from attention to preference) is thus not supported by this study.

The results are consistent, rather, with an unintended effect on decision fluency of our manipulation. We made the information harder to read, which did increase attention, but it also made our participants less sensitive to changes in the gain and loss amounts. We cannot, however, rule out the possibility that subjects were in some way confused by the task and the manipulation, increasing the degree of noise in our data.

We also tested Hypotheses 2.1a and b regarding the direct effect of attention on choice behavior. These could not be confirmed here, and thus testing of Hypothesis 2.2 regarding attentional loss aversion was not applicable.

In Section 16.1, we will propose a further empirical study, in which we again examine this causal scenario (attention driving loss aversion), with a suggested improved manipulation of attention that would allow us to again test all five hypotheses while eliminating the potentially problematic effect of fluency.

15. Conclusion of Essay Three.

Study 3.1 successfully manipulated participants' degree of attention to loss and gain information, but it failed to find the hypothesized effect of this manipulation on loss aversion, providing evidence against scenario (i), that is, against the causal influence of attention on loss aversion. Together with the conclusions of the Essay Two, this study casts some doubt on the causal relationship between the two constructs**.** Rather, our evidence suggests that scenario (iii), in which the association is caused by a third factor that influences both loss aversion and attention, may be closer to the truth. The nature of this potential factor lies beyond the scope of this research, however. One speculation is that the cause might be affective in nature, which would be consistent with some findings in the neural literature. If a stimulus related to negative emotion, such as fear, activates loss aversion (see, e.g., Tom et al. 2007), as well as captures attention (Vuilleumier and Schwartz 2001), one might observe an association between the two constructs without being able to cause a change in one by manipulating the other.

In Study 3.1 we manipulated attention by means of modifying the display format of gains and losses. This manipulation successfully increased the amount of time that participants focused their attention on the manipulated attribute; it may, however, also have caused an increase in the feeling of difficulty experienced during the decision process, that is, a decrease in fluency. The latter, as described above, is another possible explanation for our findings. The results indicate that, at least under these low-fluency conditions, loss aversion is not driven by asymmetric allocation of attention to gains and losses. Whether this is true in general cannot be answered by this study, however. In addition, we did not find support in this study for our hypotheses regarding a direct link between attention and preference for accepting versus rejecting gambles, and thus not for our attentional loss aversion prediction.

In general, the association between attention and preferences, such as loss aversion, may indeed be weaker than we had originally predicted, which may again be due partially to the decrease in fluency that our participants experienced, as well as possible participant confusion with the experimental tasks. Additionally, a third factor as common driver of attention and loss aversion, which we earlier speculated might be affective in nature, may also have been behind some of our unanticipated findings. However, based on the extant findings in the previous literature, as well as the evidence that we do find—predominantly in the previous essay's Studies 2.1 and 2.2—we still consider this topic worthy of investigation. In particular, we intend to further pursue our novel finding of attentional loss aversion, addressing the extent of the association, including its boundary conditions and generality. We believe doing so in an environment where fluency is not elevated by the experimental manipulation, as proposed in Study 3.2, will be a fruitful avenue for further research.

16. General Discussion of Essays Two and Three.

In the last chapter of this dissertation, we discuss some further empirical and theoretical issues that relate to the failure to find some of our hypothesized effects and that suggest avenues for further and improved research. We begin by addressing the suspected confound of fluency created by the manipulation used in Study 3.1 and suggesting an improved manipulation.

16.1 Proposed Study 3.2.

16.1.1 Introduction.

By manipulating the display format of gains and losses, we attempted to examine the causal influence of attention on loss aversion in Study 3.1. However, as discussed, the lack of conclusive evidence from that study may have been due to unintended and undesirable characteristics of our manipulation. In particular, an unwanted decrease in fluency is the prime candidate for a confounding factor.

To further clarify the causal influence of attention on loss aversion, we intend to perform a second study. We will use the same methodology from Study 3.1 while substituting an improved manipulation of attention. By employing a manipulation that has been previously used in the literature on attention and preferences, we hope to avoid confounding attention with fluency.

In Study 3.1 we relied on an indirect manipulation of attention—changing the display format of the stimulus—that required the active reallocation of attention by participants. Several studies in this domain have instead employed a manipulation whereby the participant's allocation of attention is more directly influenced, rather than relying on her own reallocation. Shimojo et al. (2003), Armel et al. (2008), and Nittono and Wada (2009) all used similar methodologies to manipulate their participants' attention, and we intend to adopt the same type of procedure in this proposed improvement of Study 3.1.

16.1.2 Method.

We propose to closely follow Armel et al.'s (2008) attention manipulation, while using the gambles from our Study 3.1. Rather than letting participants actively acquire information, we will instruct them to focus their attention on a point on the computer screen, where we present them with information about the gambles after a short fixation period. There will be two treatment conditions in which more exposure is given to gain and loss information, respectively. In the gain-condition, for each gamble, after a one-second fixation period, information about the potential gain (i.e., outcome and probability) of the gamble is presented for 900ms, followed by presentation of the information about the potential loss for 300ms. This cycle of presentation repeats six times for a total presentation time of 7.2 seconds. Following the six cycles of presentation, we ask participants to choose whether to accept or reject the gamble. Upon choice the participant then moves on to the next gamble. The loss-condition would be identical except for the 900ms presentation of loss information and 300ms presentation of gain information.

The analysis of the data would be similar to Study 3.1, except for the categorical rather than continuous nature of the attention variable. Loss aversion would again be measured using logistic regression of the choice data on gain and loss amounts. If our hypothesized causal link from attention to loss aversion is valid, we expect higher loss aversion in the loss-condition than in the gain-condition. Additionally, by our hypothesized direct effect of attention on choice, we would expect greater overall acceptance of gambles in the gain-condition than in the loss-condition. By varying only the time of presentation of the information, we hope to avoid the potentially confounding influence of fluency in Study 3.1.

A possible disadvantage of this methodology is that participants may detect the different exposure times and guess the hypothesis of the study, acting in accord (or discord) with the perceived wishes of the researchers (i.e., an issue of demand characteristics). This is a more relevant concern for the simpler direct-effect hypotheses (2.1a and b) than for our other, more complex hypotheses. Asking participants for their perception of the hypotheses after completion of the study would give some indication as to how serious this concern may be. We also acknowledge that such hypothesis-guessing may have occurred in the studies reported above in Essays Two and Three.

We next briefly review a process model for how preferences are constructed, which could add a cognitive link between our perceptual measure of attention and the expression of preference as choice.

16.2 A Process Model of Preference Construction: Query Theory.

In our above discussion of the connection between perception and preference, we have not examined in detail how explicit cognitive processes in the decision maker may mediate the hypothesized effects of perception on choices and preferences. Adding to the construction-based accounts of preferences introduced in Section 13.2, one possible pathway from perception to preference that does provide an explicit mechanism is provided by query theory[9] (Weber and Johnson 2006; Johnson, Häubl and Keinan 2007).

According to query theory, a decision maker constructs her preferences by posing herself queries in response to a choice situation. Examples of such queries include "What are the reasons for choosing option A?" and "What are reasons against choosing option B?" The option that she ultimately chooses then depends on the amount of information produced in response to these queries. Importantly, because of memory phenomena such as retrieval-induced forgetting, the order in which the queries are posed and answered affects the amount of information produced. Within a memory category (such as "things relating to option A"), information retrieved earlier can suppress retrieval of the remaining information. Thus, beginning the choice process by recalling information favoring option A, rather than going against it, will result in an overall more favorable evaluation than if the order of the queries were the opposite.

Applying query theory to our choice setting, we predict an effect of the order in which participants process the gamble attributes. If the choice to accept or reject the gamble is not entirely stimulus-based—that is, if the decision maker memorizes some of the information after opening the MouseLabWEB boxes and uses that memorized information rather than the displayed information to make the decision (to some extent)--then the order in which information is retrieved should influence the choice. If the gain information (i.e., what is good about accepting the gamble) is retrieved first, query theory would predict that the loss information (i.e., what is bad about accepting the gamble) would become harder to retrieve and thus increase the likelihood that the gamble is

[9] Thanks to Elke Weber for pointing this out.

accepted (and vice versa if the loss information is retrieved first). If this order is reflected in the order in which the gain and loss information is accessed in the MouseLabWEB display, then analysis of this kind of data in an improved empirical study may provide support for the query theory mechanism, which in turn would mean a richer theoretical framework for the research reported in Essays Two and Three.

16.3 Linearity of the Attention–Preference Link

Our hypothesized links between attention and preferences may not necessarily be linear[10]; for instance, more attention may be directed to stimuli that are neither very attractive nor very aversive—one could easily imagine that those stimuli are the ones selected for further evaluation and thus get more attention allocated toward them. Conversely, to the extent that increased attention to positive and negative attributes increases and decreases, respectively, liking for an alternative, such a link may well exhibit diminishing marginal effects as more and more attention is allocated. In the extreme, the relationships may even become inverse-U- and U-shaped, respectively.

16.4 Visual Attention As Proxy for Cognitive Attention.

As discussed, we have treated cognitive attention and visual attention as closely linked; that is, we assumed that in our studies people largely thought about what they were looking at. While there is evidence for this in the psychology literature (see Section 9.2.2), we cannot be certain that this was the case in our particular empirical setting. If cognitive attention is driven by other factors, our looking-time measure would not have picked up the correct construct (i.e., visual attention would not have been a valid proxy for cognitive attention). Cognitive attention may for instance have been driven by

[10] Thanks to Vicki Morwitz for pointing out this possibility.

emotional reactions to the gain and loss information.[11] A possible resolution of this issue would be to construct a measure of the amount of information remembered by the participants; if the amount of information encoded in memory is a better proxy for cognitive attention than is visual attention, using such a measure should provide better tests of our hypothesis.[12]

16.5 Generality and Applicability.

The online setting of our studies limits the results' generalizability across choice settings, and in particular to physical ones such as retail stores. Even as the online retail environment expands and more consumer decision-making takes place in front of a computer screen, it will be an important goal of further research to test the applicability of our hypothesized effects to physical environments.

Our stimuli have been intentionally abstract in order to reduce noise in the data, but we acknowledge that this does place limits on our ability to make predictions about the relationship between attention and preferences when the choice environment becomes more complex and realistic.

Real-life choices are certainly determined by a vast number of influences—whether attention allocation is a significant one when subjected to a variety of competing influences "in the wild" cannot be predicted from our findings. Similarly, we can only speculate as to whether preferences guide attention allocation in a significant way when the number and complexity of inputs from the choice environment increase. Both questions are important, however, and should be addressed in future work. Our aim with the studies reported above has been to test the existence of the potential link between

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[11] Thanks to Eric Johnson for bringing this to our attention.

[12] We are grateful to Leonard Lee for this idea.

attention and preferences, and to establish a causal direction for that link.[13] What happens to that link when other factors influence both attention and preferences remains to be investigated.

One additional concern is the fairly large number of choices we have asked our participants to make. This may have induced participant fatigue—as the participants go through the sequence of gambles, they may become less engaged and start responding by simply repeating the same answer, or use simplifying heuristics rather than a more thorough evaluation of each gamble. Such simplifications may have bypassed any existing links between attention and preferences, and thus weakened our ability to detect them.

We are grateful for the contributions of the members of the dissertation defense committee and look forward to continuing this research, addressing relevant concerns, and implementing their helpful suggestions for improvements.

[13] This link may not necessarily be unidirectional, as pointed out by Olivier Toubia.

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18. Appendix 1: Proofs of the Propositions from Essay One.

18.1. Proof of Proposition 1.

PROPOSITION 1**:** *For any fixed loss L, there exists a loss aversion coefficient* $\lambda^* = \dfrac{g'(0)}{g'(L)}$, *such that:*

• *For all λ > λ*, the value derived from integration is greater than that derived from integration for any gain G ≤ L.*

• *For all λ < λ*, there exists a gain G** $\in]0, L[$ *such that the value derived from segregation is greater than that derived from integration for any gain G < G*, and the reverse is true for any gain G > G*.*

18.1.1 Preparatory Material.

LEMMA 1: *For any fixed loss L,*

- *If segregation is optimal for a gain G, it is optimal for any smaller gain G'<G.*
- *If integration is optimal for a gain G, it is optimal for any larger gain G">G.*

PROOF OF LEMMA 1: Let us define y_0 and y_1 respectively as the loss reduction achieved by integration under G_0 and G_1 such that $G_1 < G_0$:

$y_0 = l(L-G_0) - l(L)$

$y_1 = l(L-G_1) - l(L)$

and x_0 and x_1 as the analogous gains from segregation:

$x_0 = g(G_0)$

$x_1 = g(G_1)$

Monotonicity and concavity of gains and monotonicity and convexity of losses imply that

$$\frac{y_1}{G_1} < \frac{y_0}{G_0} \quad \Leftrightarrow \quad y_1 < y_0 \frac{G_1}{G_0},$$

and $$\frac{x_1}{G_1} > \frac{x_0}{G_0} \quad \Leftrightarrow \quad x_1 > x_0 \frac{G_1}{G_0}.$$

Thus, for $x_0 > y_0$ $$x_1 > x_0 \frac{G_1}{G_0} > y_0 \frac{G_1}{G_0} > y_1.$$

Hence we have $$x_0 > y_0 \Rightarrow x_1 > y_1.$$

Recalling that $x_0 > y_0$ means that it is optimal to segregate (i.e., the gain from segregation is greater than the loss reduction from integration), we see that if it is optimal to segregate a gain G_0 from a loss L, it is also optimal to segregate any smaller gain $G_1 < G_0$.

Conversely, $x_1 < y_1 \Rightarrow x_0 < x_1 \frac{G_0}{G_1} < y_1 \frac{G_0}{G_1} < y_0$, hence if it is optimal to integrate for G_1, it is optimal to integrate for any $G_0 > G_1$.

18.1.2 Proof of the Main Result.

Proof of Proposition 1. Lemma 1 assures us that there are at most two regions: one in which it is optimal to segregate (smaller gains) and one in which it is optimal to integrate (larger gains). Clearly, the latter region is never empty as it is always optimal to integrate if $G=L$ (as long as $\lambda>1$). The former region is non-empty if and only if it is optimal to segregate as G goes to 0. The condition under which segregation is preferred is $g(G) > l(L-G) - l(L)$. Dividing both sides of this inequality by the gain G and letting it go towards zero, we obtain in the limit

$$\lim_{G\to 0}\frac{g(G)}{G} > \lim_{G\to 0}\frac{l(L-G)-l(L)}{G} \quad\Leftrightarrow\quad \lim_{G\to 0}\frac{g(G)-g(0)}{G-0} > \lim_{G\to 0}\frac{l(L-G)-l(L)}{G}$$

$$\Leftrightarrow g'(0) > -l'(L) = \lambda.g'(L) \Leftrightarrow \lambda < \frac{g'(0)}{g'(L)} = \lambda^*$$

18.2. Proof of Proposition 2.

PROPOSITION 2**:** *In the region in which G* exists (* $\lambda < \dfrac{g'(0)}{g'(L)}$*), the following comparative statics hold:*

a) G is monotonically decreasing in the loss aversion parameter λ (* $\dfrac{dG^*}{d\lambda} < 0$*)*

b) G is monotonically increasing in the amount of the loss L (* $\dfrac{dG^*}{dL} > 0$*)*

Proof of Proposition 2. As mentioned in the text, G^* is defined by: $F(G^*, L, \lambda) = 0$, where: $F(G, L, \lambda) = g(G) - \lambda g(L) + \lambda g(L-G)$.

Using the envelope theorem, $\dfrac{dG^*}{dL} = \dfrac{-\partial F/\partial L}{\partial F/\partial G}$ and $\dfrac{dG^*}{d\lambda} = \dfrac{-\partial F/\partial \lambda}{\partial F/\partial G}$

we have

- $\dfrac{\partial F}{\partial G}(G^*) = g'(G^*) - \lambda g'(L-G^*) < 0$ because

  $g'(G^*)G^* < g(G^*) = \lambda(g(L) - g(L-G^*)) < \lambda g'(L-G^*)G^*$ where the inequalities hold because g is monotonically increasing and concave and $g(0)=0$, and the equality holds by definition of G^*.

- $\dfrac{\partial F}{\partial L} = -\lambda g'(L) + \lambda g'(L-G) > 0$, because g' is monotonically decreasing

- $\frac{\partial F}{\partial \lambda} = -g(L) + g(L - G) < 0$ because g is monotonically increasing

Thus, we have $\frac{dG^*}{dL} > 0$, and $\frac{dG^*}{d\lambda} < 0$.

19. Appendix 2 (Hierarchical Bayes Model Estimation Details from Essay One).

19.1 Model.

19.1.1 Likelihood.

$$pref_{ij} = a_i + \beta_1 gain_{ij} + \beta_2 loss_{ij} + \beta_3 gain_{ij} \times loss_{ij} +$$

$$\beta_4 \times 1\left(position_{ij} = 1\right) + \beta_5 \times 1\left(position_{ij} = 2\right) + \beta_6 \times 1\left(position_{ij} = 3\right) + \varepsilon_{ij}$$

$$\hat{\lambda}_{6,i} = \lambda_i + \delta_i$$

$$\hat{\lambda}_{20,i} = \lambda_i + \zeta_i$$

$$\varepsilon_{ij} \sim N(0,\sigma^2), \delta_i \sim N(0,\nu_6^2), \zeta_i \sim N(0,\nu_{20}^2)$$

19.1.2. First-stage Prior.

$$a_i \sim N(a_0 + \lambda_i a_1 + summer_i a_2, \eta^2)$$

19.1.3. Second-stage Prior.

$$\lambda_i \sim N(\lambda_0, \tau^2)$$

19.1.4. Third-stage Prior.

Diffuse on a_0, a_1, β_1, β_2, β_3 , β_4, β_5, β_6, λ_0

$$\sigma^2 \sim IG(\frac{r_0}{2},\frac{s_0}{2}), \nu_6^2 \sim IG(\frac{r_0}{2},\frac{s_0}{2}), \nu_{20}^2 \sim IG(\frac{r_0}{2},\frac{s_0}{2}), \eta^2 \sim IG(\frac{r_0}{2},\frac{s_0}{2}), \tau^2 \sim IG(\frac{r_0}{2},\frac{s_0}{2})$$

with r_0=s_0=1.

19.2 Markov Chain Monte Carlo Estimation.

- L(a_i | rest) ~ N(m_i,V_i)

  where $V_i = (\frac{J}{\sigma^2} + \frac{1}{\eta^2})^{-1}$

and $m_i = V_i\left(\frac{1}{\sigma^2}\left(\sum_{j=1}^{J} pref_{ij} - (\beta_1 gain_{ij} + \beta_2 loss_{ij} + \beta_3 gain_{ij} \times loss_{ij} + \beta_4 \times 1(position_{ij} = 1) + \beta_5 \times 1(position_{ij} = 2) + \beta_6 \times 1(position_{ij} = 3))\right) + \frac{a_0 + a_1\lambda_i + a_2 summer_i}{\eta^2}\right)$

- $L(\eta^2 | \text{ rest}) \sim IG\left(\frac{r_0 + \sum_{i=1}^{I}(a_i - a_1\lambda_i - a_2 summer_i)^2}{2}, \frac{s_0 + I}{2}\right)$

- $L(\sigma^2 \mid \text{rest}) \sim IG\left(\frac{r_0 + \sum_{i=1}^{I}\sum_{j=1}^{J}(pref_{ij} - \hat{p}_{ij}))^2}{2}, \frac{s_0 + I.J}{2}\right)$

where $\hat{p}_{ij} = a_i + \beta_1 gain_{ij} + \beta_2 loss_{ij} + \beta_3 gain_{ij} \times loss_{ij} + \beta_4 \times 1\left(position_{ij} = 1\right) + \beta_5 \times 1\left(position_{ij} = 2\right) + \beta_6 \times 1\left(position_{ij} = 3\right)$

- $L([\beta_1; \beta_2; \beta_3; \beta_4; \beta_5; \beta_6] \mid \text{rest}) \sim N(X'X)^{-1}.X'.Y;\sigma^2.(X'X)^{-1}]$

where X_{ij} = [$gain_{ij}$, $loss_{ij}$, $gain_{ij}.loss_{ij}$, 1($position_{ij}$=1), 1($position_{ij}$=2), 1($position_{ij}$=3)],

$Y_{ij} = pref_{ij} - a_i$

- $L([a_0; a_1; a_2 \mid \text{rest}) \sim N(X'X)^{-1}.X'.Y;\eta^2.(X'X)^{-1}]$

where $X_{ij} = [1, \lambda_i, summer_i]$

$Y_{ij} = a_i$

- L(λ_i | rest) ~ N(m_i,V_i)

  where $V_i = (\frac{1}{\nu_6^2} + \frac{1}{\nu_{20}^2} + \frac{a_1^2}{\eta^2} + \frac{1}{\tau^2})^{-1}$

$$m_i = V_i\left(\frac{\hat{\lambda}_{6,i}}{\nu_6^2} + \frac{\hat{\lambda}_{20,i}}{\nu_{20}^2} + \frac{(a_i - a_0 - a_2 summer_i)a_1}{\eta^2} + \frac{\lambda_0}{\tau^2}\right)$$

- L(λ_0 | rest) ~ N(m,V) where $V = \frac{\tau^2}{I^2}$ and $m = \frac{\sum_{i=1}^{I}\lambda_i}{I}$

- L(τ^2 | rest) ~ $IG(\frac{r_0 + \sum_{i=1}^{I}(\lambda_i - \lambda_0)^2}{2}, \frac{s_0 + I}{2})$

- L(v_6^2 | rest) ~ $IG(\frac{r_0 + \sum_{i=1}^{I}(\hat{\lambda}_{6,i} - \lambda_i)^2}{2}, \frac{s_0 + I}{2})$

- L(v_{20}^2 | rest) ~ $IG(\frac{r_0 + \sum_{i=1}^{I}(\hat{\lambda}_{20,i} - \lambda_i)^2}{2}, \frac{s_0 + I}{2})$