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Losses as Modulators of Attention: Review and Analysis of the Unique Effects of Losses Over Gains

Eldad Yechiam
Technion–Israel Institute of Technology

Guy Hochman
Duke University

It has been shown that in certain situations losses exert a stronger effect on behavior than respective gains, and this has been commonly explained by the argument that losses are given more weight in people's decisions than respective gains. However, although much is understood about the effect of losses on cognitive processes and behavior, 2 major inconsistencies remain. First, recent empirical evidence fails to demonstrate that people avoid incentive structures that carry equivalent gains and losses. Second, findings in experience-based decision tasks indicate that following losses, increased arousal is observed simultaneously with no behavioral loss aversion. To account for these findings, we developed an attention-allocation model as a comprehensive framework for the effect of losses. According to this model losses increase on-task attention, thereby enhancing the sensitivity to the reinforcement structure. In the current article we examine whether this model can account for a broad range of empirical phenomena involving losses. We show that as predicted by the attentional model, asymmetric effects of losses on behavior emerge where gains and losses are presented separately but not concurrently. Yet, even in the absence of loss aversion, losses have distinct effects on performance, arousal, frontal cortical activation, and behavioral consistency. The attentional model of losses thus explains some of the main inconsistencies in previous studies of the effect of losses.

Keywords: negativity bias, loss aversion, attention, decision making, performance

Various studies in psychology have shown profound asymmetries in people's subjective response to gains and losses (see reviews in Baumeister, Bratslavsky, Finkenauer, & Vohs, 2001; Rozin & Royzman, 2001; Vaish, Grossmann, & Woodward, 2008). In a controlled laboratory setting, for example, McGraw, Larsen, Kahneman, and Schkade (2010) had participants perform thought experiments where they either gained or lost an amount of money. The retrospective distress people reported about losing was larger than the excitement about winning. Likewise, in a diary study, David, Green, Martin, and Suls (1997) reported greater effects of negative than positive daily events on subsequent mood on the next day (see also Sheldon, Ryan, & Reis, 1996). Ganzach and Karsahi (1995) demonstrated the applied significance of this phenomenon in a field study in which they sent letters to credit card holders who did not use the card for a couple of months. The message in the letter was framed in terms of either gain or loss of benefits. The results showed that in the loss frame condition about twice as many consumers started using the card. The dominance of losses over gains found in these studies is considered a robust principle manifested in almost all human activities and is referred to as the *negativity bias* (Baumeister et al., 2001). This notion is stressed by Kahneman and Tversky's (1979) seminal work on decision under risk, which suggests that "most people find symmetric bets of the form (x, .50; $-x$, .50) distinctly unattractive" (p. 279) because of *loss aversion*: loss outcomes having larger subjective weight than symmetric gain outcomes.[1]

Moreover, the asymmetric effect of losses is not limited to overt psychological responses. Losses were found to have larger effects than gains on physiological arousal (e.g., Hochman, Glöckner, & Yechiam, 2010; Hochman & Yechiam, 2011; Löw, Lang, Smith, & Bradley, 2008; Satterthwaite et al., 2007) and brain activation in cortical and striatal areas (Gehring & Willoughby, 2002; Holroyd & Coles, 2002; Sokol-Hessner et al., 2009; Yeung & Sanfey, 2004). For example, in a recent article Hochman and Yechiam (2011) found significantly larger pupil diameter and higher heart rate in response to losses than to equal-sized gains. Similarly, in a functional magnetic resonance imaging study, Tom, Fox, Trepel, and Poldrack (2007) reported greater frontal cortical sensitivity to increases in losses compared to equivalent increases in gains.

Clearly, much is understood about the effect of losses on cognitive processes and behavior. Still, in the past decade several studies have challenged the loss aversion model. Loss aversion was reported in some studies of decisions under risk (e.g., Gneezy & Potters, 1997; Redelmeier & Tversky, 1992; Schmidt & Traub,

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Eldad Yechiam, Max Wertheimer Minerva Center for Cognitive Studies, Technion–Israel Institute of Technology, Haifa, Israel; Guy Hochman, Fuqua School of Business, Duke University.

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Correspondence concerning this article should be addressed to Eldad Yechiam, Max Wertheimer Minerva Center for Cognitive Studies, Faculty of Industrial Engineering and Management, Technion–Israel Institute of Technology, Haifa 32000, Israel. E-mail: yeldad@tx.technion.ac.il

[1] For example, when selecting between getting zero or tossing a coin for an equal chance to win or lose $10, the loss of $10 would loom larger than the gain, and therefore people would avoid the coin toss.

2002; Sokol-Hessner et al., 2009; Tom et al., 2007; Tversky & Kahneman, 1992; Wedell & Böckenholt, 1994). However, these studies did not use the choice paradigm ascribed by Kahneman and Tversky (1979), but rather measured the maximum amount an individual would be willing to pay to secure an option, or used an accept–reject format. Perhaps more important, recent studies of the choice paradigm examining the very example employed by Kahneman and Tversky (i.e., a symmetric bet of *x*, .50; −*x*, .50) have found no evidence of loss aversion in decisions under risk (Battalio, Kagel, & Jiranyakul, 1990; Birnbaum & Bahra, 2007; Ert & Erev, 2008; Koritzky & Yechiam, 2010; Yechiam & Ert, 2011) and in experiential decisions under uncertainty (e.g., Erev, Ert, & Yechiam, 2008; Koritzky & Yechiam, 2010; Yechiam & Ert, 2007). The fact that loss aversion is not reliably exhibited in monetary choices was noted in a review of the literature by Rozin and Royzman (2001, p. 306), who concluded,

> Although we are convinced of the general validity of loss aversion, and the prospect function that describes and predicts it, we confess that the phenomenon is only realizable in some frameworks. In particular, strict loss and gain of money does not reliably demonstrate loss aversion.

To address these inconsistent findings, the current review aims to examine whether an asymmetry in decision weight implied by loss aversion is indeed a necessary condition for the extant behavioral and physiological phenomena attributed to losses. We propose an alternative model for the effect of losses based on attention. Under this model losses have a distinct effect on attention but do not lead to an asymmetry in subjective value (i.e., losses are not given more subjective weight than gains). We begin by describing the line of research that provided the impetus for the current attentional model and then present the model and its predictions. Next, in the main part of the article, we review the extant literature concerning the effect of losses on performance, decision making, brain activation, and behavioral consistency; and examine its alignment with the assumption of loss aversion and the attentional model.

An Attention-Based View of Losses

We developed the attentional model following recent findings on physiological responses to losses in experience-based choice tasks (Hochman et al., 2010; Hochman & Yechiam, 2011; Yechiam & Telpaz, 2011b). Several experiments have demonstrated that when making repeated choices and receiving feedback, individuals simultaneously show no loss aversion but at the same time exhibit increased arousal following losses compared to gains.

For example, Hochman and Yechiam (2011) examined two experience-based choice tasks with the following payoff structure:

Problem 1. Mixed (gains and losses) condition

S: 50% to win 1, 50% to lose 1 [P(S) = 0.54]

R: 50% to win 2, 50% to lose 2

Problem 1. Gain condition

S: 50% to win 2, 50% to win 4 [P(S) = 0.49]

R: 50% to win 1, 50% to win 5

In each condition, participants were asked to repeatedly select between two alternatives, S (safe) and R (risky), presented as two blank buttons on a computer screen.[2] Throughout the task, the unique autonomic responses following gains versus losses were assessed by measuring the participants' pupil diameter (see Granholm & Steinhauer, 2004) and heart rate. In a previous pupillometry study, Satterthwaite et al. (2007) administered a task in which the participants guessed which of two cards would turn up higher and received positive or negative monetary feedback according to their success. The results showed that pupil diameter became larger following losses. Hochman and Yechiam (2011) used this measure in the context of a decision task.

As typical in experience-based tasks, participants were not informed about the probabilities and outcomes of their selections but rather had to learn them by repeatedly experiencing their outcomes. There were 60 selections in each condition. Each led to the presentation of the obtained outcome from the current selection. For example, in the mixed condition (i.e., an incentive structure including both gains and losses) one button produced either −1 or +1 with equal probability and the other produced −2 or +2. Final amounts were converted to money at the end of the experiment.

Since the mixed condition includes symmetric gains and losses, loss aversion implies that people will avoid option R in order to evade the higher possible losses. However, in contrast to this prediction, Hochman and Yechiam (2011) found that participants were indifferent between the two alternatives, and exhibited no risk aversion in the mixed condition. The learning curves for the different conditions appear in Figure 1A. By contrast, autonomic arousal, as indexed by pupil diameter and heart rate, was significantly higher in response to losses than to equivalent gains (the pupil diameter results are presented in Figures 1B and 1C). Moreover, no significant correlations were found between the participants' arousal following losses compared to gains and their tendency to avoid the risky option in any of the physiological indices. This pattern of results suggests that although an asymmetry in response to losses versus gains was observed in autonomic arousal, it was not associated with loss aversion.

In a different experiment, Hochman et al. (2010) replicated these findings in a choice task that enabled participants to avoid losses (the safe alternative was a fixed low-magnitude positive payoff). Participants selected between gaining 1 with certainty and a risky option producing 8.5, 6, 3.5, −1.5, −4, or −6.5 with equal probability (of 1/6). The mean proportion of selections from the safe alternative was 0.48, implying that participants did not avoid the option that incurred losses. Still, increased peripheral vasoconstriction (a sympathetic measure of arousal; Gayton, 1977) was observed following losses compared to gains.

We have found the observed gap between experiential behavior and autonomic arousal puzzling given the fact that arousal was

[2] Despite the different tasks used to elicit risk preferences, behavioral measures of risk-taking behavior tend to be quite uniform. In the vast majority of reported studies, risk taking was operationalized as the rate of choice of (or preference for) the option associated with higher outcome variability. We follow this convention in our review as well. The term *P*(*S*) will denote the mean proportion of selections from the low variance (i.e., safe) alternative.

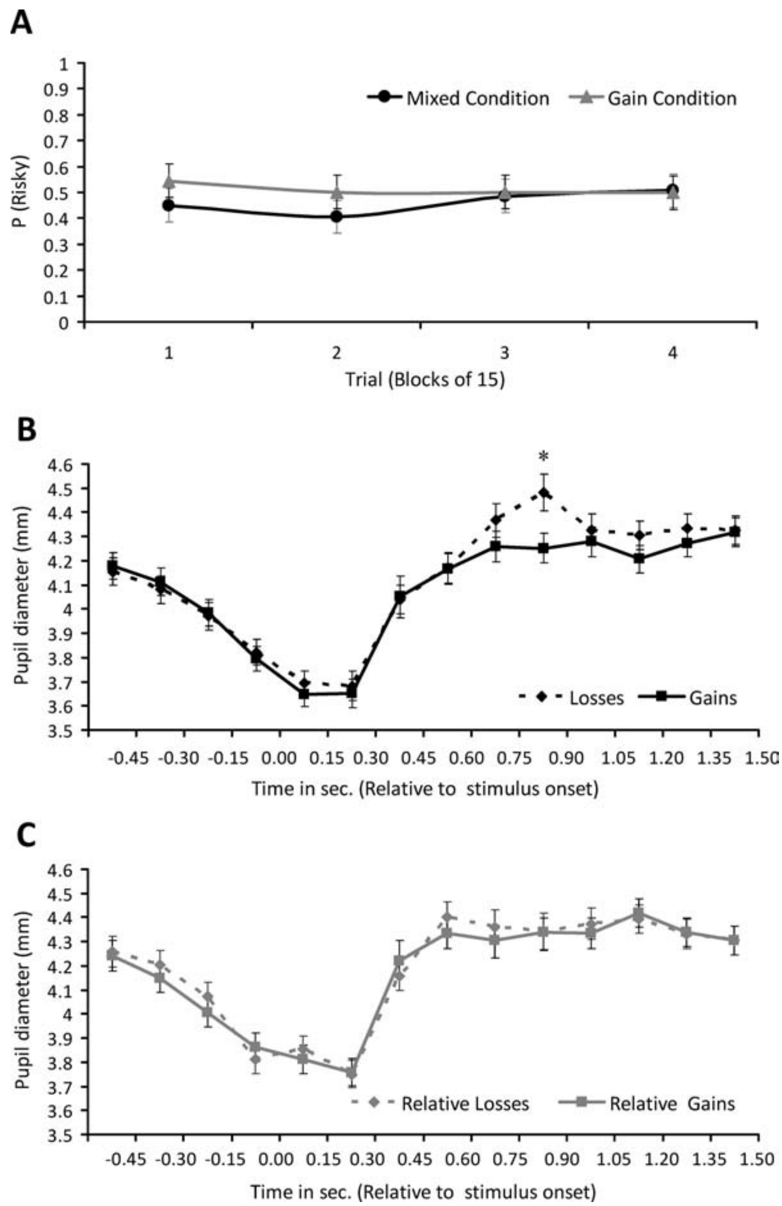

Figure 1. The effect of losses on risk taking and pupil diameter. (A) Proportion of participants selecting the risky option in the mixed and gain conditions (blocks of 15 trials). (B) Average pupil diameter in the mixed condition as a function of the event type (gain vs. loss). (C) Average pupil diameter in the gain condition as a function of the event type (relative gain vs. relative loss). Time 0 denotes the outcome presentation onset. The error bars indicate the standard error, and significant differences are marked by an asterisk. Data from "Loss Aversion in the Eye and in the Heart: The Autonomic Nervous System's Responses to Losses," by G. Hochman and E. Yechiam, 2011, *Journal of Behavioral Decision Making, 24,* 143–146. Copyright 2011 by John Wiley & Sons.

previously posited to be a mechanism guiding behavior (Damasio, 1994; Loewenstein, Weber, Hsee, & Welch, 2001) and was found to be correlated with behavioral responses to incentives (Heitz, Schrock, Payne, & Engle, 2008; Richter & Gendolla, 2009). As described next, our interpretation of this gap is that although losses have no effect on the subjective weighting of outcomes, they do lead to an attentional orienting response, as evidenced by the increase in arousal.

The Attentional Model

Our framework is based on the notion that losses lead to more attention than equivalent gains (cf. Taylor, 1991), but this model is further developed with respect to implications to risk taking and performance level. Specifically, we posit an attentional model where attention is not specific to the loss component of the task. Following the theories of Kahneman (1973) and Kanfer and Ackerman (1989), attention is considered as a limited resource allocated to task-related and unrelated events. Increased on-task attention implies greater likelihood of responding in a manner that is more consistent with the task reinforcement structure and less random (Kanfer, 1996). The main arguments of the current model are therefore as follows:

1. Losses lead to an orienting response characterized by a momentary increase in arousal, which directs attention to on-task events.

2. The heightened attention increases the sensitivity to the task reinforcements and decreases the likelihood of random responses. This effect is not specific to losses and impacts other task reinforcements as well.

Therefore, whereas the prevailing approach suggests that losses directly affect the attractiveness of alternatives, our attentional model suggests that losses affect the decision whether to invest attention in the task, and if so, how much. In particular, losses that are experienced or potential losses that are described lead to an orienting response and facilitate an increase in the attention allocated to the task. This enhances the modulation of behavior by task-related outcomes and decreases the randomness of behavior. The Appendix summarizes this argument formally under Luce's (1959) choice rule.

It should be clarified that similar to classical theories of attention, an inverted U-shaped relation is assumed between the level of attention and task performance. As noted by Watchel (1967), "performance first improves (as irrelevant cues are excluded) and then gets worse (as relevant cues are also excluded)." (p. 421). A related effect in tasks requiring simultaneous performance of a primary and a secondary task is that heightened attention tends to deteriorate performance in the secondary task (Bahrick, Fitts, & Rankin, 1952; Easterbrook, 1959). Still, as the majority of the studies that have examined the effects of losses on performance avoided strong manipulations of attention (i.e., loss amounts were typically hypothetical or small to moderate) and administered relatively simple tasks, we mostly address the positive effect of losses on performance.

Predictions of the Attentional Model

The arguments of the present model suggest two distinct lines of predictions concerning the link between losses and task performance. These two classes of predictions depend on whether losses and gains are presented concurrently:

1. Gains and losses that are separately presented in different conditions. In this case, either one group of participants receives (probabilistic or riskless) gains and the other receives losses, or the same group of participants is exposed to gains and losses in temporally distant sessions. Since gains and losses are separated, an increase in task attention is predicted only in the loss condition, which leads to increased sensitivity to payoff (i.e., to the losses) in this condition. As a result, losses are predicted to modulate behavior more than gains. In line with this prediction, it has indeed been demonstrated that compared to pleasant outcomes, unpleasant events tend to evoke relatively more attention as well as stronger and longer lasting changes in mood and emotion (Baumeister et al., 2001; Rozin & Royzman, 2001; Taylor, 1991). It should be noted, however, that in these kinds of situations, a similar prediction is made by the prevailing assumption that losses increase the subjective weight of outcomes.

2. Gains and losses that are presented concurrently. When gains and losses are presented simultaneously or subsequently within a close time range, the effect of losses on attention is posited to be nonspecific to the losses that produced it. Consequently, and in contrast to the loss aversion assumption, losses are not assumed to be weighted differently from gains, and when gains and losses are equal in magnitude, no loss aversion is predicted to emerge. The behavioral effect of losses becomes apparent, though, where the alternatives differ in their expected value: Losses are predicted to lead to higher maximization rates, as they increase the sensitivity to the outcomes and lead to less random selection.[3] For the same reason, losses are also predicted to enhance consistency in choice behavior.

In both of these types of situations, increased autonomic arousal is expected following losses (compared with gains), autonomic arousal being the physiological hallmark of the orienting response (Graham & Clifton, 1966; Pribram & McGuinness, 1975). Importantly, in cases in which gains and losses are presented concurrently, increased arousal following losses is predicted even in the absence of loss aversion.

It should be noted that these two conditions (i.e., losses presented separately from or concurrently with gains) could be viewed as extreme cases varying along the temporal continuum of the intervals between losses and subsequent nonlosses. As in other orienting stimuli, the effect of losses on performance is considered to decay in time following their presentation (Porges, 1992). Specifically, the attentional orienting response is often accompanied by temporary disappearance or marked reduction of the brain's alpha waves (which are associated with cortical inhibition), and these two phenomena typically last less than 5 s (Andreassi, 2000; Shaw, 2003). Additionally, the orienting response increases sustained attention by means of two pathways: (a) a longer duration parasympathetic response (Porges, 1992) and (b) facilitatory and suppressive effects on the activity of the central nervous system, which can have a time course of several minutes (Samuels, 1959; Shaw, 2003, p. 147). Thus, losses in one trial are posited to affect performance in a subsequent trial, or even in a subsequent task, if the second task is administered in a close time range (for similar effects in a different domain, see Strayer & Kramer, 1994).[4]

An important variable that is assumed to moderate these effects of losses is outcome magnitude. Extremely large outcomes can lead to risk aversion (i.e., avoiding the option with the higher variance), thereby masking the symmetric sensitivity to gains and

[3] As noted above, although this is predicted for relatively simple decision tasks (see, e.g., Hinson, Jameson, & Whitney, 2003), increased attention may have adverse effects in complex tasks, such as those having time sharing requirements (Bahrick et al., 1952).

[4] An additional long-term effect of the orienting response involves behavioral reactions. Porges (1992) gave the example of a person leaning forward in her chair due to an orienting response. This behavior, which focuses attention on the task, can continue well after the initial couple of seconds of the acute orienting response.

losses. If one assumes varying weights to gains and losses (e.g., in the case of a gamble of the form (x, .50; $-x$, .50)), risk aversion can be wrongly interpreted as increased weight to losses compared to gains. Risk aversion at high stakes is conceptually different from loss aversion for two reasons: First, loss aversion is assumed to be independent of the stakes of the outcomes, as even low-risk incentives with symmetric gains and losses are assumed to be avoided (Kahneman & Tversky, 1979). Second, risk aversion at high stakes is well known to develop in the absence of losses as well, namely, in the gain domain (Fehr-Duda, Bruhin, Epper, & Schubert, 2010; Hogarth & Einhorn, 1990; Holt & Laury, 2002), and thus appears to be a separate phenomenon from loss aversion. It should be noted, though, that focusing only on very small losses may also lead to erroneous conclusions. Harinck, Van Dijk, Van Beest, and Mersmann (2007) suggested that such losses are much easier to discount and rationalize than large losses.

The Source of the Attentional Bias

An attentional bias in response to losses has been proposed in the past. Yet previous studies suggested that it is not an independent effect, but rather part of the compound phenomenon of the negativity bias, which also incorporates loss aversion (Denes-Raj & Epstein, 1994; Dunegan, 1993; Rozin & Royzman, 2001; Taylor, 1991). For instance, Dunegan (1993) suggested that whereas loss aversion is a manifestation of the negativity bias at a late stage of cognitive processing, losses also have an effect at earlier processing stages; specifically, they increase the reliance on deliberate and controlled cognitive processing.

The most well known explanation for the attentional bias of losses is the argument that in the real world, losses have more debilitative potential than gains; therefore in order to increase the chances of survival, an organism should be more attuned to losses than to gains (Rozin & Royzman, 2001; Taylor, 1991). An interesting alternative model can be proposed based on the decision by sampling theory of Stewart, Chater, and Brown (2006). This theory is based on the notion that stimuli are evaluated against a norm of their class (see Kahneman & Miller, 1986). Empirical studies in a variety of financial domains have shown that there are more small losses than large losses (e.g., in expenditures on parking, groceries) and more small gains than large gains (e.g., in bank deposits). However, the ratio of small losses to large losses is larger than the ratio of small gains to large gains. Thus, when evaluated against the norm of the class (of losses or of gains), losses are judged against a lower absolute reference point. Stewart et al. (2006) suggested that this leads to an asymmetry in the subjective value of gambles similar to the one proposed by Kahneman and Tversky (1979). Namely, "a loss of a given magnitude will have a higher relative rank than a gain of the same monetary amount" (Stewart et al., 2006, p. 7; see also Stewart, 2009). One could, however, suggest an attention-based interpretation of this theory, whereby arousal effects are determined by the value of an outcome compared to a standard. Accordingly, because losses are evaluated against a smaller reference point, they lead to greater arousal.

Under the current model (and differently from the accounts proposed by Rozin & Royzman, 2001; Stewart et al., 2006; and Taylor, 1991), although losses affect attention more than gains, the orienting response elicited by a loss does not necessarily give rise to increased subjective weight to that loss. Specifically, inhibitory mechanisms exist (cf. Bechara, Damasio, & Damasio, 2000; Critchley, Mathias, & Dolan, 2001) to prevent early attentional signals from directly affecting behavior in situations involving limited actual danger (e.g., when the outcomes are monetary). This gives rise to increased arousal in response to losses even if no behavioral loss aversion is exhibited.

Empirical Regularities of Losses

In the subsequent sections we review the literature concerning the effect of losses on behavioral and physiological variables and examine whether the findings conform to different models of losses. In the first section, we examine the asymmetric effect of losses on behavior in cases in which they are presented separately from gains; namely, whether losses drive behavior more than gains in these situations. The second section evaluates the asymmetric effect of losses in situations involving concurrent gains and losses (either in riskless decisions or in decisions under risk and uncertainty). The third section examines the effect of losses on maximization. The fourth section focuses on the effect of losses on autonomic arousal, cortical activation, and response time, and the final section addresses the effect of losses on behavioral consistency. This evaluation is followed by a note concerning the relation between the effects of losses and two well-known behavioral regularities: (a) the reflection effect, people's tendency to avoid risk in the gain domain and take risk in the loss domain (Kahneman & Tversky, 1979); and (b) the framing effect, the idea that manipulating the way information is presented affects the way in which people make decisions and judgments (Tversky & Kahneman, 1981). Throughout the article, three main theoretical frameworks concerning the effect of losses are evaluated: the prevailing loss aversion assumption, the attention-based model proposed here, and an assertion that losses have no unique effect at all and that there is complete symmetry in attention and decision responses to gains and losses (Ert & Erev, 2008; Farley & Fantino, 1978; Levy & Levy, 2002).

Loss Aversion in Separately Presented Gains and Losses

Performance. In tests of loss aversion in riskless choice, the individual faces either deterministic gains or losses following behavioral choices. The relative weight individuals ascribe to gains and losses has been a topic of interest for over 50 years. Early studies focused on task performance, where learning was facilitated by either punishing errors or reinforcing correct responses (e.g., Meyer & Offenbach, 1962; Miller, 1959; Penney, 1967; Penney & Lupton, 1961; Spence, 1966; Tindall & Ratliff, 1974). Although these studies have generally demonstrated a negativity bias, they used qualitatively dissimilar outcomes for punishments and reinforcements (e.g., a loud noise compared to food, respectively). Thus, these studies do not provide an accurate comparison between the effects of gains and losses (Magoon & Critchfield, 2008). A more direct comparison has been provided by later studies employing equal magnitude gains and losses. For example, Costantini and Hoving (1973) found that the development of response inhibition among second graders was faster under punishment (i.e., removing tokens for errors) than under reward (i.e., adding an equivalent amount of tokens for successes). Several studies have replicated this effect in adults using real monetary outcomes (e.g., Andreoni, Harbaugh, & Vesterlund, 2003; Dickinson, 2001; Pietras, Brandt, & Searcy, 2010). Similar findings were also observed when the same choice outcomes were framed as possible losses compared to possible equivalent gains (Ganzach & Karsahi, 1995; Ganzach, Weber, & Ben Or, 1997; Maheswaran & Meyers-Levy, 1990; Meyerowitz & Chaiken, 1987).

Although multiple studies demonstrated a negativity bias in separately presented losses, Higgins's (1997, 2000) influential theory of regulatory focus posited that the effect of losses is completely moderated by individual differences in promotion–prevention focus. This claim was demonstrated in several experiments that have found no effect of a positive–negative framing on performance (e.g., Grimm, Markman, Maddox, & Baldwin, 2008; Maddox, Baldwin, & Markman, 2006; Otto, Markman, Gureckis, & Love, 2010; Shah, Higgins, & Friedman, 1998). Still, at least in some of these experiments there was an effect of negative framing on performance at the beginning of the task (Maddox et al., 2006; Otto et al., 2010). For example, Maddox et al. (2006) used a classification task and examined accuracy under two feedback conditions. Participants in the positive-framed condition were told that they would be given the opportunity to obtain an entry into a drawing for $50 if they gained a certain number of points in the last block of the experiment. Participants in the negative-framed condition were given an entry into a drawing for $50 upon arrival to the laboratory but were informed that they would lose the entry if they failed to gain the same number of points in the last block. The negatively framed instructions had no effect over the entire task. However, in the first block of 48 trials, the proportion of participants reaching the criterion level in the negative-framed condition was about twice than in the positive-framed condition, regardless of individual differences in promotion–prevention.

The positive effect of losses on performance in riskless choices is typically explained by loss aversion in that participants give greater weight to losses and therefore select behavioral strategies that minimize them (e.g., "perform fast"; Meyerowitz & Chaiken, 1987; Rasmussen & Newland, 2008). However, an alternative explanation is that losses enhance on-task attention, which increases the modulation of behavior by task-related outcomes and decreases random responses.[5] The findings concerning the effect of losses on performance in different payoff conditions therefore do not clearly distinguish between predictions of the attention-allocation and loss aversion models. However, these findings do appear to reject the suggestion that the effect of gains and losses is completely symmetric (Ert & Erev, 2008; Farley & Fantino, 1978; Levy & Levy, 2002), as they clearly point out to a case in which losses have a marked effect.

Valuation of goods. Several economic phenomena involving riskless choices have been suggested to be due to loss aversion, most prominently the *endowment effect* (Kahneman, Knetsch, & Thaler, 1990) and *asymmetric price elasticity* (Hardie, Johnson, & Fader, 1993). The endowment effect is the tendency to evaluate goods more when you own them than when you do not own them (Kahneman et al., 1990). This can be interpreted by loss aversion in comparison to a status quo option (Kahneman et al., 1990): The act of losing the item pains more than the pleasure of obtaining it. Recently, however, various alternative explanations for the endowment effect have been proposed (for a review, see Rick, 2011), including the status quo bias (Gal, 2006), asymmetric information (Dupont & Lee, 2002), and the reluctance to trade (e.g., Beggan, 1992; Mackenzie, 1997) and to make a bad deal (e.g., Brown, 2005). The endowment effect may also be due to different processes involved in the construction of preferences when selling and buying (Carmon & Ariely, 2000; Johnson, Häubl, & Keinan, 2007). Asymmetric price elasticity refers to the finding that people cut back purchases following a price increase to a greater extent than they increase purchases following a price decrease (Hardie et al., 1993; Putler, 1992). This phenomenon also has alternative explanations (Hardie et al., 1993). Under the current attentional model, asymmetric price elasticity may emerge because it is embedded in a situation where (financial) losses are not concurrently presented with gains. Hence, the increased attention induced by losses only affects the response to these losses. Specifically, a price increase focuses consumers' attention on what they might lose from the purchase, whereas a price decrease focuses their attention on what they might gain out of it; consequentially, people are more sensitive to the change in the incentive structure in the loss frame condition (and this condition has a larger effect on their purchasing behavior).

Loss Aversion in Concurrently Presented Gains and Losses

Riskless choices. The sensitivity to gains and losses was also evaluated in studies of concurrent positive and negative reinforcements (Critchfield & Magoon, 2001; Magoon & Critchfield, 2008; Rasmussen & Newland, 2008; Ruddle, Bradshaw, & Szabadi, 1981; Ruddle, Bradshaw, Szabadi, & Foster, 1982). The typical paradigm used in these experiments simultaneously presents two types of reinforcement schedules from which participants need to select: one producing gains and the other eliminating losses. For example, in Magoon and Critchfield's (2008) study participants sat in front of a computer screen split into two areas. Their outcomes were contingent on clicking on a smaller target area within a certain time interval. Clicking in one area produced immediate monetary rewards (1.5 U.S. cent) following the designated response, whereas clicking in the other area canceled a loss of equal magnitude, which was delivered in the case of no response. Typically in these tasks the participants tend to frequently switch from one area to the other (Menlove, Moffitt, & Shimp, 1973).

The loss aversion model predicts faster learning of the correct response in the area leading to avoiding losses, relative to the area leading to gains. In contrast, the attention-based model implies that in this situation the effect of losses would be diffused to the temporally proximate gains, thus eliminating the asymmetry between gains and losses, and leading to similar learning rates in both areas.

In line with the predictions of the attentional model, the results from this line of research typically indicate loss neutrality. Namely, in most cases, negative and positive reinforcements yield similar learning rates (Critchfield & Magoon, 2001; Magoon & Critchfield, 2008; Ruddle et al., 1981, 1982; though for a different finding, see Rasmussen & Newland, 2008). Magoon and Critchfield (2008) suggested that "further research is needed to reconcile

[5] Under the attention-allocation model the emergence of the effect of losses on performance at the beginning of the task is due to high temporal proximity to the explicit presentation of losses.

this outcome with apparently robust findings in other literatures of superior behavior control by aversive events" (p. 1). Still, these discrepancies are explained by the attentional model of losses, exactly because this situation is different from the one studied in the negativity bias studies in that it involves concurrent gains and losses (in this case, under the attentional model losses enhance sensitivity to the overall reinforcement structures and not only to the loss component).

Decisions under risk and uncertainty. Kahneman and Tversky (1979) indicated that "most people find symmetric bets of the form (x, .50; $-x$, .50) distinctly unattractive" (p. 279), which implies that losses are given greater weight than gains even when gains and losses are presented concurrently. In their seminal study, this example involving symmetric gains and losses remained a hypothetical experiment. Although subsequent studies did demonstrate this phenomenon, their results are confounded by alternative explanations. For example, in several studies, the researchers employed accept–reject or willingness-to-pay paradigms, in which participants decide whether to shift from their current state (i.e., the status quo) to a state where they own a gamble involving losses and gains (see, e.g., Gneezy & Potters, 1997; Redelmeier & Tversky, 1992; Schmidt & Traub, 2002; Sokol-Hessner et al., 2009; Tom et al., 2007; Tversky & Kahneman, 1992; Wedell & Böckenholt, 1994). In these kinds of situations, the status quo bias (Samuelson & Zeckhauser, 1988) is expected to bias choices in the same direction as loss aversion (i.e., retaining the current situation implies rejecting the risky gamble or paying little for it). In other studies, the risky alternative was positively skewed; namely, it had higher gains and lower losses (e.g., Barron & Erev, 2003; Payne, Laughhunn, & Crum, 1980, 1981; Thaler, Tversky, Kahneman, & Schwartz, 1997; Tom et al., 2007). In these studies diminishing sensitivity to the distance from zero is likewise expected to bias choices in the direction of loss aversion (see review and analysis in Erev et al., 2008). Several recent studies sought to avoid these methodological problems by using either completely symmetric (0.5 probability) gains and losses or random gambles. Some of these studies used experiential tasks, where participants receive trial-to-trial feedback and learn from their experience to make subsequent choices. Others presented outcomes descriptively with no feedback. Because of the large difference between these two paradigms (as reviewed in Rakow & Newell, 2010), they are presented in different subsections. In two other subsections we review studies of complex dynamic tasks with nonstationary feedback and examine whether the effect of losses on risk taking is moderated by the situational context.

Experiential tasks. As noted above, in experiential tasks, decision makers are required to repeatedly select between options with no prior description concerning the outcomes and their probabilities. The only information available is the experience with the outcomes of previous selections (see, e.g., Barron & Erev, 2003). In this section we make a broad sweep of the literature concerning asymmetric effects of losses in this type of task.

A list of relevant studies appears in Table 1. This table includes all published studies that we identified using appropriate keywords and phrases that (a) employed the choice paradigm for studying the effect of losses on risk taking and (b) used choice alternatives with payoff distributions having equal expected value (studies with expected value differences are detailed in The Effect of Losses on Maximization section).[6] The studies of experiential tasks indicate no asymmetric effect for losses, as the average decision maker was indifferent between alternatives that incur losses and gains and alternatives that incur either losses or gains of lower magnitude or zero (e.g., Erev et al., 2008; Gehring & Willoughby, 2002; Glöckner & Hochman, 2011; Hochman & Yechiam, 2011; Silberberg et al., 2008; Yeung & Sanfey, 2004).[7] For example, an early empirical demonstration of such loss neutrality was recorded by Katz (1964), who administered the following choice problem:

Problem 2

S: 50% to win 1, 50% to lose 1 [P(S) = 0.49]

R: 50% to win 4, 50% to lose 4

In each trial, the participants were asked to guess which of two light bulbs (S or R) would turn on. The participants were not given further instructions. In reality, the two bulbs were equally likely to switch on. Guessing S was safer: The implied payoff was +1 if the guess was correct, and −1 otherwise. Guessing R was riskier: The

Table 1
Studies on the Effect of Losses on Risk Taking

Study	Loss aversion[a]
Experience	
Katz (1964)	No
Gehring & Willoughby (2002)	No
Yeung & Sanfey (2004)	No
Masaki et al. (2006)	No
Yechiam & Ert (2007)	No
Erev et al. (2008)	No
Silberberg et al. (2008)	No
Kamarajan et al. (2009)	No
Koritzky & Yechiam (2010)	No
Ert & Yechiam (2010)	No
Glöckner & Hochman (2011)	No
Hochman & Yechiam (2011)	No
Yechiam & Telpaz (2011a)	No
Description	
Battalio et al. (1990)	No
Thaler & Johnson (1990)	No
Brooks & Zank (2005)	Yes
Abdellaoui et al. (2007)[b]	Yes
Birnbaum & Bahra (2007)	No
Abdellaoui et al. (2008)[b]	Yes
Ert & Erev (2008)	No
Rabin & Weizsäcker (2009)[b]	Yes
Ert & Erev (2010)	No
Koritzky & Yechiam (2010)	No
Yechiam & Ert (2011)	No

Note. This table includes studies that examined the effect of losses using the choice paradigm with alternatives having symmetric expected values, that is, similar to the (x, .50; $-x$, .50) format. The studies are organized according to the decision task type: experience- versus description-based decisions.
[a] The rate of the high-variance option was significantly lower than 50%. [b] Hypothetical large amounts (exceeding $500).

[6] We included the study of Rabin and Weizsäcker (2009) in which there was a minor difference in expected value (less than 10% of the gamble's range).

[7] In these studies the likelihood of obtaining a gain or a loss was .50 in each choice trial. Hence, the results are not confounded by an order effect.

implied payoff was +4 if the guess was correct, and −4 otherwise. The results showed that participants were indifferent between the two options, with 0.49 choices of S. Similar experimental results were obtained with real monetary outcomes (Erev et al., 2008; Hochman & Yechiam, 2011; Yeung & Sanfey, 2004). These findings do not support the loss aversion model, because if one assumes larger weight to losses than to gains, then participants should avoid the alternative that produces larger losses in choosing among symmetric gain–loss gambles.

In more recent studies, another condition was added to this basic task (Erev et al., 2008; Ert & Erev, 2010; Ert & Yechiam, 2010; Hochman & Yechiam, 2011; Koritzky & Yechiam, 2010; Yechiam & Ert, 2007). By adding a constant to each payoff, a mixed domain condition (involving gains and losses) was compared with an all-gains domain (with high and low gains). This provides another test for loss aversion (proposed by Payne et al., 1980; Thaler et al., 1997): The loss aversion model predicts more risk taking in the gain domain, where the risky alternative does not produce losses, than in the mixed domain. To evaluate this prediction, Erev et al. (2008) examined the following choice problems:

Problem 3. Mixed (gains and losses) condition

S: Get 0 with certainty [P(S) = 0.48]

R: 50% to win 1,000, 50% to lose 1,000

Problem 3. Gain condition

S: Win 1,000 with certainty [P(S) = 0.70]

R: 50% to win 2,000, 50% to get 0

The two conditions were administered experientially, and participants were required to make 100 selections between two options presented as unmarked virtual buttons. Each selection yielded an outcome drawn from the corresponding payoff distribution. The amounts were converted to money at a rate of 1 Israeli shekel per 10,000 points, keeping the overall financial stakes small.

In the mixed problem, no loss aversion was found, as the participants did not avoid the risky alternative producing losses. Additionally, there was no decrease in risk taking with losses compared to the gain domain: In fact, significantly more S choices were observed in the gain than in the mixed domain (0.70 compared to 0.48). This rather surprising result was replicated in other experiments (e.g., Ert & Yechiam, 2010; Koritzky & Yechiam, 2010) and was also observed with an addition of noise around the zero point (Erev et al., 2008).

The interdomain pattern was explained by Erev et al. (2008) as due to asymmetry in the size of the outcomes rather than a direct effect of losses. Specifically, diminishing sensitivity (or an S-shaped value function) can lead to discounting the largest outcome of the risky alternative in the gain domain (the outcome of 2,000 is discounted at a greater rate than the outcome of 1,000), making the risky alternative less attractive. Follow-up experiments using lower outcomes (up to 10 tokens) indeed found no difference between the gain and mixed conditions (Erev et al., 2008; Hochman & Yechiam, 2011; Yechiam & Ert, 2007), consistent with the assumption of symmetric weighting of gains and losses. Moreover, an examination of the initial trials in these studies (see, e.g., Figure 1A) does not reveal an early negativity bias as noted above for riskless choices.

Descriptive tasks. In descriptive tasks, decision makers are presented with all the information about the options (in a format similar to that of Kahneman & Tversky, 1979) and are required to provide one choice. Some researchers using this paradigm focused on high-stakes hypothetical problems (Abdellaoui, Bleichrodt, & Haridon, 2008; Abdellaoui, Bleichrodt, & Paraschiv, 2007; Rabin & Weizsäcker, 2009). For example, consider the following problem from Rabin and Weizsäcker (2009):

Problem 4

S: Get 0 with certainty ("Not winning or losing anything") [P(S) = 0.77]

R: 50% to win $600, 50% to lose $500

The problem was presented in written form with actual dollars. The results showed that the participants avoided the risky alternative, and this was interpreted by Rabin and Weizsäcker as an indication of loss aversion. However, increased weighting of losses over gains is just one interpretation of the results. The other interpretation is that as monetary amounts are increased, risk aversion becomes more prominent (Hogarth & Einhorn, 1990; Holt & Laury, 2002).

This latter interpretation was confirmed by studies using lower stakes hypothetical payoffs, which did not find evidence of loss aversion in choices among descriptively presented gambles (Ert & Erev, 2008; Yechiam & Ert, 2011). For example, Yechiam and Ert (2011) administered the following hypothetical choice problem in a sample of 139 students:

Problem 5

S: Get 0 with certainty [P(S) = 0.51]

R: 50% to win 500, 50% to lose 500

Students were asked to treat the payoffs as representing outcomes in Israeli shekels (1 shekel = $0.24), which implies a much lower risk level than in Rabin and Weizsäcker's study (2009). In this case, the participants did not avoid the risky outcome that contained symmetric gains and losses, implying no loss aversion.

Findings showing no behavioral indication of loss aversion in small stakes were also reported in studies of description-based tasks where actual gains or losses were added or deducted from the participants' earning (Battalio et al., 1990; Birnbaum & Bahra, 2007; Ert & Erev, 2010; Rieskamp, 2008; Thaler & Johnson, 1990). For example, Battalio et al. (1990) examined 15 choice problems, including two of the form (0) or (x, 50%; $-x$, 50%), where x was either $10 or $20. Selection rates from the safe alternative were 0.40 and 0.57, respectively. Battalio et al. also replicated their findings in a nonsymmetric choice between (−$6, 70%; $14, 30%) versus (−$3, 70%; $7, 30%). The rate of selections from the safe alternative was 0.54 in a hypothetical setting and 0.38 in a real loss setting. In Birnbaum and Bahra (2007), the participants completed 21 lottery questions, including three that involved a choice between zero and a gamble offering an equal chance to win or lose $100. The rate of selections from this risky gamble was 0.52 across three items differing in phrasing (loss aversion was not revealed in any phrasing condition).

An exception is the study of Brooks and Zank (2005), who used a large battery of 96 lottery questions, requiring a choice between a safe alternative and a risky alternative incorporating an additional gain of £1 and an additional loss of £1. For example, some of the gambles had the form (x, 33%; 0, 33%; $-x$, 33%) versus ($x + 1$, 33%; 0, 33%; $-x - 1$, 33%), with the values for x ranging between £1 and £9. The average rate of selections from the safe alternative in their study was 0.63. Still, if this amounts to loss aversion, then it is indeed weak evidence for it, in terms of the departure from loss neutrality.

Recall also that loss aversion predicts that risk aversion will increase in mixed gambles (Payne et al., 1980). The results for descriptive decisions are similar to those reviewed above for experiential decisions: Actually, participants take more risk in mixed gambles than in all-gain gambles for high nominal outcomes (Birnbaum & Bahra, 2007; Ert & Yechiam, 2010; Koritzky & Yechiam, 2010; though no effect was found in Rabin & Weizsäcker, 2009), and this effect disappears for low nominal outcomes (Battalio et al., 1990; Brooks & Zank, 2005).

It therefore appears that loss aversion is not reliably exhibited in low-stakes descriptive gambles. Loss aversion does appear for hypothetical high-stakes descriptive gambles (e.g., Rabin & Weizsäcker, 2009), but in this case it is indistinguishable from risk aversion. Loss aversion is more easily distinguished from risk aversion in small to moderate amounts, as it implies that participants are risk averse even in this case. This prediction of Kahneman and Tversky's (1979) prospect theory does not appear to be empirically supported. As summarized in Table 1, for the most part only descriptive-based studies administering high stakes show evidence of loss aversion.

Somewhat similarly, studies using accept–reject or willingness-to-pay formats also focused primarily on large hypothetical outcomes, suggesting that their results could be due to risk aversion (Redelmeier & Tversky, 1992; Schmidt & Traub, 2002; Wedell & Böckenholt, 1994). The only study that explicitly compared the effect of payoff size on loss aversion using the willingness-to-pay paradigm is that of Harinck et al. (2007). Their findings showed that participants only began to indicate higher paying prices for losses exceeding €30, suggesting that the tendency to overprice losses is driven by risk aversion.[8]

Dynamic tasks. Most investigations of the effect of losses in decisions under risk and uncertainty focused on relatively simple nondynamic tasks. Very few studies examined the role of losses in more complex tasks. In Kuhnen and Knutson's (2005) study there were three fixed choice alternatives: a safe "bond" and an advantageous and a disadvantageous "stock," but the location of the advantageous and disadvantageous stock options was changed randomly every 10 trials. It was clearly indicated (on the experimental screen) that one option is the bond and the other two are the stocks. The choice outcomes were as follows:

Problem 6

Bond: Get 0 with certainty [P(S) = 0.46]

Stock: Advantageous: 50% to win 10, 25% to lose 10, 25% to get 0

Stock: Disadvantageous: 25% to win 10, 50% to lose 10, 25% to get 0

The participants were divided into naive subjects and individuals with some background in finance, economics, or statistics. Both groups of participants did not show a significant aversion to the risky stock and were statistically indifferent between the bond and stock options. Moreover, an analysis of errors did not reveal a bias favoring the loss-free bonds. A "risk seeking mistake" (RSM) was defined as the likelihood of the participant selecting a stock when the bond was the optimal choice, and a "risk aversion mistake" (RAM) was defined as the likelihood of selecting a bond when a stock was the optimal choice. The likelihood of these two errors was similar for the naive (RSM: 35%, RAM: 29%) and experienced (RSM: 26%, RAM = 23%) participants. Thus, the results indicated no asymmetric tendency to avoid losses in this problem. Interestingly, Kuhnen and Knutson (2005) argued that compared to Bayesian updating, the participants did not learn quickly enough to move to the risky advantageous option, thereby suggesting that they were loss averse. The problem with this conclusion is that people are known to deviate strongly from the predictions of Bayesian learning in experiential decision tasks (see, e.g., Biele, Rieskamp, & Gonzalez, 2009; Yechiam & Busemeyer, 2005). Therefore, the slow learning can be argued to simply represent nonoptimal adaptation. Additional studies of dynamic tasks were conducted by Biele, Erev, and Ert (2009); Rakow and Miler (2009); and Ben Zion, Erev, Haruvy, and Shavit (2010). In these studies as well the participants were found to exhibit no loss aversion.

Effects of context. As in the case of riskless choices (e.g., the endowment effect), economic studies of decisions under risk have proposed that loss aversion could explain a number of complex phenomena (Camerer, 2004). These include investors' tendency to hold losing stocks too much and sell winning stock too early (i.e., the disposition effect; M. Weber & Camerer, 1998), decisions concerning the duration of the workday (Camerer, Babcock, Loewenstein, & Thaler, 1997), and expenditure rates (Shea, 1995). However, instead of assuming an asymmetric weighting of losses, these phenomena could be explained by the reflection effect (as noted by Shea, 1995; M. Weber & Camerer, 1998). For instance, under the reflection effect, a stock broker is expected to take more risk by keeping the stock when it is losing. As is discussed below, the current model does not rule out the reflection effect, and the attentional effects of losses coexist with it.

Moreover, context effects can account for the inconsistency between these findings, which are assumed to support loss aversion, and the absence of reliable effects of losses on risk taking in laboratory studies. Ert and Erev (2008) espoused the view that in naturalistic situations losses serve as a signal that a person is about to be cheated or harmed. In their study they administered the following hypothetical choice question in the laboratory (replicating the problem used by Redelmeier & Tversky, 1992):

Problem 7

S: 0 with certainty [P(S) = 0.22]

R: 50% to win 2,000, 50% to lose 500 (EV = 750)

Most people chose the riskier option containing losses, which is also the advantageous option in this choice task. In another condition, Ert and Erev administered this same question by approach-

[8] The difference between the findings of Harinck et al. (2007) and the results of studies using the choice paradigm appears to be mostly in the amount where risk aversion surfaces with losses. For instance, as noted above, in Birnbaum and Bahra (2007) loss aversion was not exhibited for amounts as high as $100. This could be due to the fact that in the willingness-to-pay paradigm the status quo is not to have the gamble. As mentioned above, this can contribute to the tendency to avoid risk.

ing students casually in the faculty hallways. In this case, 48% of the students chose the low expected value (EV) option of 0. Interestingly, Ert and Erev also administered these two conditions in an accept–reject format similar to that used by Redelmeier and Tversky (1992). The results showed that the selection of the safe alternative in the laboratory setting was 45%, whereas in the corridor it increased to 68%. Thus, the context of being outside the laboratory intensified the tendency to avoid losses, as did the accept–reject format.

In conclusion, the findings reviewed in this section are not consistent with a simple asymmetric effect of gains and losses. It appears that a negativity bias is not exhibited when a task involving gains is performed concurrently with a task involving losses. Also, in decisions under risk and uncertainty losses are not reliably avoided. Even with high stakes, risks involving losses are not avoided to a greater extent than equivalent risks in the gain domain. The only case in which losses have an asymmetric effect on decision weights appears to be when the context warrants some sort of suspicion concerning the motivation of the experimenter.

One interpretation of this pattern is that the effect of losses and gains is completely symmetric (equal; e.g., as proposed by Levy & Levy, 2002). However, this interpretation is inconsistent with the findings reviewed in the previous section, showing an asymmetric effect of losses on performance when gains and losses are presented in separate conditions. Alternatively, the results of both sections can be accounted for by assuming an effect of losses on attention and performance, but no bias in the weight of losses compared to gains.

The Effect of Losses on Maximization

The "successful loser" effect (Bereby-Meyer & Erev, 1998; see also Denes-Raj & Epstein, 1994) is the finding that when choice alternatives differ in their expected value, losses lead to greater maximization. This effect of losses appears to emerge even in a situation where gains and losses are presented concurrently. The original paradigm used by Bereby-Meyer and Erev (1998) to demonstrate this pattern involved a prediction task with two virtual buttons of different color (red or blue). One of these colors was the "correct prediction" 70% of the time, and the other 30% (at random trials). The participants had 500 trials to learn to select the correct response. Three conditions were compared:

Problem 8: Gain condition

Correct: Win 4 with certainty [P(Correct) = 0.78]

Incorrect: Get 0 with certainty

Problem 8. Mixed condition

Correct: Win 2 with certainty [P(Correct) = 0.89]

Incorrect: Lose 2 with certainty

Problem 8. Loss condition

Correct: Win 0 with certainty [P(Correct) = 0.87]

Incorrect: Lose 4 with certainty

Points were converted into money that was added to an initial endowed amount. Bereby-Meyer and Erev found that participants converged to the correct response faster in the mixed and loss conditions compared to the gain condition, demonstrating that people learned to maximize better with loss outcomes (the difference between the mixed and loss domain was not significant). This effect was replicated by Erev, Bereby-Meyer, and Roth (1999; see also Haruvy & Erev, 2002), and a similar pattern was observed in simple games (Erev et al., 1999). The disparity between the gain and loss conditions was originally attributed to loss aversion (Bereby-Meyer & Erev, 1998), but it is also consistent with the attentional model of losses that predicts a general increase in payoff sensitivity in the conditions with losses, and therefore greater maximization.[9]

Recently, however, Yechiam and Ert (2007) demonstrated that the successful loser effect can lead people to make more advantageous selections even from an alternative producing losses. The following two choice problems were studied:

Problem 9. Gain condition

H: 50% to get 0, 50% to win 6 (EV = 3) [P(H) = 0.36]

M: 50% to win 1, 50% to win 4 (EV = 2.5) [P(M) = 0.28]

L: Win 2 with certainty [P(L) = 0.36]

Problem 9. Mixed condition

H: 50% to win 4, 50% to lose 2 (EV = 1) [P(H) = 0.52]

M: 50% to win 2, 50% to lose 1 (EV = 0.5) [P(M) = 0.31]

L: Get 0 with certainty [P(L) = 0.17]

Participants selected among the different alternatives by pressing virtual buttons and receiving feedback sampled from the associated payoff distributions (points were later converted to money). The three alternatives were labeled according to their expected value as H (High), M (Medium), and L (Low). Notice that the risky alternative H has the highest expected value, but it also produces the largest (absolute or relative) losses. A comparison of the gain and mixed conditions showed that participants maximized more in the mixed condition, in direct opposition to the prediction of loss aversion. This pattern of results is consistent with the attentional model of losses which posits that losses increase the sensitivity to task outcomes. Losses therefore increase the attractiveness of the advantageous alternative even if selecting it implies getting more losses. The effect in the mixed condition appears to reflect increased maximization rather than risk taking: In a second condition where the options were equal in their expected value (Yechiam & Ert, 2007), no preference for the risky alternative was found in the mixed condition.

One could still argue, though, that the positive effect of losses on performance in Yechiam and Ert (2007) was due to the smaller outcomes in the mixed condition, which might have made it easier to calculate the expected values. To account for this, Yechiam, Hochman, and Telpaz (2011) recently administered the following choice problem using a similar experience-based paradigm:

Problem 10. Gain condition

[9] A different effect of losses on maximization was found by Thaler et al. (1997) and replicated by Barron and Erev (2003). However, they used an asymmetric distribution where the gain–loss conditions were confounded with the nominal values of the payoffs, and therefore this effect can be explained by mere diminishing sensitivity (see review in Erev et al., 2008).

H: 50% to win 1, 50% to win 200 (EV = 100.5) [P(H) = 0.56]

L: Win 35 + N

Problem 10. Loss condition

H: 50% to lose 1, 50% to win 200 (EV = 99.5) [P(H) = 0.66]

L: Win 35 + N

where N is a noise factor randomly sampled from [−5, −4, −3, −2, −1, 0, 1, 2, 3, 4, 5]. In this choice task, as in Problem 9, the advantageous alternative (H) is the one that produces losses. Specifically, it produces a minor loss of 1 in the loss condition compared to a gain of 1 in the gain condition. According to the loss aversion model, people should perform worse in the loss condition (i.e., select H less) due to the increased weighting of losses compared to gains. This is also predicted by the expected utility theory assumption of dominance. In contrast, according to the attentional model, losses should increase the sensitivity to the different task payoffs, leading to more choices from H in the loss condition. This problem was administered to 57 participants (29 in the gain condition and 28 in the loss condition). The results showed that across 100 trials there were significantly more choices from the advantageous alternative in the loss condition—even though it was only the advantageous alternative that produced losses. This pattern can only be explained if one assumes that the effect of losses is not specific to the loss component but rather that it extends to the gain component as well, as postulated by the attentional model.

An alternative explanation for the potentially positive effect of losses on maximization was proposed by Slovic, Finucane, Peters, and MacGregor (2002), based on norm theory (Kahneman & Miller, 1986). According to this explanation, a gain-only option is compared against other gains experienced in the past and may appear as a mediocre instance of gain domain outcomes. The addition of a loss moves the outcome into a mixed loss–gain domain, and there—if the gain is much higher than the loss—it stands out when compared against other reference points of this domain. According to this account, positive effects of losses on maximization are produced by the availability of a contrast between the gamble's loss and gain outcomes and not by mere losses (see also a related explanation based on affective contrasts in Slovic et al., 2002). However, although this contrast-based explanation can account for the findings in Problem 10, it falls short of explaining the findings in Problem 8, which show that when a certain choice leads only to a loss (e.g., in the loss condition), this increases maximization. Furthermore, in Problem 9 there are two choice alternatives with contrasts (M and H), but the availability of losses leads people to select the more advantageous option of the two. Thus, even when losses are not contrasted with gains or when this effect is controlled for, they are still conducive to maximization. On a more general note, it seems that a contrast-based explanation cannot account for the asymmetric effect of separately presented losses (compared to gains) on performance, reviewed above in Loss Aversion in Separately Presented Gains and Losses. Still, although not providing sufficient conditions for the extant effects of losses, it may be that in some settings contrasting asymmetric gains and losses could increase the sensitivity to the payoff structure.

In further support of the attention-based explanation for the effect of losses on maximization, several studies have shown that the effect of losses in one task can carry over to a different task performed immediately after it (Chen & Corter, 2003; Dawson, Gilovich, & Regan, 2002; Fischer, Jonas, Frey, & Kastenmüller, 2008). For example, Dawson et al. (2002) found that after the presentation of a personal loss, participants made better decisions in the Wason Selection Task. This supports an attentional view of losses rather than a model assuming increased weighting of losses over gains or a contrast effect.

With respect to the specific attentional process underlying the impact of losses on maximization, Denes-Raj and Epstein (1994) proposed a two-system account whereby losses increase the reliance on the cognitive system associated with more deliberative and verbally mediated reasoning (i.e., System 2; see, e.g., Kahneman & Frederick, 2002). Activation of System 2 is assumed to enhance abstract logical analysis and reduce the rate of errors stemming from following concrete exemplars (Kirkpatrick & Epstein, 1992). To test whether losses increase the reliance on more abstract considerations, Denes-Raj and Epstein required participants to draw a bean from one of two bowls,[10] with the following decision outcomes:

Problem 11. Gain condition

Bowl A: 7 beans out of 100 provide a win of $1, the rest provide 0

Bowl B: 1 bean out of 10 provides a win of $1, the rest provide 0

Problem 11. Loss condition

Bowl A: 7 beans out of 100 provide a loss of $1, the rest provide 0

Bowl B: 1 bean out of 10 provides a loss of $1, the rest provide 0

Bowl A is clearly inferior to Bowl B in the gain condition and superior in the loss condition (e.g., 7/100 to get a dollar is a worse chance than 1/10). However, relying just on absolute numbers without processing their ratios can lead to an error (e.g., selecting 7/100 over 1/10 because 7 > 1 and 100 > 10). The results indicated that in the gain condition 31% of the participants selected the suboptimal bowl, whereas in the loss condition only 19% of the participants made this error. Denes-Raj and Epstein suggested that losses therefore facilitated the use of abstract logical reasoning. Possibly, this could explain the effect of losses on maximization in the previous experiments described above (e.g., Yechiam & Ert, 2007).

Still, Denes-Raj and Epstein's (1994) findings do not rule out the possibility that other cognitive mechanisms may be implicated in the attentional effect of losses. For instance, the presence of losses could have led to more prolonged encoding and processing of relevant task events. This is consistent with experimental evidence demonstrating that people invest more time in decision tasks with losses than in corresponding conditions with no losses (e.g., Xue et al., 2009; Yechiam & Telpaz, 2011a; see the next section). Increased response time is well known to have a positive effect on response accuracy (Wagenmakers, van der Maas, & Grasman, 2007; Wickelgren, 1977).

[10] The bowls were initially visible, but prior to drawing one the beans were scrambled, and the bowls were shielded from view such that the participants could select the bowl of their choice, but drew blindly from it. This protocol was clarified to the participants beforehand.

The Effect of Losses on Arousal

Autonomic arousal. As we mentioned in the introduction, the current attention-based model was formulated in view of findings showing a gap between autonomic arousal and behavioral responses following losses in experience-based tasks. In this section we therefore review research results concerning effects of losses on arousal in a broader range of paradigms.

The results of several studies that examined the effect of gains and losses in separate conditions (in riskless choice) have indicated increased autonomic arousal following losses compared to equivalent gains (see review in Vaish et al., 2008), as predicted by the attentional model. Asymmetric effects of losses have also been demonstrated for the activity of the anterior cingulate, a brain region considered to regulate the autonomic system (Frank, Woroch, & Curran, 2005; Yeung, Botvinick, & Cohen, 2004). Yet these findings could also be accounted for by loss aversion.

Sokol-Hessner et al. (2009) examined whether similar increases in arousal would occur in decisions under risk using descriptive gambles. The participants' task in their study was to decide whether to accept or reject a visually presented gamble with mixed gains and losses; and this was followed by presenting the choice outcomes. Sokol-Hessner et al.'s findings showed increased galvanic skin response (and by proxy, sympathetic arousal) following loss compared to gain outcomes. However, in this study as well, loss aversion was not observed for most participants, both under a condition where they were given the instructions in the absence of any context and under a condition where they were asked to think in the context of a portfolio choice (see Figures 1 and 2 in their study). Sokol-Hessner et al. did find a correlation between arousal following losses and prospect theory's loss aversion parameter, and this is inconsistent with the prediction of the attention-based model (and the findings of Hochman & Yechiam, 2011). However, the gambles used for the physiological measures in Sokol-Hessner et al. had expected values that were lower than zero (see Sokol-Hessner et al., 2009, Supplement, p. 1), which implies that rejecting these gambles was also the advantageous selection. Thus, the association between arousal and the tendency to avoid risk could be interpreted as due to maximization, and this is actually quite consistent with the attentional model.

The average pattern in Sokol-Hessner et al.'s study (2009) was similar to that obtained in experience-based tasks (e.g., Hochman et al., 2010; Hochman & Yechiam, 2011). Namely, losses led to more arousal than equivalent gains, whereas in subsequent behavioral choices participants did not exhibit loss aversion. Together, these findings point out a gap between the attentional effect of losses and their impact on decision weight.

Cortical activation. Perhaps the most well known effect of losses on brain activation is the error-related negativity (ERN) brain potential (Gehring & Willoughby, 2002; Holroyd & Coles, 2002; Yeung & Sanfey, 2004). The ERN is a frontocentral negativity in event-related cortical potentials appearing 100–200 ms poststimulus, which is considered to denote the outcomes of an early evaluation process that is especially attuned to potential threats (Hajcak & Foti, 2008). It is also considered a precursor of autonomic responses (Dywan, Mathewson, Choma, Rosenfeld, & Segalowitz, 2008), which have a similar role in rapid harnessing of resources to address potentially dangerous or beneficial environmental stimuli.

Originally, an increased ERN was found after errors compared to successful responses (Falkenstein, Hohnsbein, Hoormann, & Blanke, 1991; Gehring, Goss, Coles, Meyer, & Donchin, 1993). Subsequently, an increase in feedback-related ERN (fERN) was found 200–300 ms after experiencing losses (compared to equivalent gains), even when losses did not imply errors (Gehring & Willoughby, 2002; Masaki, Takeuchi, Gehring, Takasawa, & Yamazaki, 2006; Nieuwenhuis, Yeung, Holroyd, Schurger, & Cohen, 2004; Yeung & Sanfey, 2004). This suggests sensitivity to losses in this early evaluation process.

Yet a review of the literature on the fERN reveals that as in autonomic arousal, increased fERN in response to losses occurs without behavioral indications of loss aversion. In one of the first studies examining this rapid cortical response in the context of monetary decisions, Gehring and Willoughby (2002) administered an experiential choice task involving the following two alternatives:

Problem 12

S: 50% to win 5, 50% to lose 5 [P(S) = 0.42]

R: 50% to win 25, 50% to lose 25

Losses and gains were presented by predesignated colors (red or green). The association of the color with the sign of the payoff (gain or loss) was counterbalanced such that for half the participants losses were denoted by red and for the other half they were denoted by green. This ensured that the results would not be driven by differences in the stimulus presentation. The participants exhibited a larger negative polarity 265 ms following the presentation of losses compared to gains. The activation was centered in the anterior cingulate cortex, an area considered to regulate sympathetic autonomic activation, as well as cognitive functions such as reward anticipation, affective reaction, and decision making (Critchley, Tang, Glaser, Butterworth, & Dolan, 2005; Luu & Posner, 2003). This was interpreted by Gehring and Willoughby as evidence of loss sensitive cortical processes that directly contribute to the asymmetry in the subjective value of gains and losses.

However, the participants in Gehring and Willoughby's (2002) study did not favor the safe alternative and exhibited loss neutrality. In the context of the current review, a methodological problem in this experiment is that participants did not experience real losses, since they quickly learned that only the gains, and not the losses, influenced their total earnings. Nonetheless, the negatively biased fERN occurring simultaneously with no behavioral loss aversion was replicated in subsequent studies that controlled for this problem (Kamarajan et al., 2009; Masaki et al., 2006; Yeung & Sanfey, 2004). Furthermore, at the individual level as well, these studies showed no interindividual correlation between the magnitude of the fERN and the selection of the loss-producing alternative (Fein & Chang, 2008; Kamarajan et al., 2009; Masaki et al., 2006).

An interesting feature of these studies is that the difference between brain responses to losses and gains was retained even after many repetitions of the task. Sailer et al. (2007) conducted a functional magnetic resonance imaging study that sheds light on this pattern. Sailer et al. examined a dynamic experiential task in which the order of gains and losses produced by each of the alternatives was a prefixed series, so that participants could learn to move to the correct alternative. Their results showed that, as found previously (Breiter, Aharon, Kahneman, Dale, & Shizgal, 2001; Kringelbach & Rolls, 2004; Tom et al., 2007), some cortical regions responded more to losses, and others to gains. However, they also found that whereas the response to gains tended to diminish as the participants gained proficiency, the response to losses remained invariant, suggesting that the increased sensitivity to losses in brain activation remained even after repeatedly experiencing them.

The co-occurrence of neural activation following losses with no behavioral loss aversion in studies examining the fERN (e.g., Gehring & Willoughby, 2002; Yeung & Sanfey, 2004) suggests that although losses are reacted to with greater early processing efforts, this is not necessarily translated to increased weighting of these losses. Similarly, the analyses of individual differences in the fERN studies seem to be consistent with the findings of Hochman and Yechiam (2011) and show no direct association between the extent of the asymmetry in cortical activation (in response to losses vs. gains) and the degree of loss aversion.

Reaction time. Several studies have found an increase in response times in the loss domain compared to the gain domain (Porcelli & Delgado, 2009; Xue et al., 2009; Yechiam & Telpaz, 2011a, 2011b), and more generally in the face of negative versus positive stimuli (Derryberry, 1991; Leppänen, Tenhunen, & Hietanen, 2003). In contrast, no such difference in response time was found when gains and losses were produced by the same choice alternative (Preuschoff, Bossaerts, & Quartz, 2006), even if an increased fERN following losses was observed (Fujiwara, Tobler, Taira, Iijima, & Tsutsui, 2009; Masaki et al., 2006).

Although this complex relation between reaction times and gains and losses cannot be reconciled by the loss aversion model, it does support the attention-based model. Namely, if we assume that reaction time represents an extended attentional component rather than the extent of the acute orienting response (Porges, 1992), this can explain why losses lead to greater response time relative to gains in a separate condition. However, when losses are concurrently presented with gains, this attentional effect is carried over to other outcomes, thus eliminating the asymmetry.

The Effect of Losses on Behavioral Consistency

Recently, a novel effect of losses on the consistency of behavioral choices was observed (e.g., Baucells & Villasis, 2010; Vlaev, Chater, & Stewart, 2009; Weller, Levin, & Denburg, 2011). For example, in Vlaev et al. (2009), a battery of gain and loss domain prospects was presented as two identical web-based surveys, with the second survey administered 3 months after the first. The test–retest reliability of the proportion of risky selections was only significant for the loss-framed prospects.

Loss aversion can account for this effect if one assumes that important and significant events lead to greater behavioral consistency (Judd & Krosnick, 1989). Thus, if the subjective significance of losses is larger than that of gains, people should take risk more consistently with losses (Weller et al., 2011). Our attentional model also predicts enhanced consistency in risk taking with losses because it posits that people's responses to risk with losses are less random, and therefore more reliable. However, this pattern is predicted to emerge simultaneously with no behavioral loss aversion.

A study conducted by Yechiam and Telpaz (2011a) enabled us to examine this latter prediction. In this study 130 participants performed two experiential decision tasks in two sessions that were administered 6 weeks apart:

Problem 13. Mixed condition

S: Get 0 with certainty [P(S) = 0.57]

R: 50% to win 200, 50% to lose 200

Problem 13. Gain condition

S: Win 200 with certainty [P(S) = 0.66]

R: 50% to win 400, 50% to get 0

Problem 13. Loss condition

S: Lose 200 with certainty [P(S) = 0.59]

R: 50% to lose 400, 50% to get 0

The study included a mixed condition with symmetric gains and losses, which can be used to evaluate whether the effect of losses on behavioral consistency is contingent on loss aversion. The results showed that in general the participants were slightly risk averse (since the proportion of selecting the risky option was lower than 50% in all three conditions). Still, the fact that the same pattern was found in the mixed and gain conditions suggests that this risk aversion was not affected by losses. To explore the effect of losses on behavioral consistency, Yechiam and Telpaz calculated the test–retest reliability for each choice task. This analysis showed that behavioral consistency was much higher with losses (mixed domain task: $r = .36$, $p < .01$; loss task: $r = .26$, $p < .01$; gain task: $r = .12$; $p = .16$), thus replicating previous findings (e.g., Vlaev et al., 2009) even in the absence of behavioral loss aversion. These results indicate that attentional effects of losses provide sufficient conditions for the effect of losses on behavioral consistency. Yechiam and Telpaz also found that the response time in the conditions with losses partly mediated their effect on behavioral consistency. Individuals who had longer response times in the conditions with losses also had higher consistency between tasks. This suggests that the effect of losses on consistency is partly due to participants spending more time encoding and processing task-related information when it includes losses.

Another interesting finding in Yechiam and Telpaz's (2011a) study is that the correlation between risk taking in the laboratory task and a self-report measure of risk taking (the Domain-Specific Risk-Taking Scale; E. U. Weber, Blais, & Betz, 2002) was only significant in the conditions that included losses. This suggests that losses also increase the external validity of decision tasks and that this effect as well is not contingent on loss aversion. Indeed, many of the decision tasks used for assessing individual differences that have been shown to possess high external validity, such as the Iowa Gambling Task (Bechara, Damasio, Damasio, & Anderson, 1994) and its variants (e.g., Kerr & Zelazo, 2004; Lane, Cherek, Pietras, & Tcheremissine, 2004), and the Balloon Analog Risk Task (Lejuez et al., 2003; Wallsten, Pleskac, & Lejuez, 2005), include frequent losses.

A Note About the Reflection Effect and the Framing Effect

In this final section we discuss two of the most well known effects of losses, the reflection effect and the framing effect (Kahneman & Tversky, 1979; Tversky & Kahneman, 1981), and their relation to the findings reviewed above. For the reflection effect, consider the following example presented by Tversky and Kahneman (1981):

> Problem 14. Gain condition
>
> S: Win 240 with certainty [P(S) = 0.84]
>
> R: 25% to win 1,000, 75% to get 0
>
> Problem 14. Loss condition
>
> S: Lose 750 with certainty [P(S) = 0.13]
>
> R: 75% to lose 1,000, 25% to get 0

In this choice problem, the participants show risk aversion in the gain domain and risk seeking in the loss domain (see also Kahneman & Tversky, 1979). These findings appear to be robust and were also replicated in experiential decisions (Ert & Yechiam, 2010; E. U. Weber, Shafir, & Blais, 2004).

In a similar vein, Kahneman and Tversky (1979) originally demonstrated the framing effect (the effect of the form by which information is presented on judgments and decisions) in variants of Problem 14, by presenting the same outcomes as losses or gains taken from an initial endowed amount. A famous example of this framing effect is the "Asian disease problem" (Tversky & Kahneman, 1981), where the outcomes are presented as lives that are lost or saved following the adoption of a certain treatment program. In this problem as well, the participants exhibited risk aversion in the gain domain and risk seeking in the loss domain (Tversky & Kahneman, 1981). A recent meta-analysis of 150 studies showed that this pattern of responses is reliable (Kühberger, 1998).

Some authors have suggested that the reflection and framing effects are a result of loss aversion (e.g., Eysenck, 2004, p. 351; Santos & Lakshminarayanan, 2008). However, Tversky and Kahneman's (1981, p. 454) explanation of these effects rests on two other properties of prospect theory: (a) The S shape value function, which implies diminishing sensitivity to large gains and large losses, and (b) the underweighting of moderate to high probabilities. Indeed, these two properties provide sufficient conditions for the reflection effect, even if one assumes no loss aversion. In contrast, loss aversion, at least as defined by Kahneman and Tversky (1979), is not a sufficient condition for the reflection effect (because small and large outcomes are multiplied by the same amount).[11]

Although the reflection effect and related framing effects were explicated by factors that are not related to a negativity bias (see reviews in Fagley, 1993; Kühberger, 1998; Levin, Schneider, & Gaeth, 1998; Wakker, Köbberling, & Schwieren, 2007), the current attentional model does predict differences in attention and performance between the loss and gain domains that occur simultaneously with these effects. In line with this, De Martino, Harrison, Knafo, Bird, and Dolan (2008) found that risks presented as losses led to more autonomic arousal than risks presented as choices among gains (as denoted by increased galvanic skin response) even while the participants exhibited the classic reflection effect. Similarly, in Porcelli and Delgado (2009) participants' reaction times were longer with losses while exhibiting the reflection effect.

Conclusions

Under a loss aversion interpretation of the negativity bias, the metaphor that can be used to understand the effect of losses is that of tilted scales, where the subjective weight of losses is larger than the weight of gains. By contrast, under attentional models of the negativity bias, the metaphor to portray the effect of losses is that of an attention sign. The core assumptions of the current attentional model are that losses enhance on-task attention and that this increases the sensitivity to task reinforcements. This increased sensitivity is global, as it impacts all available outcomes and is not specific to the loss component. In this review we have shown that the proposed attentional model captures many of the diverse effects of losses. Moreover, we have highlighted several diagnostic cases (i.e., cases in which the two models provide contrasting predictions) and demonstrated how the findings generally support the attention-based model, and not the loss aversion model.

The findings of studies on riskless choices appear to be consistent with the loss aversion model (Baumeister et al., 2001; Rozin & Royzman, 2001; Vaish et al., 2008) in showing an asymmetry between the (strong) avoidance of negative outcomes and the (weaker) approach to positive ones. However, loss aversion also implies an avoidance of (or an aversion to) risky outcomes producing symmetric gains and losses. This latter prediction was not reliably confirmed in small to moderate outcomes (see Table 1). The apparent discrepancy is well explained by the attentional model, which posits that losses increase on-task attention and the sensitivity to task payoffs, while not leading to an asymmetry in the weight of gains and losses when these are presented in temporal proximity. In support of this explanation, even in riskless decisions, under concurrent schedules of reinforcement people do not exhibit loss aversion (e.g., Magoon & Critchfield, 2008; Ruddle et al., 1981). The only case in which risk aversion is reliably increased with losses seems to be in naturalistic situations where losses signal potential danger (Ert & Erev, 2008).

Also, consistent with both the attention-allocation and loss aversion models, losses were found to lead to increased arousal, as indicated by classic autonomic measures (e.g., Satterthwaite et al., 2007) as well as brain-evoked potentials (Gehring & Willoughby, 2002; Kamarajan et al., 2009; Masaki et al., 2006; Yeung & Sanfey, 2004) and response latencies (Porcelli & Delgado, 2009; Xue et al., 2009). Under a loss aversion interpretation, this delineates the general increase in processing efforts due to the enhanced subjective weight of losses. In contrast, under the attentional model these effects are the result of a more intense orienting response brought about by losses. Hence, under the attentional model increased arousal and cortical activation following losses are expected even in situations where no behavioral loss aversion is exhibited. We have proposed the attention-based model on the basis of findings in experience-based tasks that have demonstrated effects of losses on arousal even with no behavioral loss aversion (e.g., Hochman et al., 2010; Hochman & Yechiam, 2011). Our review of the literature revealed similar data in a study of decisions under risk (Sokol-Hessner et al., 2009) and in a variety of studies

[11] In Problem 13, one could argue that the reflection effect is driven by "loss avoidance," which could be defined as a tendency to select the option that reduces the likelihood of losing. However, the reflection effect was also found for unavoidable losses (e.g., Rabin & Weizsäcker, 2009).

of frontal cortical activation (e.g., Gehring & Willoughby, 2002; Yeung & Sanfey, 2004). Increased rapid cortical response was found following losses compared to gains in an extensive area of the frontal cortex, even while the participants did not avoid the risky alternative producing symmetric high gains and losses that served as stimuli for this brain activation.

At the individual level as well, most studies have found no reliable association between the level of arousal and cortical activation following losses (compared to gains) and the tendency to avoid them when they are accompanied by equivalent gains (e.g., Hochman & Yechiam, 2011; Kamarajan et al., 2009; Masaki et al., 2006; Yeung & Sanfey, 2004). An exception is Sokol-Hessner et al.'s (2009) finding of a positive correlation between galvanic skin response following losses and the behavioral sensitivity to losses. However, because in this study the outcomes were not symmetric in terms of their expected value, this association can also be interpreted as denoting a link between arousal following losses and the degree of maximization.

The effect of losses on autonomic arousal also has implications for an interesting set of findings in the field of affective forecasting. Kermer, Driver-Linn, Wilson, and Gilbert (2006) demonstrated that when predicting the effect of losses and gains on subjective well-being, people tended to inflate the impact of losses. However, after experiencing actual losses and gains in a mixed gamble, this asymmetry disappeared (see also Andrade & Iyer, 2009). This gap may be explained by the attentional model because affective predictions are associated with arousal responses (cf. Loewenstein & Lerner, 2003). Possibly, the enhanced orienting response incurred by losses is wrongly interpreted by individuals as being in correlation with the subjective impact of the stimulus.

We also contrasted the predictions of the loss aversion and attentional models concerning maximization. According to the attention-based model, the presence of losses leads to greater sensitivity to the difference between outcomes, resulting in higher maximization rates. In contrast, the loss aversion model predicts this effect only when the advantageous alternative does not include the highest losses. In support for the attention-allocation model, a positive effect of losses on maximization was found even when the highest losses were produced by the advantageous alternative (Yechiam & Ert, 2007; Yechiam et al., 2011). Moreover, the positive effects of losses on performance were found to be carried over to a subsequently performed task (e.g., Chen & Corter, 2003; Fischer et al., 2008). Such carry-over effects cannot be predicted by a model assuming that losses simply increase the weight of certain outcomes (i.e., only losses).

Finally, losses were found to lead to increased consistency in risk-taking behavior (e.g., Baucells & Villasis, 2010). This was previously interpreted as a result of the increased subjective weight of losses compared to gains (Weller et al., 2011). However, as predicted by the attentional model, the effect of losses on behavioral consistency was recently observed even in the absence of loss aversion (Yechiam & Telpaz, 2011a).

Several findings in attention research may provide important insights into the mechanisms by which the attentional orienting response to losses can cause changes in performance and behavioral consistency. First, increased attention leads to greater focusing, which enhances the ability to ignore irrelevant stimuli (Kahneman, 1973; Kanfer & Ackerman, 1989). Second, with increased attention, more time is allocated to encoding and processing of relevant events (Kahneman, 1973). Third, increased attention leads to a stronger reliance on controlled rather than automatic processes (Schneider & Shiffrin, 1977), which promotes abstract logical reasoning (Denes-Raj & Epstein, 1994; Kahneman & Frederick, 2002). Although the majority of the reviewed articles did not examine the role of specific attentional processes in the effect of losses on task performance, the existing findings suggest that more than one process is involved (as previously proposed by Taylor, 1991). For instance, losses were found to increase response times (e.g., Yechiam & Telpaz, 2011a) and to reduce the rate of concrete reasoning errors (Denes-Raj & Epstein, 1994).

Attentional effects similar to those of losses may be implicated in the response to negative information concerning persons and events. In marketing, attentional effects may result from negative product information. For instance, the so-called blemishing effect is the finding that a weak negative feature in a particular product improves its attractiveness (Ein-Gar, Shiv, & Tormala, 2012). In a similar vein, messages discussing the disadvantages as well as the advantages of a particular claim or product were found to be more persuasive than one-sided messages (Etgar & Goodwin, 1982; Golden & Alpert, 1987; Kamins, Brand, Hoeke, & Moe, 1989). Negative features of the situation may capture attention (in a similar way to negative personal consequences), and this may improve the ability to recognize a valuable product. Processes of social evaluation could be affected in a similar way. For instance, experiments using simulated interviews with job candidates have indicated that when a generally favorable candidate has some small negative feature (e.g., he or she spills coffee), this can actually improve the candidate's evaluation (Beauvois & Cambon, 1997; Helmreich, Aronson, & Lefan, 1970; Nisbett & Bellows, 1977). Although this phenomenon has been previously interpreted as due to an increase in the ability to empathize with the candidate, it can also be due to increased attention. Similar attentional processes may also be implicated in the selection of romantic partners (Rebellon & Manasse, 2004). Of course, the generalization of the attentional model's prediction from negative outcomes to negative information is speculative and should be further examined.

Limitations of the current model include the fact that it does not address the situation involving repeated punishments known as the "learned helplessness" condition (Seligman, 1975; Seligman & Maier, 1967), which has been posited to emerge with financial penalties as well (Rudski, Lischner, & Albert, 1999). Some experimental evidence suggests that people put in less attention when exposed to unavoidable losses than unavoidable gains (Alloy & Abramson, 1979; Rudski et al., 1999). The attention-based model might be extended to include this set of findings. However, this would require adding a third proposition asserting that when recurring choices between alternatives all lead to similar losses, people develop a sense that allocating attention to the task is futile and tend to invest less attention in the task. Additional evidence needs to be collected in order to substantiate this argument.

A second line of situations that received only minor coverage in the present review involves high-stakes real losses. As far as we know, the only relevant studies of loss aversion in monetary decisions used high-stakes hypothetical payoffs (e.g., Abdellaoui et al., 2007; Rabin & Weizsäcker, 2009). Yet note that regardless of whether hypothetical or real payoffs are used, when high-stakes losses are part of a risky prospect, the predictions of the loss aversion model are not differentiated from those of risk aversion.

The current article also briefly addressed some of the complex economic phenomena that were previously attributed to loss aversion (see reviews in Camerer, 2004; Rick, 2011). As noted above, perhaps the most famous of these phenomena is the endowment effect, that is, the finding that people indicate higher selling prices than buying prices (Kahneman et al., 1990). As there are several equally plausible explanations for this effect (Rick, 2011), the current review focused on simpler tasks in which it was possible to clearly test alternative theories concerning the effect of losses.

A more general limitation is that we addressed studies conducted in the past and did not test ad hoc predictions. Although this is an inherent limitation with reviews of this type, it is interesting to consider ad hoc predictions of the attention-based model. Specifically, whereas most of the reviewed studies focused on positive effects of losses on performance, the attention-based model predicts that losses also have negative effects under certain conditions. Various theories of attention assert that if an individual is already investing a very high level of attention, then additional attention can be detrimental to performance (i.e., the famous Yerkes–Dodson rule; Kahneman, 1973; Watchel, 1967; Yerkes & Dodson, 1908). This implies that at high levels of attention, presenting losses will have a negative effect on performance.

One way of studying this is by examining the interaction between losses and the effect of drugs that are known to elevate attention and arousal, such as methylphenidate (see, e.g., Hink, Fenton, Tinkleberg, Pfefferbaum, & Kopell, 1978). A crossover interaction is expected such that at high dosage, losses will have negative effects on performance. An alternative avenue of research is by using complex and engaging tasks and providing very high incentives, so that people spontaneously invest their highest attention to the task. It is predicted that differently from the rather monotonic tasks used in the experimental literature and reviewed here, in this setting losses would have positive effects on arousal but negative effects on performance. A similar phenomenon, though in a different area, is the negative effect of difficult goals on performance in complex and dynamic tasks, such as air traffic control simulation (Earley, Connolly, & Lee, 1989; Kanfer & Akerman, 1989). Similarly to losses, difficult goals increase task attention (Gellatly & Meyer, 1992), and this probably has a positive effect on performance, but only in tasks where attention level is low. A related prediction concerns individuals who spontaneously invest their attention in the task. For these individuals the effect of losses on performance should be lower than for others, and in extreme cases they could be negatively affected by losses. Finally, if a high-load task is administered simultaneously with a secondary task, then the presence of losses in the primary task is expected to reduce performance in the secondary task, as found for other manipulations of attention (see, e.g., Bahrick et al., 1952).

A more novel paradigm for future studies examining the attentional model of losses involves the interaction between various predisposition factors and actual behavior. In particular, psychological theories often describe an association between a certain personality trait and a certain behavioral tendency. Since losses are assumed to affect behavioral consistency via increased attention and reduced random response, our model predicts that losses should facilitate the association between predispositions and behavior. For example, several personality theories predict that individuals with low tonic (i.e., baseline) arousal have greater propensity to take risk (Eysenck, 1967; Gray, 1987; Zuckerman, 1990), as low-arousal individuals are assumed to require more environmental stimulation. Although the negative association between tonic arousal and risk taking was demonstrated in some studies (e.g., Gatzke-Kopp, Raine, Loeber, Stouthamer-Loeber, & Steinhauer, 2002), the attention-based model suggests that this association should be stronger for loss-incurring risks, even in the absence of behavioral loss aversion. Thus, losses are expected to be an important factor modulating the expression of behavioral traits.

Final Remarks

As noted at the onset of this article, the most common explanation for the attention-grabbing effect of losses involves the fact that they signal potential danger to the organism (Peeters & Czapinski, 1990; Rozin & Royzman, 2001; Taylor, 1991). The idea is that a small penalty, such as the sight of a snake or a spider, serves as a predictor of an imminent larger penalty (Öhman, Flykt, & Esteves, 2001). This explanation suggests an asymmetry in the basic ecological significance of losses and gains. A complementary explanation that does not assume this asymmetry implicates the fact that natural defense mechanisms often signal the existence of resources. For example, plants that have edible leaves tend to protect themselves with thorns and spines to a greater extent than plants with leaves having no nutritional value (Esau, 1965). Similarly, in a given species of deer, animals with greater body mass and fat levels tend to grow larger antlers (Scribner, Smith, & Johns, 1989). In human culture as well, high potential costs are very often associated with high potential gains in barter situations and in security systems. Consequentially, in some settings losses and threats may signal greater resources and potential opportunities, and not only substantial dangers. In these contexts, it might be evolutionarily adaptive to attend to situations involving losses in order to identify cases where such opportunities could be exploited. This suggests that keeping alert and focused in situations involving losses may be an adaptive strategy, even without assuming a basic asymmetry in the survival value of losses and gains. In keeping with this notion, in the present review we have demonstrated that losses lead to increased arousal, performance, and behavioral consistency, even in the absence of loss aversion.

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Appendix

A Formal Account of the Attention-Based Model

The assumption that losses decrease the likelihood of random responses can be modeled with Luce's (1959) choice rule, under which the probability of selecting alternatives is a function of their expectancies, representing the outcomes predicted upon selecting them, and random noise:

$$P[j] = \frac{e^{\theta \cdot E_j}}{\sum_j e^{\theta \cdot E_j}}. \qquad \text{(A1)}$$

The probability (P) of selecting an alternative j is assumed to be a function of the distance between its expectancy (E_j) and the expectancy of other available alternatives, but also to be affected by random noise. The parameter θ controls the sensitivity of the choice probabilities to the expectancies. Setting θ to 0 produces random guessing, whereas as θ increases, the likelihood of basing one's behavior on the expectancies increases. The prediction of the attention-allocation model is that θ would be larger for tasks involving losses than for equivalent tasks with no losses.

Thus, for example, the prediction of a negativity bias in separately presented losses compared to gains is implied by having θ larger in a task with losses, therefore leading to more sensitivity to payoff in this task. Similarly, the prediction of greater maximization with losses is implied by having θ larger in decision tasks that include losses (i.e., a loss or a mixed domain task compared to a gain domain task). Finally, the prediction of no loss aversion in concurrently presented gains and losses is implied by having θ constant within a mixed domain task.

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