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Losses as Ecological Guides: Minor losses lead to maximization and not to avoidance

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Abstract

Losses are commonly thought to result in a neuropsychological avoidance response. We suggest that losses also provide ecological guidance by increasing focus on the task at hand, and that this effect may override the avoidance response. This prediction was tested in a series of studies. In Study 1a we found that minor losses did not lead to an avoidance response. Instead, they guided participants to make advantageous choices (in terms of expected value) and to avoid disadvantageous choices. Moreover, losses were associated with less switching between options after the first block of exploration. In Study 1b we found that this effect was not simply a by-product of the increase in visual contrast with losses. In Study 1c we found that the effect of losses did not emerge when alternatives did not differ in their expected value but only in their risk level. In Study 2 we investigated the autonomic arousal dynamics associated with this behavioral pattern via pupillometric responses. The results showed increased pupil diameter following losses compared to gains. However, this increase was not associated with a tendency to avoid losses, but rather with a tendency to select more advantageously. These findings suggest that attention and reasoning processes induced by losses can out-weigh the influence of affective processes leading to avoidance.

Keywords: attention; performance; loss aversion; loss attention;

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Material losses are believed to serve as *avoidance signals* which deter people from interacting with objects and/or situations that can reduce their chances of survival (Rozin & Royzman, 2001). This view is consistent with "loss aversion", the notion that losses are given more subjective weight than gains (Kanhnman & Tverksy, 1979). Specifically, loss aversion studies (e.g., Tversky & Kahneman, 1992; Sokol-Hessner et al., 2009; Glöckner & Pachur, 2012; see review in Rick, 2011) suggest that a loss is given a subjective weight of 1.5 to 2.5 times the weight of an equivalent gain, implying that losses seriously bias decision making to avoid the choice option which has yielded them. Kahneman and Tversky (1979) further argued that the avoidance response is mediated by an affective process: "The aggravation that one experiences in losing a sum of money appears to be greater than the pleasure associated with gaining the same amount" (p. 279). This view that losses result in an affective avoidance response, has been supported by findings showing increased autonomic arousal in response to losses (Satterthwaite, et al., 2007; Sokol-Hessner et al., 2009). We contend that the arousal following losses is a marker of increased attention rather than an affective reaction. Hence, losses leads to *ecological guidance* rather than avoidance; losses lead to increased focusing on the task at hand which under certain circumstances (see review in Yechiam & Hochman, 2013a) improves the sensitivity to the task incentive structure.

Our approach is supported by recent reviews showing that loss aversion only emerges in limited situations, such as with extremely high outcomes or in cases where the status quo involves avoiding losses (Yechiam & Hochman, 2013a; Ert & Erev, 2013). By contrast, relatively small or repetitive losses do not lead to loss aversion (e.g., Ert & Erev, 2008, 2013; Yechiam & Hochman, 2013a). Previously, it has been suggested that unlike larger losses, small losses are underweighted compared to small gains (Harinck et al., 2007). Alternatively, we propose that when the stakes are low, the role of losses as ecological guides is not counter-balanced by negative affective responses, and is therefore most pertinent. Hence, we argue that small losses do have an important role manifested in increased task attention and performance (Yechiam & Hochman, 2013a, b). In line with this notion, it was found that a small loss can lead to greater expected-value (EV) maximization (Denes-Raj & Epstein, 1994, Bereby-Meyer & Erev, 1998; Yechiam & Hochman, 2013b) and improved performance in a dual-task setting (Yechiam & Hochman, 2014). For example, Yechiam and Hochman (2013b) presented a repeated choice between a gain of 35 tokens with certainty and a riskier but more advantageous lottery offering a 50-50 chance to get 200 or 1 tokens in the gain condition and 200 or -1 tokens in the loss condition. As predicted, more selections from the risky lottery were observed in the loss condition, even though it was the very alternative that produced the losses.

Nevertheless, it could be argued that rather than increasing maximization, losses simply increased risk taking. Alternatively, it could be that the contrast between stimuli in the loss condition (i.e., the "+" and "-" signs) rather than the loss itself draws more attention. Thus, the first goal of the present research was to juxtapose the prediction of the loss avoidance and ecological guidance approach while testing these possible alternative interpretations, (i.e., whether losses affect risk taking, or whether the increase in attention results merely from the visual contrast). The second goal was to examine the psychological significance of the increased arousal induced by losses in this setting. Under the ecological guidance approach, the elevated autonomic arousal following losses marks the extent of the orienting response leading to an attentional investment, and should therefore be correlated with increased maximization. This prediction has not been explored before, since previous research examining physiological arousal in response to losses has focused on alternatives with similar expected values (e.g., Satterthwaite, et al., 2007; Sokol-Hessner et al., 2009; Hochman & Yechiam, 2011).

In a series of studies, we focused on an advantageous alternative (in terms of its EV) that is also accompanied by minor losses. Under a loss aversion explanation, even a small loss is likely to be unpleasant and deter people from selecting an advantageous alternative, thereby biasing their decision. Still, it has been previously suggested that the behavioral outcomes of the avoidance response to losses may not be straightforward. According to the affect heuristic (Slovic et al., 2002), while a small loss constitutes an avoidance signal, when the same option produces a small loss and a larger gain this leads to a more positive affective response for that gain (because it seems more attractive when compared to the loss). Alternatively, under our ecological-guidance approach a loss improves task focusing and therefore guides behavior to the best option (given one’s cognitive limitations). Therefore, if a small loss is yielded by a favorable alternative, this alternative should be selected more often; but if a loss is produced by an unfavorable alternative, it should be selected less often. Study 1 was designed to evaluate these behavioral predictions of the avoidance-signal and ecological-guidance approaches, while addressing alternative explanations such as a visual contrast effect (Study 1b) and an effect of losses on risk taking (Study 1c). In Study 2 we examined the arousal dynamics associated with the behavioral effects of losses. Specifically, we tested whether arousal following a loss is associated with an avoidance response or with increased sensitivity to the incentive structure.

Study 1a: Selection between options with asymmetric expected values

In this study, the participants were required to perform a repeated decision making task in two conditions. In one condition, the task included minor gains, and in the other it included minor losses, as follows:

Gain condition

L: Get 1 or 60 + ε (equal odds) [EV = 30.5]

M: Get 50 + ε [EV = 50]

H: Get 1 or 200 + ε (equal odds) [EV = 100.5]

Loss condition

L: Get -1 or 60 + ε (equal odds) [EV = 29.5]

M: Get 50 + ε [EV = 50]

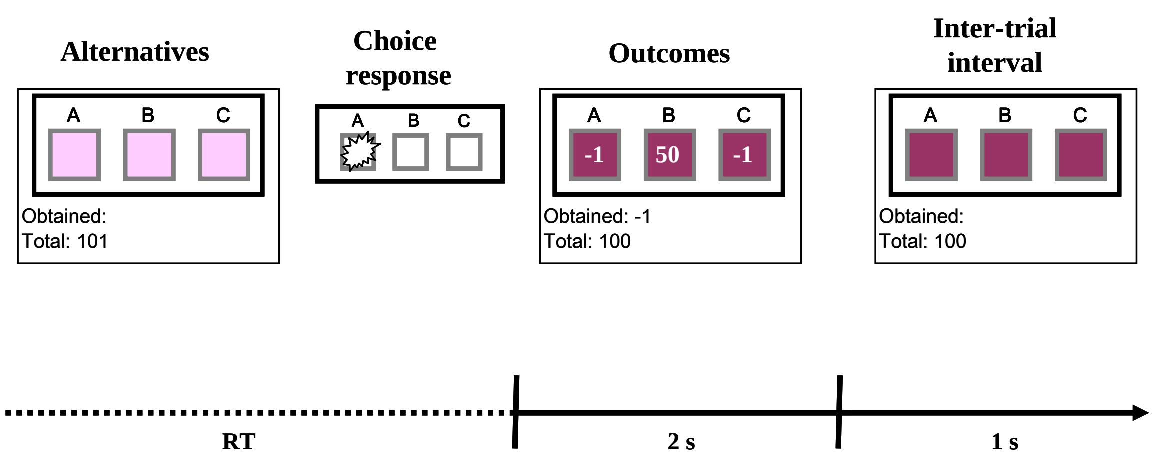
H: Get -1 or 200 + ε (equal odds) [EV = 99.5]

Each trial involved a choice between three alternatives (L, M, and H) that produced monetary outcomes. A random noise factor ε (an integer between -5 and 5) was added to decrease the transparency of the task. Under our ecological guidance framework losses were expected to increase selections from the High-EV alternative (H) but decrease selections from the Low-EV alternative (L). By contrast, a loss aversion explanation implies that losses would lead to more selections from the Medium-EV alternative (M), since it does not include losses. Finally, the affect heuristic implies more selections from both H and L in the Loss condition, since both options become more attractive with the addition of a contrast.

Method

Participants. Ninety-four Technion undergraduates (47 men and 47 female) took part in the experimental study. They were randomly allocated to the Gain and Loss condition (n = 48, 46, respectively). The participants earned a fixed fee of NIS 20 as well as a performance-based stipend.

Figure 1: An illustration of stimulus events in the experimental task. In Study 1a at the beginning of each trial three buttons were presented on the screen (Alternatives A, B, C). The participants had to choose one of the buttons. Each selection was followed by a presentation of the obtained and foregone payoff on the selected and unselected alternatives for 2 seconds. After a 1 second interval the next trial began. Following each choice response the total payoff counter was updated. In this example the participant selected the left button and lost 1 point.



Task and procedure. The experimental task involved making 150 repeated selections between three choice options that appeared as virtual buttons, labeled only as A, B, and C (See Figure 1). Selections were performed using a standard computer mouse. Upon pressing a button with the mouse, the image of the button changed to a "pressed" form. The participants received no prior information about the payoff distributions or the number of trials. The allocation of alternatives L, M, H to buttons A, B, C was randomized for each participant, but was kept constant throughout the 150 trials. Each choice was followed by a realization of the selected alternative, which was randomly drawn from the relevant distributions described above. Two types of feedback immediately followed each choice: (1) The basic payoff for the chosen and unchosen alternative, which appeared on each button for two seconds during which the participants could not respond, and (2) an accumulating payoff counter, which was displayed constantly. Importantly, forgone payoffs (i.e., the payoffs from the unchosen alternatives) were presented to ensure that after the initial exploration stage, participants learn that H is the alternative with the high expected value.

Participants in both conditions received the following written instructions: “In this experiment you will perform a decision making task. Your basic payoff is NIS 20. Additionally, you will earn NIS 1 for every 1,000 game points. In the presented window you will immediately see three buttons, A, B, and C. Your task is to select between buttons by pressing them. You can press a button several times repeatedly (as much as you wish) or switch between buttons (as you wish). The payment for your selection will appear on the button you have chosen and under the two buttons. Also, in each trial you will be able to see the results from the unselected button on the button you did not press. Your accumulating payoff will appear at the bottom of the screen. Please notice that the outcome obtained after each selection is only affected by the last selection and not by your previous choices (there is no dependency between rounds).”

Analysis. To analyze the data, the choice in each trial was ranked ordered according to the EV of the alternative (L = 1, M = 2, H = 3), creating a single Maximization score which served as the dependent variable. The data was analyzed in blocks of 25 trials. Hence, the sampling distribution of the Maximization score within each block was approximately normal.

Results

Figure 2 presents the proportion of selections from the different choice alternatives in the two experimental conditions. As can be seen from the figure, the Loss condition was conducive to more choices from H (the advantageous option) but fewer choices from L, even though both alternatives were accompanied by losses. The Maximization scores were submitted to a mixed analysis of variance with trial block as a within-subject factor and condition as a between-subject factor. The findings showed that in addition to the effect of block ($F (5, 460) = 37.65, p < .001$), there was a significant effect of condition ($F(1, 92) = 11.14, p = .001$), with higher maximization in the Loss than in the Gain condition. There was also a significant interaction of block by condition ($F(5, 460) = 3.75, p = .01$). Post-hoc t-tests with Bonferroni corrections showed that the positive effect of losses on maximization was significant for all trial blocks expect for the very first block (blocks 2-4, $p \leq 0.01$; blocks 5-6, $p < 0.05$).

Figure 2: Study 1a results. Selection from the three choice alternatives (High, Medium, and Low expected-value options) as a function of task condition (Gain vs. Loss) and experience in six blocks of 25 trials. Error terms denote the standard error in each between-subject condition.

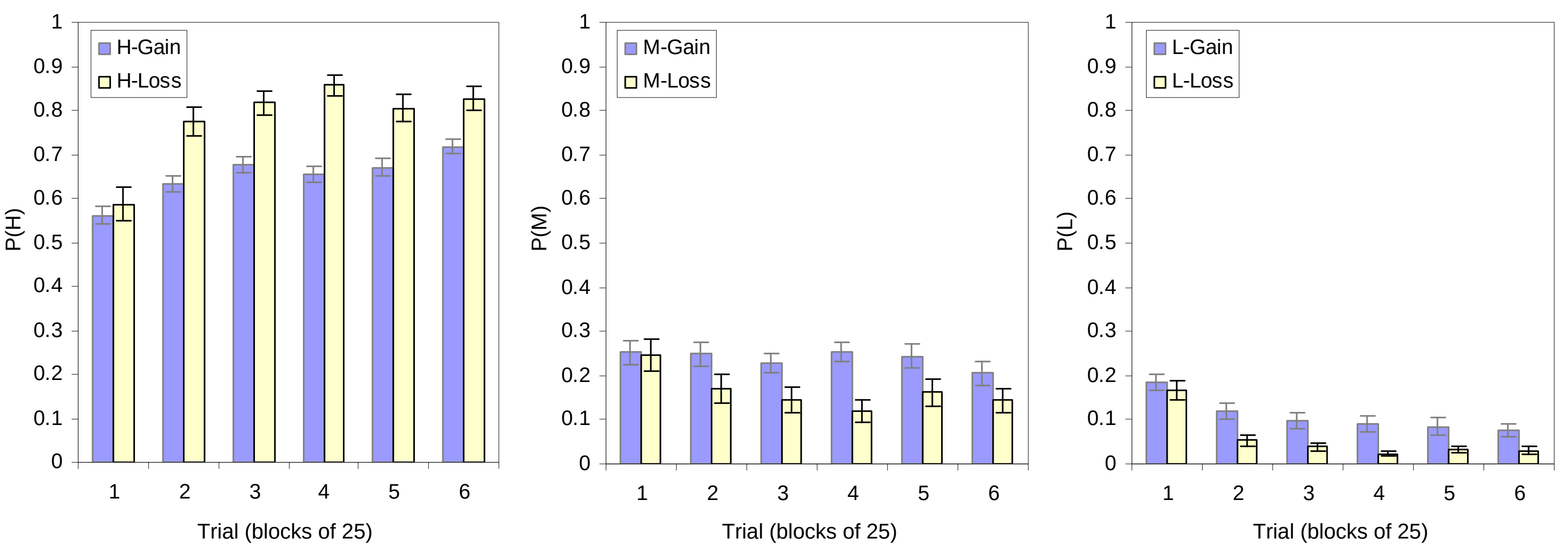
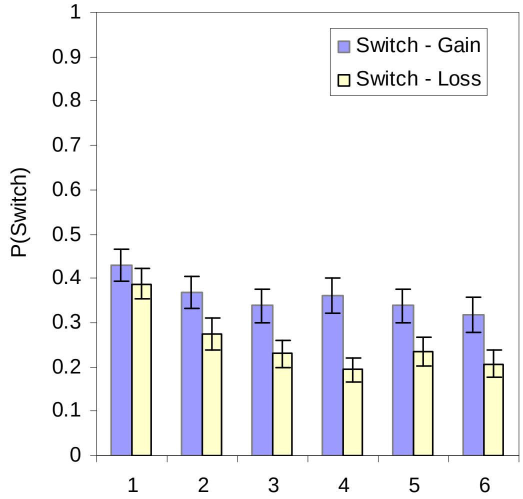


Figure 3: Study 1a results. Switching rate (P(switch) in a given trial) as a function of task condition (Gain vs. Loss) and experience. Error terms denote the standard error.



We next separately examined the H option, which in the Loss condition is advantageous albeit producing losses. An ANOVA for the rate of H selections in each trial block showed that the main effect of condition was significant ($F(1,92) = 9.01$, $p = .003$), with more choices from H in the Loss condition. Additionally, there was a significant block by condition interaction ($F(5,460) = 4.09$, $p = 0.005$). Post-hoc t-tests with Bonferroni corrections revealed that the effect of condition was significant in most blocks (with the exception of blocks 1 and 6).

We further analyzed the proportion of disadvantageous L choices from those trials where H was not selected (P (L | Not H). This analysis produced some missing values in blocks where H was selected in all trials (23% of all trial blocks), leaving only 53 participants with data from all trial blocks. The results again showed a significant main effect of condition ($F(1,51) = 5.52$, $p = .02$), with fewer participants who did not select H opting for L (the poorest EV alternative) in the Loss condition. We also reran this analysis for each half of the task (collapsed across 3 blocks), which lowers the rate of missing cases (to 11%). The results replicated the significant effect of condition ($F(1,73) = 10.33$, $p = 0.002$). Thus, while losses increased the rate of H selections, they also decreased the rate of L selections.

Interestingly, however, the effect of losses was only manifested in the second block of trials (a similar finding was also observed in Yechiam & Hochman, 2013b). To clarify this pattern, we examined participants' rate of choice switching in the different blocks of trials (see Figure 3). As can be seen, losses led to more focusing and less switching. An ANOVA showed that in addition to the reduced switching as a function of trial block ($F(5, 460) = 9.93$, $p < .001$), there was a main effect of condition ($F(1, 92) = 6.53$, $p = .01$). While there was no interaction between condition and trial block, in the first block where choice switching was at its peak, the effect of losses on choice switching seemed to be weaker ($p = 0.40$ compared to 0.007 for the remaining blocks). Thus, it appears that losses affected the participants' strategy as well, mitigating unnecessary choice switching after an initial period of exploration.

Study 1b: The effect of visual contrast

We next examined whether the loss component is necessary in order to obtain a positive effect on maximization, or if this positive effect is merely an artifact caused by the increased perceptual contrast between the small loss and the remaining gain stimuli (which does not exist in the gain condition). To examine the latter possibility, we replicated the gain condition from Study 1a, and compared it to a new gain condition, in which the small gain was presented in a different color. Thus, we were able to examine if increasing the visual contrast in the gain domain will result in higher maximization.

Method

Participants. Eighty-five Technion undergraduates (42 men and 43 female) took part in the experimental study. They were randomly allocated to the Control and Visual-Contrast condition (n = 41, 44, respectively). The participants earned a fixed fee of NIS 20 as well as a performance-based stipend.

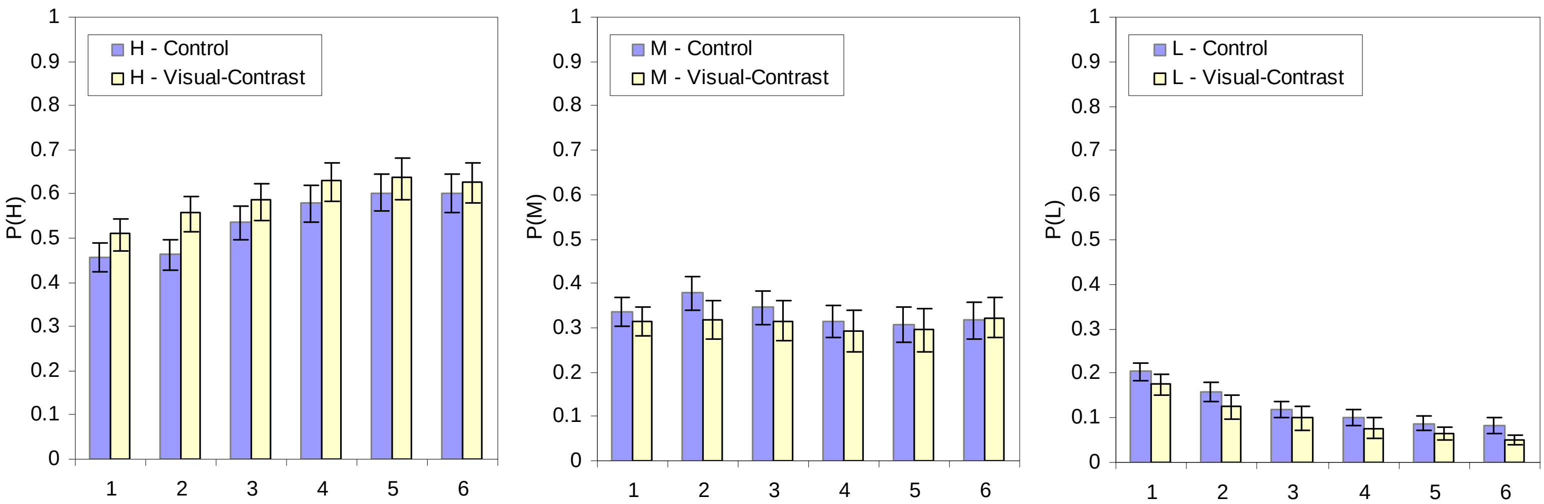
Task and procedure. In the Control condition the experimental task was identical to that of the Gain condition of Study 1a. In the Visual-Contrast condition when a button produced a small gain of 1, its back color was changed to a different color (see supplementary file); for half of the participants in this condition, the regular back color was gray and the color for the 1 outcome was pink; and for the other half this was reversed. As there was no difference between these two color schemes, they were pooled in the analysis. The color of the button remained as long the payoff for the button was presented (for 2 seconds).

Results

Figure 4 presents the proportion of selections from the different choice alternatives in the two experimental conditions. As can be seen, choices were quite similar in the Control and Visual-Contrast condition. Examination of the Maximization scores showed no main effect of condition ($F(1,83) = 1.66$, $p = 0.20$) or interaction between condition and trial block ($F(1,83) = 0.37$, $p = 0.87$). This pattern of results suggests that the increased maximization found in Study 1a is unique to losses, and is not a mere visual contrast effect. As previous research suggests that only stimuli that signal a potential urgent event are likely to draw more attention (Franconeri &

Simons, 2003), our data is consistent with the idea that the effect of losses on maximization is due to an attentional mechanism triggered in the face of a potential threat (Hochman & Yechiam, 2011).[1]

Figure 4: Study 1b results. Selection from the three choice alternatives (High, Medium, and Low expected-value options) as a function of task condition (Control vs. Visual Contrast) and experience in six blocks of 25 trials. Error terms denote the standard error.



Study 1c: Selection between options with equal expected value

To further verify that the effect of losses on maximization observed in Study 1a is driven by EV differences and is not due to increased risk taking with losses, we conducted another experiment involving 100 selections between two options with similar EVs:

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[1] We also ran another experiment where we increased visual contrast by underlining or adding a comma after the 1 outcome in the Gain condition. This also had no effect on maximization rates.

Gain condition

R: Get 1 or 60 + ε (equal odds) [EV = 30.5]

S: Get 30 +ε

Loss condition

R: Get -1 or 60 + ε (equal odds) [EV = 30.5]

S: Get 30 +ε

Where ε was again an integer between -5 and 5. We expected that even though alternative R (=Risky) is riskier than S (in that it contained higher variance), it will not be chosen more often (or less often) in the Loss condition.

Method

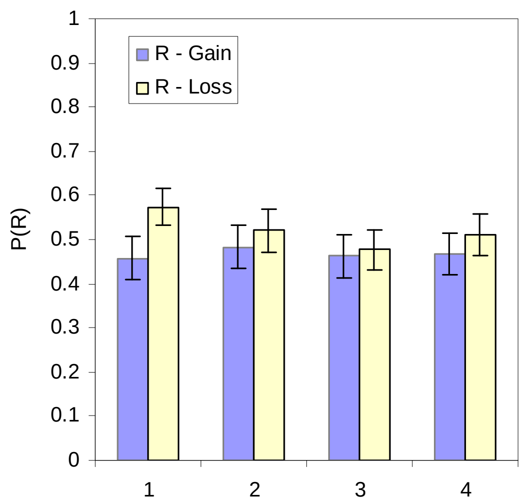
Participants. Eighty-five Technion undergraduates (43 men and 42 female) took part in the experimental study. They were randomly allocated to the Gain and Loss condition (n = 40, 45, respectively). The participants earned a fixed fee of NIS 20 as well as a performance-based stipend.

Task and procedure. The experimental task involved making 100 repeated selections between the two choice options that appeared as virtual buttons, labeled only as A and B. The task was otherwise identical to that of Study 1a.

Results

Figure 5 presents the proportion of selections from the different choice alternatives in the two experimental conditions. As can be seen, the proportions of R selections in the Gain and Loss condition were rather similar (0.47±0.04, 0.52±0.04, respectively) and there was no main effect of condition ($F(,1, 83) = 0.78$, $p = 0.38$) or interaction between condition and trial block ($F(,1, 83) = 1.79$, $p = 0.16$).[2] Thus, as suggested by the ecological account, the effect of losses only emerged when one of the alternatives was considerably advantageous (e.g., in Study 1a), and in this case they led to increased maximization.

Figure 5: Study 1c behavioral results. Selection from the risky alternative (R) as a function of task condition (Gain vs. Loss) and experience in four blocks of 25 trials. Error terms denote the standard error.



[2] The slight increased risk taking in the first block of trials in the Loss condition was not statistically significant ($t(83) = 1.81$, $p = 0.07$).

Study 2: Pupil diameter analysis

The results of our first study showed that losses guided participants towards an ecologically advantageous option and away from an ecologically disadvantageous option. We next examined whether this effect is mediated by arousal, indexed by changes in pupil diameter. Pupil diameter (PD) is considered an immediate and direct index of autonomic activation (Granholm & Steinhauer, 2004), and has been found to increase following losses compared to equivalent gains (Satterthwaite, et al., 2007; Hochman & Yechiam, 2011). As noted above, under the notion of losses as avoidance signals, the arousal following losses should be associated with loss aversion (Sokol-Hessner et al., 2009), and hence with fewer selections from the option that incurs losses. Alternatively, if the arousal following losses marks an attentional orienting response which provides ecological guidance, it should be associated instead with increased EV maximization.

To test these two possibilities, the experimental task in Study 2 included both minor gains and equivalent minor losses, as follows:

L   Get 35 + ε   [EV = 35]

H   25% to get 1, 25% to get -1, 50% to Get 200   [EV = 100]

Each trial involved a choice between two alternatives. The noise factor ε was drawn from the integers between -5 and 5, as in Study 1. The main experimental focus was on the PD response following the outcomes of -1 and +1. We examined whether PD would increase following losses compares to gains, and the behavioral correlates of this phenomenon.

Method

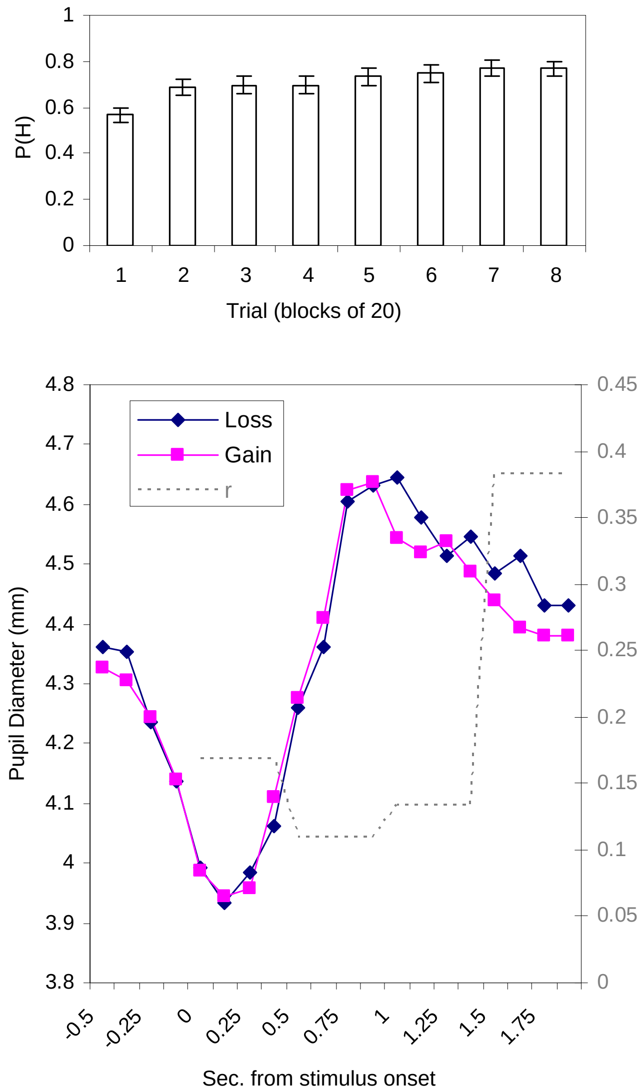
Participants. The participants were 45 Technion undergraduates (20 men and 25 women; sample size was determined in advance). Each participant earned a fixed fee of NIS 30 as well as a performance-based stipend.

Task and procedure. The experimental task involved making 160 repeated selections between two choice options labeled as A and B that appeared as virtual buttons. The outcomes were drawn from the distributions of H and L above. Otherwise, the task was identical to that used in Study 1. Pupillometry data was collected using ViewPoint PC 60 EyeFrame system (Arrington Research, Scottsdale, Arizona). The system operates with a single tiny camera and an infrared illuminator mounted on a lightweight frame facing toward the participant's dominant eye, and supported by comfortable head straps. It records pupil data at approximately 30 frames per second (fps).

Participants came to the lab and after signing an informed consent form were told that during the experiment they would wear a device for measuring eye movements and pupil size. This was followed by attaching the eye tracking device, which was then calibrated. Next, participants performed the experimental task. The task instructions were as in Study 1 with the exception that two (A, B) rather than three choice alternatives were used.

Analysis. The physiological responses before and after the presentation of each choice outcome were averaged in epochs of 125 seconds and analyzed in blocks of 0.5 seconds. The first 125 ms. post-stimulus epoch which reflects pre-attentive scanning (Velichkovsky et al., 2000) was excluded. To reduce noise, the PD following each choice outcome was baseline corrected based on the 0.5 seconds prior to viewing the stimulus.

Figure 6: Study 2 behavioral and physiological results. Top: Proportion of selections from the High expected-value option as a function of experience. Error terms denote the standard error. Bottom: Approximated pupil diameter (PD) in mm prior to and following an equivalent gain or loss of 1 token. The dotted line shows the correlation between PD(loss-gain) and the rate of H selections (axis on the right) in each 0.5 second following the stimulus presentation.



Results

The proportions of selections from the advantageous choice alternative H are presented in Figure 6. As can be seen, the learning pattern is similar to that observed in Study 1a (for H). Figure 6 bottom panel presents the PD recorded following different task outcomes. Following both losses and gains of 1 token there was an increase in PD that peaked around 1 second following outcome presentation. However, at the 1 second peak and thereafter, the PD following a loss was larger than following an equivalent gain. To examine the statistical significance of this pattern we conducted an all-within ANOVA with the post-stimulus epochs (in time blocks of 0.5 second) and valence (Gain vs. Loss) as within subject factors. The results showed that in addition to the main effect of time ($F(3, 42) = 21.13$, $p < .001$), the interaction between time and valence was significant ($F(3, 42) = 3.23$, $p = .03$), indicating the occurrence of a difference in the pupillary response to gains and losses over time. Specifically, while in the first second PD was similar following gains and losses, in the next second it was higher for losses than for gains. These differences were weak however: the difference did not reach significance in any specific epoch (in a t-test for paired samples): p =0.63, 0.40, 0.16, and 0.13, respectively.

We next evaluated the functional significance of an increase in arousal following a loss. For each participant, we calculated the mean PD for a loss minus a gain of 1. This PD(loss-gain) score represents the respective increase in autonomic arousal in response to the loss component (Hochman & Yechiam, 2011). We then examined the correlations between PD(loss-gain) and overall choices from H. When examining the entire post-outcome response window of 2 seconds there was a correlation of $r = 0.31$ ($p = 0.04$) between the PD(loss-gain) and the selection from H. As shown at the bottom panel of Figure 6, this positive correlation peaked at the 1.5 to 2.0 seconds epoch ($r = 0.38$, $p = .01$; correcting for multiple comparisons for 4 blocks, $p = 0.038$).

Note that the correlation peaked at about the same time period where arousal was relatively higher for losses compared to gains. Thus, higher PD following a loss compared to an equivalent gain was associated with making more choices from the advantageous alternative that produced the loss.

Discussion

In Study 1 we have found that when a choice alternative containing a gain was paired with a minor loss this did not lead to avoidance as predicted by loss aversion (Kahneman & Tversky, 1979). It also did not lead to an increase in the attractiveness of the alternative as predicted by the affect heuristic (Slovic et al., 2002). Moreover, as shown in Study 1c losses also did not merely affected risk taking behavior. Instead, losses seemed to guide participants to select the ecologically advantageous choice option and to avoid the disadvantageous choice option.
This was accompanied by reduced switching behavior and greater focusing in the loss condition after an initial block of exploration. Interestingly, in some previous studies losses were found to increase the tendency to switch choices (Lejarraga, Hertwig, & Gonzalez, 2012; Yechiam, Zahavi, & Arditi, in press). However, these studies focused on alternatives having similar expected value. In the current study, where there was a disparity between the alternatives' expected value, losses increased focusing on the high expected-value alternative and reduced unnecessary switching. The effect of losses on choice switching thus appears to be contingent on the ecological structure of the task.

In Study 1b we demonstrated that the effect of losses on maximization is not merely a product of the higher visual contrast between outcomes in the loss condition. When a minor gain was presented in a different color (compared to other payoffs) it did not have the same effect as turning this outcome into a loss. Our interpretation of this finding is that the effect of losses is an attention-motivational phenomenon (cf. Kanfer & Ackerman, 1989) involving an increase in the overall attentional resource pool available for the task (at the expense of spare capacity), when a potential threat is experienced.

In Study 2 we examined the functional correlates of the increased autonomic arousal in response to losses. Our results replicated the pattern of increased pupil diameter following losses compared to gains (e.g., Satterthwaite, et al., 2007; Hocham & Yechiam, 2011). However, individuals who exhibited this pattern most distinctly were not those who avoided losses. Instead, it was individuals who made more selections from the advantegous alternative producing losses. These findings are consistent with the idea that the increased arousal and attention induced by a minor loss does not lead to a breakup or even to a bias in the utility function, but instead increases the sensitivity to the ecological structure of the task (Yechiam & Hochman, 2013a).

Psychologists and behavioral economists often portray humans as being led by their affective responses, deploying reason only to rationalize their gut feelings (Pinker, 2011). Our findings suggest that there is an overlooked role of incentives in promoting reasoning, as defined by increased sensitivity to ecological cues of valence. Moreover, our findings demonstrate that the physiological hallmarks of reasoning processes in response to losses are closely similar to those of affective responses, hinging on gross increases in arousal. Possibly, this physiological similarity has contributed to overlooking the link between losses and reasoning processes.

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