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Feeling the Numbers: On the Interplay Between Risk, Affect, and Numeracy

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ABSTRACT

People overweigh small and underweigh large risks, resulting in probability weighting functions with an inverted S-shape. This bias is stronger for affect-rich outcomes: For two outcomes of the same monetary value, people are less sensitive to probability variation for affect-rich than for affect-poor outcomes (e.g., winning a $100 voucher toward a romantic dinner versus an electricity bill). In the current research, we investigated the interactive influence of affect and cognitive skills on probability weighting. Participants decided about buying insurance against the loss of an object, given various probabilities of loss. The description of the object was neutral, affect-rich, or affect-rich followed by an affective reappraisal task. The reappraisal task consisted of thinking about effective coping strategies and possible positive consequences of the loss. We also investigated the effect of numeracy on probability weighting. In particular, we investigated whether people have different affective responses to risks depending on their numerical abilities. Participants showed more overweighting of small probabilities for an affect-rich than for a neutral outcome. This effect was mediated by fear. When participants were given the opportunity to reappraise the loss of the affect-rich object, the effect disappeared. After reappraisal, participants' decisions were influenced by both fear and hope and were more in line with expectations based on normative models. The latter applied in particular to participants who had higher numeracy; they showed more emotional sensitivity to risks and assigned weights closer to linearity. Implications for the role of emotions and numeracy in risk communication are discussed. Copyright © 2013 John Wiley & Sons, Ltd.

KEY WORDS risk judgment; probability weighting function; emotions; affect; numeracy

One of the most prominent theories of risky decision-making is prospect theory—a theory based on the psychophysical principle of diminishing sensitivity (Kahneman & Tversky, 1979, 1984). When evaluating risks, decision makers are assumed to transform probabilities in a non-linear fashion. People overweigh small and underweigh medium to large probabilities, resulting in a probability weighting function (PWF) with an inverted S-shape (Kahneman & Tversky, 1979; Wu & Gonzalez, 1996). Prospect theory, like most theories introduced in the second half of the last century, makes no prediction about the role of affect in probability weighting. Rottenstreich and Hsee (2001), however, differentiated between utilitarian and affective determinants of value. They suggested that affect-rich outcomes are likely to elicit more hope and fear than neutral outcomes. This should in turn result in a more curved S-shape. This proposition rests on the assumption that for positive outcomes, a change from impossibility to possibility (0% to 1% chance of winning) elicits hope, while a change from certainty to possibility (100% to 99% chance of winning) elicits fear. For losses, this pattern would be reversed. Accordingly, Rottenstreich and Hsee (2001) showed that for affect-rich prizes, people are more sensitive to departures from impossibility and certainty, and less sensitive to intermediate probability variations. In their view, at least a part of the diminishing sensitivity posited by prospect theory might be diminishing *emotional* sensitivity to risks. In particular, more affect-laden outcomes or decisions might evoke similar emotional responses for various probabilities, which would result in more uniform probability weights. The role of affect (e.g., Finucane, Alhakami, Slovic, & Johnson, 2000; van Gelder, de Vries, & van der Pligt, 2009) and specific emotions (e.g., Kugler, Connolly, & Ordóñez, 2012; Lerner & Keltner, 2001; Loewenstein & Lerner, 2003) in risky decisions has been emphasized in other contexts as well. Loewenstein, Weber, Hsee, and Welch (2001) proposed the risk-as-feelings hypothesis (see also Slovic, Finucane, Peters, & MacGregor, 2004; Slovic & Peters, 2006). This theory posits that both *immediate affect* (fear or worry experienced when deciding) and *anticipated affect* (regret in the future) can influence *cognitive evaluations* of risk.

In the current research, we sought to investigate the interactive influence of affect and cognition on risk evaluation. Our purpose was twofold: to investigate how the affective value of risks influences probability weighting and to test if this influence is moderated by numerical skills. In particular, we aimed to extend the findings of Rottenstreich and Hsee (2001) concerning the role of affect in three ways. First, we explicitly assessed hope and fear in order to test whether these emotions mediate the relationship between probabilities and weights, and whether an affect-rich outcome indeed elicits stronger emotions. Second, Rottenstreich and Hsee (2001) focused on gains. To the best of our knowledge, there is no research that investigated a true loss situation, in which the endowment effect is at play (see Kahneman, Knetsch, & Thaler, 1990). To address this issue, we used a loss scenario in our study. Third, we introduced a simple intervention and assessed its impact on probability weighting. In particular, we investigated the effectiveness of an *affective reappraisal* strategy aimed to reduce the negative emotional impact of the loss. The affective reappraisal consisted of thinking of effective coping strategies and possible positive consequences of the loss. If this debiasing strategy turns out to be effective, it

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would provide additional evidence for the role of affect in risk evaluation. Finally, we investigated whether the affective responses to risks and the effect of our intervention were related to numerical skills. Numeracy is the ability to understand and use numerical expressions of probability and affects risk understanding and decision making in important ways (Garcia-Retamero & Cokely, in press; Garcia-Retamero & Galesic, 2010a; Reyna, Nelson, Han, & Dieckmann, 2009). Moreover, individuals with high and low numeracy might have different affective reactions to risks (Peters, 2012). Hence, if affect indeed underlies probability weighting, we might expect different degrees of probability distortion depending on people's numeracy and affective reactions to risks. This would provide further evidence that at least part of the diminishing sensitivity underlying probability weighting could be diminishing *emotional* sensitivity to risks.

In order to examine the PWF under loss, we used a common loss prospect, that is, a decision about insurance against potential loss of an object. The PWF for insurance decisions might differ from that for the more commonly studied monetary gambles. Kusev and colleagues compared the PWFs for insurance decisions and more abstract monetary gambles (Kusev, van Schaik, Ayton, Dent, & Chater, 2009), and found that people exaggerated insurance risks relative to risks of the gambles. In particular, their participants overweighed small, medium, and moderately large probabilities when they made decisions about insurance against loss. This effect was related to the accessibility of events in memory and is possibly due to affect-laden imagery (see, e.g., Kensinger, Addis, & Atapattu, 2011; Reisberg, Heuer, McLean, & O'Shaughnessy, 1988). This imagery might have made insurance risks more vivid and worrisome irrespective of the risk estimates that were provided, resulting in more cautious decisions. This claim is supported by Hsee and Kunreuther (2000); they found that the more affect-laden an object is, the more people want to insure it. In a similar vein, a more emotional description of a disease resulted in increased willingness to pay to avoid the risk (Sunstein, 2003; Sunstein & Zeckhauser, 2010). Interestingly, none of these studies tested the impact of specific emotions on the PWF; yet, they all suggest that more affect-laden losses might result in relative overweighting of probabilities, which is consistent with an increase in fear. Obviously, the prospect to lose something precious with a high probability can also evoke hope, but feelings of fear are likely to be more important, because of a more general negativity bias (e.g., Rozin & Royzman, 2001). Moreover, fear leads to risk aversion (Lerner & Keltner, 2001), which would translate into relative overweighting of all probabilities for losses. In order to investigate this hypothesis, we used a task similar to that of Rottenstreich and Hsee (2001) and manipulated the affect-richness of the loss prospect by altering the description of the object to be insured: neutral for some participants and affect-rich for others. In the neutral condition, the object was purchased online, while in the affect-rich condition, it was a present from a loved one.

As indicated before, we also investigated whether affective reappraisal reduced the weighting of probabilities. Weighting could be a result of anticipated affect as well (see, e.g., Brandstätter, Kühberger, & Schneider, 2002; Mukherjee, 2011), so our reappraisal manipulation aimed to attenuate such affect. In addition, some studies suggest that loss aversion is a result of anticipated negative affect. Research on affective forecasting shows that people tend to overestimate the hedonic impact of losses (Kermer, Driver-Linn, Wilson, & Gilbert, 2006) and overlook coping strategies that can reduce distress (Hoerger, 2012). Thus, in our experiment, some participants first read the affect-rich description, followed by a request to think of effective coping strategies and possible *positive* consequences of such a loss. We hypothesized that this intervention would reduce anticipated negative affect and attenuate the effects of immediate emotions, resulting in a PWF closer to linearity. Similar emotion regulation and reappraisal strategies have been effective in reducing the impact of affect on arousal, loss aversion, and the experience of rewards (Martin & Delgado, 2011; Sokol-Hessner et al., 2009).

In sum, we expected that the prospect of an emotion-evoking loss would result in an increase of fear and overweighting of probabilities (i.e., a stronger elevation of the function in an affect-rich condition as compared with both neutral and reappraisal conditions). Specifically, we expected more overweighting of probabilities of loss in the affect-rich compared with the neutral condition. Following an affect-rich description, the reappraisal manipulation should reduce weighting compared with a condition without reappraisal (i.e., the PWF will be closer to linearity in the reappraisal condition than in the affect-rich condition). We also expected that emotions would mediate the relationship between probabilities and weights. Because we presented participants with a loss prospect, we expected fear to be the more important mediator in the affective and neutral condition but not in the reappraisal condition. In the latter case, the impact of fear would be attenuated by the manipulation.

Finally, we considered numeracy as a potentially important moderator of the relationship between probabilities, emotions, and judgments. High numeracy is associated with less susceptibility to biases and fallacies in probability judgment (Liberali, Reyna, Furlan, Stein, & Pardo, 2012). Moreover, individuals with high numeracy show stronger number-related affective reactions and draw more precise affective meaning from numerical comparisons (Peters, 2012; Peters et al., 2006). This might help them overcome the influence of irrelevant information like mood (Västfjäll, Peters, & Starmer, 2011), message framing (Garcia-Retamero & Galesic, 2010b), credibility of the narrative (Dieckmann, Slovic, & Peters, 2009), or the size of the numerator alone (Garcia-Retamero & Galesic, 2009, 2011). In the current research, we investigated whether individuals with high numeracy showed less distortion in probability weighting than less numerate individuals and whether this was due to higher emotional sensitivity to risks. Biased weighting could be a result of more uniform emotional reactions to various risks (e.g., feeling a similar amount of fear regardless of the probability of a negative event). If this is the case, then high numeracy individuals should show more differentiated affective reactions to risks and translate these reactions into probability weights that are more in accordance with normative models. We then expected

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that people with relatively high numeracy would show higher emotional sensitivity to risks and higher probability discriminability than those with low numeracy.

METHOD

Participants

Participants were 148 undergraduates from the University of Amsterdam (mean age = 21, $SD = 5.13$) who participated in return for course credit or €7. The experiment was administered online via Qualtrics survey software (www.qualtrics.com).

Materials and procedure

Participants had to imagine that they owned a camera and decided to insure it against loss or theft. It was explicitly stated that the current market value of the camera was €500. The affective value of the camera was manipulated between-subjects via its description. In the *neutral* condition, the camera was described in a neutral way (you ordered it via a website). In the *affective* condition, the camera was described in a more affect-rich way (it was a birthday present from your favorite grandfather). Finally, in the *reappraisal* condition, the camera was described as in the affective condition. In addition, participants were asked to list two to three strategies they could use to successfully cope with a potential loss or any positive consequences it might bring. The full text provided to participants in the three conditions can be found in the Appendix.

To assess probability weights, we used a version of the certainty equivalents (CE) procedure (Gonzalez & Wu, 1999). In particular, each participant was presented with a range of probabilities of loss (1%, 5%, 10%, 25%, 50%, 75%, 90%, 95%, and 99%). For each probability, they indicated how much they would pay to insure the camera. To make the task more straightforward, participants first saw 1% and 99% (order randomized), followed by the remaining probabilities in a random order. To get familiarized with the procedure, participants received a practice block at the beginning of the experiment. In this practice block, they had to imagine that they had €500 and indicate how much they would pay to avoid losing the amount with a certain probability.

For each probability and on scales ranging from 0 (*not at all*) to 100 (*very much*), participants estimated to what extent they were (i) afraid of losing their camera, (ii) hopeful of not losing their camera, and (iii) how likely it was that they would lose their camera (filler item). The three questions were presented in a random order. Then, they reported how many Euros per year they would pay for the insurance. Finally, on 9-point Likert scales ranging from 1 (*absolutely disagree*) to 9 (*absolutely agree*), participants responded to the following statements: (i) If I lose such a camera, I would be very upset; (ii) The camera is very valuable to me; and (iii) It would not be easy to replace the camera. These statements aimed to assess the *emotional value* of the camera. Participants also answered several questions about the decision process. In particular, they evaluated whether they (i) found it difficult to think of ways to cope with the loss, (ii) followed their intuition when they decided about the insurance, (iii) deliberated carefully when they decided about the insurance, and (iv) calculated the insurance premium. Finally, participants completed the Berlin Numeracy Test (Cokely, Galesic, Schulz, Ghazal, & Garcia-Retamero, 2012) that aimed to assess numeracy in highly educated samples. The test uses an adaptive algorithm to classify participants in four levels according to their score (1 to 4, where a larger score denotes higher numerical skills).

RESULTS

Data preparation

The raw CEs in Euros showed substantial variance, which increased disproportionately with probability. In order to correct for this variance and obtain probability weights, the premiums in Euros denoted by € were normalized to range from 0 to 1 (wp) (1). This was carried out by subtracting the insurance premium each participant was prepared to pay for a zero probability of loss ($€_{(0\%)}$) from the insurance premium for each probability and then dividing it by the premium the participant would pay when the loss was certain ($€_{(100\%)}$). However, because we did not ask participants how much they would pay for insurance when the chance was 0% and 100%, we assumed that (i) when there was no chance of loss, participants would not pay anything (($€_{(0\%)} = 0$), and (ii) when loss was certain, participants would pay the highest price they indicated (e.g., for 99%), plus the price when there was 1% chance of loss ($€_{(100\%)} = €_{(99\%)} + €_{(1\%)}$).[1]

$$wp(p) = \frac{€ - min}{max} = \frac{€_{(p)} - €_{(0\%)}}{€_{(100\%)}} = \frac{€_{(p)}}{€_{(99\%)} + €_{(1\%)}} \quad (1)$$

The fear and hope ratings were divided by 100 (i.e., scaled as weights to ease interpretation). For every participant, the probability weights were modeled following Gonzalez and Wu's (1999) two-parameter PWF estimation procedure (2). This procedure was preferred because the parameters (δ and β) have a neat psychological interpretation. In particular, δ primarily controls the elevation of the function or the unattractiveness of the outcome in a loss context, whereas β primarily controls the curvature or probability discriminability. The parameters were estimated using the nls (weighted) least-squares procedure in R.

$$wp^{+,-}(p) = \frac{\delta p^{\beta}}{\delta p^{\beta} + (1-p)^{\beta}} \quad (2)$$

[1]It could be argued that this procedure contradicts the typical finding of subcertainty (i.e., $wp(p) + wp(1-p) < 1$; Kahneman & Tversky, 1979). This is indeed the case for one pair of probabilities, $wp(p) + wp(1-p) = 1$. However, in their examination of the PWF, Gonzales and Wu (1999) showed that subcertainty does not always hold, and a proportion of people even show supercertainty, $wp(p) + wp(1-p) > 1$. Indeed, for the rest of the probability pairs, our participants showed both subcertainty and supercertainty. As we apply the same procedure to all conditions, this should not have an impact on the results.

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Six participants gave answers that did not follow any logical pattern. They were excluded from all subsequent analyses. Fourteen participants were excluded from the parameter analysis because they were outliers or the model could not converge.[2]

In the following, we first checked if the affective manipulation was successful. We then examined the effect of the affective manipulation on emotions, the elevation of the function (δ), and probability discriminability (β). We also tested the mediating role of emotions. Finally, we investigated whether numeracy had an effect on the parameters and on the mediating role of emotions.

Manipulation check

The three questions about the value of the camera were combined to assess *emotional value* (Cronbach's alpha = .70). Scores differed between conditions, $F(2, 135) = 4.43$, $p < .05$, $\eta^2_p = .06$; numeracy had no effect and did not interact with condition. Participants in the neutral ($M = 6.46$, $SD = 1.43$) and the reappraisal ($M = 6.66$, $SD = 1.33$) conditions found the camera to be of less value than participants in the affective condition ($M = 7.25$, $SD = 1.51$), both $p < .05$ according to post-hoc tests. Ratings in the neutral and reappraisal conditions were similar, indicating increased emotional value for the affect-rich description, followed by a decrease due to reappraisal. There were no differences in the decision process questions. Participants in the reappraisal condition listed a variety of coping strategies and positive consequences. Common examples were "I will talk to my grandfather and we'll buy a new camera together," "I would keep in mind that it is just a replaceable material thing," "There are worse things in the world," "I will start saving for a new one," and "Now I can buy an even better one with the latest improvements."

Affect

Overall results were consistent with prospect theory (Figure 1) and showed overweighting of small and underweighting of large probabilities. We analyzed the effect of condition on the parameters in a repeated-measures ANOVA.[3] The rationale of this analysis is that the parameters are not entirely independent, and high discriminability might be often paired with low elevation (Gonzalez & Wu, 1999). Condition showed the hypothesized effect on the parameters, $F(2, 125) = 2.84$, $p = .03$ (one-tailed), $\eta^2_p = .04$. In line with our predictions, elevation increased and discriminability decreased from the reappraisal to the neutral to the affective condition (Figure 2). Planned comparison indicated that the affective condition was marginally more biased than the neutral condition,

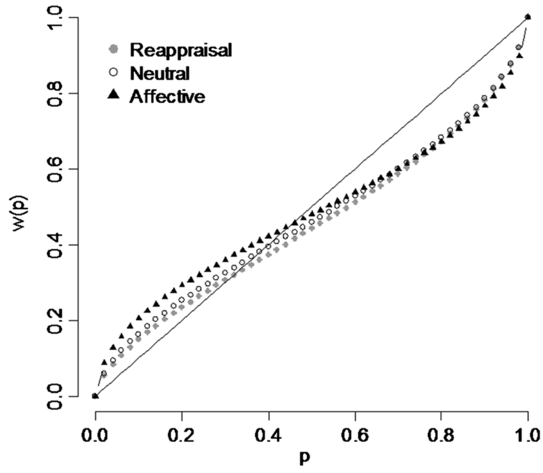

Figure 1. Fitted probability weighting functions by condition

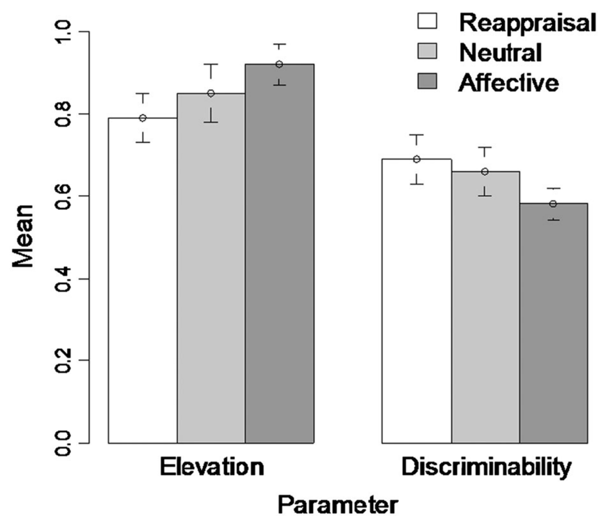

Figure 2. Mean estimates of δ (elevation) and β (discriminability) according to condition. Error bars are ±2*SE*

$F(1, 81) = 2.62$, $p = .055$ (one-tailed), $\eta^2_p = .03$. Figure 1 shows that differences are more pronounced in small (1% to 25%) than medium or large probabilities (50% to 99%). Indeed, in contrast with our predictions, weights for medium to large probabilities did not differ in the three conditions. However, weights for small probabilities were larger in the affective ($M = .20$, $SD = .10$) than in the neutral condition ($M = .17$, $SD = .07$), $F(1, 81) = 3.22$, $p = .04$ (one-tailed), $\eta^2_p = .04$. As expected, the reappraisal condition was significantly less biased than the affective condition, $F(1, 85) = 5.24$, $p < .05$, $\eta^2_p = .06$: Elevation was larger in the affective ($M = .92$, $SD = .30$) than in the reappraisal condition ($M = .79$, $SD = .35$), and discriminability was lower in the affective ($M = .60$, $SD = .22$) than in the reappraisal condition ($M = .69$, $SD = .33$).

Next, we tested if fear differed between conditions after controlling for hope. Fear increased with probability, $F(5.04, 695.99) = 79.58$, $p < .05$, $\eta^2_p = .37$ (Greenhouse–Geisser corrected), and condition did not moderate this relationship. Planned comparisons showed that fear was stronger in the affective condition than in the neutral condition for all probabilities, $F(1, 92) = 4.89$, $p < .05$, $\eta^2_p = .05$. There were no other differences between conditions. Similar analyses for hope

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[2]Twelve participants were excluded from the parameter analyses because they were clear outliers (they deviated from an otherwise normal-looking distribution) on elevation, discriminability, or both. After excluding these cases, both variables did not deviate from a normal distribution (Kolmogorov–Smirnov statistic <1, $p > .05$). The results from the mediation analyses with the weights were similar, both with and without these participants.

[3]We also estimated PWF parameters from the cash loss practice trial. Including them as covariates in the subsequent analyses did not change the direction of results.

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revealed that hope decreased with probability, $F(3.18, 439.17) = 7.20, p < .05, \eta_p^2 = .05$ (Greenhouse–Geisser corrected). There were no further differences.

Finally, we tested whether emotions mediated the relationship between probabilities and weights in three separate models (one for each condition) following Baron and Kenny (1986) and Kenny, Korchmaros, and Bolger (2003). The two mediators (fear and hope) were tested simultaneously (Preacher & Hayes, 2008). In all three models the c' paths were reduced but still significant after including the mediators, indicating *partial mediation* (Figure 3). In the reappraisal condition, Sobel tests indicated that both fear $a * b_{fear} = 1.96$, $SE = .02$, $p = .05$ and hope $a * b_{hope} = 2.78$, $SE = .02$, $p < .05$ were mediators. Fifteen percent of the total effect was due to mediation: 6% by fear and 9% by hope. In the neutral condition, only fear $a * b_{fear} = 2.18$, $SE = .03$, $p < .05$ was a mediator, responsible for 10% of the explained variance. In the affective condition, again only fear $a * b_{fear} = 2.23$, $SE = .03$, $p < .05$ was a mediator, explaining 9% of the variance.

Numeracy

The numeracy score was included as a continuous variable in all analyses. In specific comparisons, participants were divided into two groups: a low (1st and 2nd levels) and a high (3rd and 4th levels) numeracy group. Numeracy had no effect on elevation or discriminability but marginally moderated the effect of condition on discriminability, $F(1, 124) = 3.24$, $p = .07$, $R^2_{change} = .03$. Condition had an effect on participants with high numeracy ($p < .05$) but not on those with low numeracy. A follow-up contrast, $F(2, 72) = 2.70$, $p = .07$, $\eta_p^2 = .07$, indicated that high numeracy participants showed similar discriminability in the neutral and the affective condition but showed more discriminability in the reappraisal condition compared with the other two conditions ($p = .03$). We further tested if high numeracy participants in the reappraisal condition had higher discriminability scores as compared with those with high numeracy in the neutral and affective conditions and with those with low numeracy in all conditions. The overall contrast was marginally significant, $F(3, 124) = 2.40$, $p = .07$. High numeracy participants in the reappraisal condition showed more discriminability than all other groups ($M = .79$, $SD = .33$ vs. $M = .61$, $SD = .28$, $p < .05$). The other groups did not differ from each other.

Next, we tested whether high numeracy is associated with more differentiated affective reactions to probabilities and whether this leads to more discriminability between the various probabilities. Although there was no direct effect of numeracy on the parameters, we conducted a mediation analysis. Several authors have emphasized that a significant direct effect of the independent on the dependent variable is not always a necessary condition for an indirect effect to take place (e.g., when the expected effect is small). Such cases can be tested with bootstrapping (Preacher & Hayes, 2008; Shrout & Bolger, 2002). Another advantage of this method is that it does not assume normality of the distribution of indirect effects. For each participant, we calculated the variances of the emotion ratings (fear and hope) for the nine probabilities and averaged them (Cronbach's alpha = .85) to create an index of emotional sensitivity to probabilities. Higher numeracy was associated with higher variance in emotions, $B = .008$, $SE = .003$, $p < .05$. Variance of emotion ratings did not predict elevation but did predict discriminability, $B = 1.56$, $SE = .57$, $p < .05$. In line with our predictions, there was a small indirect effect of numeracy on discriminability mediated by emotion variance, *estimate* = .05, $SE = .03$ (95% *CI*s excluding 0 from .01 to .12). The indirect effect accounted for 88% of the total effect.

Finally, to investigate the moderating effect of numeracy on the mediation effect of emotions, we estimated the fit of one model over all conditions (condition was included as a random effect; results are depicted in Figure 4). The c' path was reduced compared with the c path, indicating again partial mediation. In this collapsed model, only fear was a significant mediator ($a * b_{fear} = 3.31$, $SE = .02$, $p < .05$) and accounted for 9% of the overall effect. Probability predicted hope, but the path from hope to probability weight was not significant. Hope and the probability weights did not vary between conditions, but fear did, $\sigma^2 = .01$, $SE = .001$, $p < .05$. A model with condition as a fixed effect again revealed that participants in the neutral condition reported less fear than participants in the affective condition, $B = -.4$, $SE = .02$, $p < .05$. As hypothesized, numeracy had an effect on both a paths: It

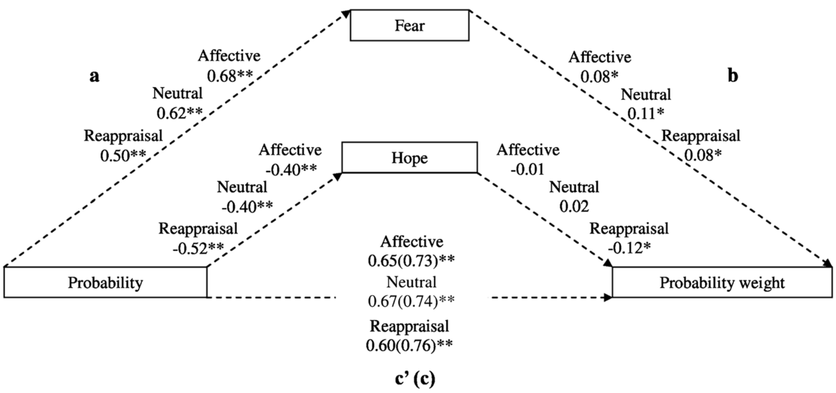

Figure 3. Results from three mediation analyses. Values are standardized coefficients (equal to unstandardized due to scaling). Values in parenthesis are coefficients for the direct path (without mediators). Asterisks indicate significance (*$p < .05$; **$p < .001$)

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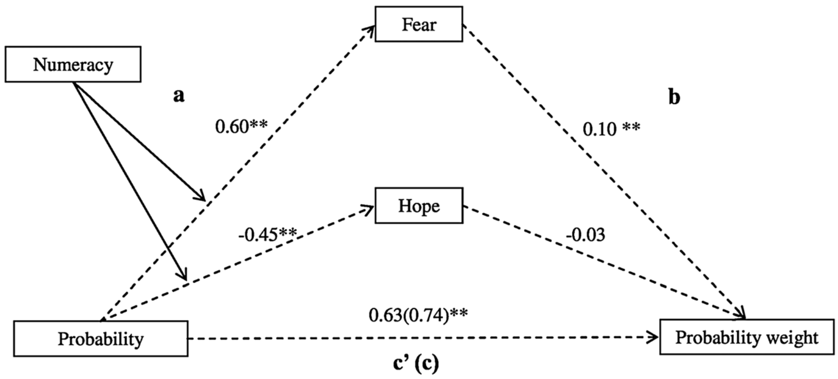

Figure 4. Results from the moderated mediation analysis. Values are standardized coefficients (equal to unstandardized due to scaling). Values in parenthesis are coefficients for the direct path (without mediators). Asterisks indicate significance (*$p < .05$; **$p < .001$)

moderated the effect of probability on fear, $B = .04$, $SE = .01$, $p < .05$ and hope $B = -.04$, $SE = .02$, $p < .05$, but had no effect on the *c* or *b* paths. Simple regression slopes showed that probability was a better predictor of emotions for participants with high numeracy (fear: $B = .85$, $SE = .02$; hope: $B = -.78$, $SE = .03$) than for participants with low numeracy (fear: $B = .73$, $SE = .03$; hope: $B = -.67$, $SE = .04$). In line with our predictions, participants with low numeracy reported more similar emotional responses and were less affected by differences in probability levels (Figure 5).

DISCUSSION

Consistent with prospect theory, participants showed overweighting of small and underweighting of large probabilities. A subtle manipulation of the description of an object to be insured resulted in small but reliable changes in probability weighting. An affect-rich description increased fear of loss relative to a neutral description. It also

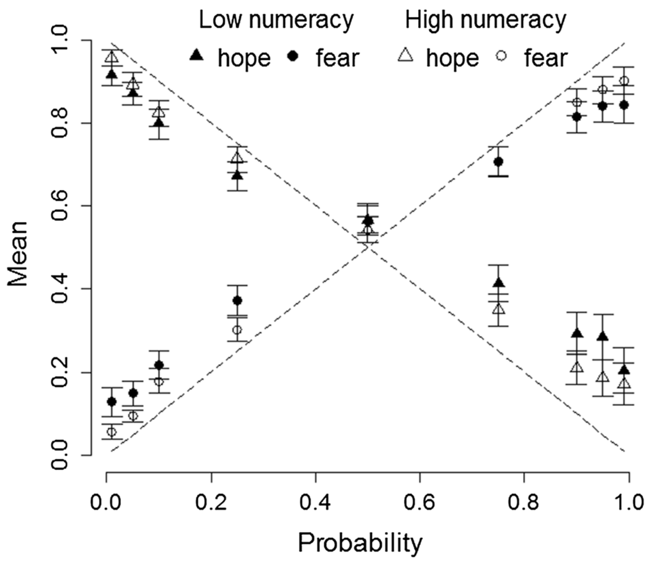

Figure 5. Fear and hope ratings for every probability according to numeracy level. Error bars are ±2*SE*. Dashed lines represent linear responses

increased overweighting of small probabilities, replicating the findings of Rottenstreich and Hsee (2001). However, this was not the case for large probabilities. The latter is inconsistent with both the hope-and-fear predictions of stronger curvature and our predictions of larger elevation overall. One explanation of this result could be that participants found those probabilities difficult to imagine, because they seem unlikely in daily life (i.e., outside of the laboratory). Another explanation, which we consider more plausible, is that the effects of discriminability and elevation cancel each other out for large probabilities (for a similar discussion, see Mukherjee, 2011). An affective description decreases discriminability (i.e., increases curvature) relative to a neutral description. This "pulls" the function downward in the large probabilities and upward in the small probabilities region; an increase in elevation would pull it upward across all probabilities. Thus, the simultaneous increase in elevation and curvature caused by the affective description could explain the absence of differences for large probabilities. The increased fear for all probabilities in the affective relative to the neutral condition also supports this interpretation. A similar result was obtained by Mukherjee (2011), who investigated the effect of different thinking styles on the shape of the PWF in the domain of gains. He found that while holding the affective value of the outcome constant, individuals with a more affective thinking style were more prone to overweigh small probabilities. However, these participants were not more prone to underweigh large probabilities.

To the best of our knowledge, this is the first study that tests the direct impact of specific emotions on the weighting of a large range of probabilities. We demonstrated that emotions, felt at the prospect of taking a risky decision, mediated the relationship between probabilities and their weights. In addition, their relative importance varied as a function of decision context. Affective reappraisal decreased elevation and increased discriminability as expected. However, rather than decreasing fear or increasing hope, the reappraisal manipulation might have made participants' positive feelings more salient. Indeed, the mediation analyses showed that only participants in the reappraisal condition relied on hope in their decisions. In the neutral and affective conditions, only fear functioned

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as a mediator. This makes sense in a loss situation, where security motivation is important and fear plays a more prominent role. We expect hope to be more important in the gain domain. Indeed, Lopes (1987) used security versus potential motivation to explain differences between risk-averse and risk-seeking individuals.

Numeracy is a valuable skill, which benefits decision makers when dealing with exact risk estimates. Our process-driven approach once again revealed that numeracy goes beyond the ability to understand and use numbers (see also Peters, 2012). The reappraisal manipulation successfully reduced elevation regardless of numeracy but increased discriminability for more numerate participants to such an extent that they were the most accurate group. The reappraisal strategy might have helped participants with good numerical skills to focus on the estimated risk or their affective response to it, rather than on the affect-rich outcome. Similar results were obtained by Pachur and Galesic (2012), who compared decision strategies used by individuals high and low on numeracy. They modeled the affect heuristic (Finucane et al., 2000) as a strategy that fully focuses on the affective valuation of the outcome, while ignoring the probability of its occurrence. They showed that participants low in numeracy were more likely to use such a strategy. In our experiment, participants with high numeracy showed emotions that were more clearly related to the various probabilities. This helped them to assign more normative weights. In contrast, participants with low numeracy could not derive such a clear emotional meaning from numerical comparisons. For example, faced with a small probability of loss, they perceived disproportionally more fear and less hope than the highly numerate; the emotions reported by the more numerate participants varied more proportionally with risks. Thus, our participants with high numeracy seemed to have a clearer idea of how bad a bad chance is. It seems that when faced with an estimated level of risk, individuals with different levels of numerical abilities use different sources of affective information. Those high on numeracy might be more prone to rely on "number-related" affect rather than focus on more general impressions triggered by the frame (Garcia-Retamero & Galesic, 2010a), the credibility of the story (Dieckmann et al., 2009), or the outcome (Pachur & Galesic, 2012). Overall, these results suggest that the benefits of high numeracy are not restricted to understanding and calculating proportions. High numeracy participants might also have a well-developed number sense. Number sense is a more basic skill of having a non-algorithmic "feel" for numbers developed early in childhood (Lipton & Spelke, 2003). Indeed, research shows that individuals with a more precise number magnitude representation have better numeracy and that this basic skill might underlie more complicated processes like the valuation of decision options (Peters, Slovic, Västfjall, & Mertz, 2008).

To sum up, our results confirm the role of emotions in probability weighting. The shape of the PWF obtained in the present research is consistent with the principle of diminishing sensitivity put forward by prospect theory (Kahneman & Tversky, 1979). Our experiment shows that when it comes to real-life loss prospects, at least part of this reduced sensitivity might be due to diminishing *emotional* sensitivity. We demonstrated how an emotion-based intervention could help give a more balanced focus on emotions and lead to probability weights that deviate less from normative models. However, one important condition for this effect is that numbers also have an *affective* meaning to the individual. This finding could be informative when designing tools for improved risk communication, especially in domains where emotional outcomes are likely (medical, insurance, or financial). For example, the impact of probability on decisions could be increased by selecting a numerical format (e.g., percentage vs. frequency) that conveys the most differentiated or precise affective meaning for people that differ in terms of numerical skills. A good decision might be the result of both balanced information and balanced emotion.

APPENDIX

Condition	Camera description
Neutral	You have a digital camera, whose current market value is €500. The camera has a 16.2-megapixel sensor, a 27-mm wide angle, and 30× zoom lens, and automatically records the location where a photo was taken (GPS location tagging). *You bought it via the website "camera.nl" because they had the best price. The instructions for use were clear, and the camera is quite easy to use*. Now, you want to insure your camera against theft or loss.
Affective	You have a digital camera, whose current market value is €500. The camera has a 16.2-megapixel sensor, a 27-mm wide angle, and 30× zoom lens, and automatically records the location where a photo was taken (GPS location tagging). The device is quite easy to use. *It was a birthday present from your grandfather, a professional photographer. The camera always reminds you how much he cares about you*. Now, you want to insure your camera against theft or loss.
Reappraisal	[Affective description followed by affective reappraisal task] People differ in how they cope when they lose something they own. Some people tend to cope better than others. Before you decide about the insurance of your camera, please take the time to think of ways you could cope with the loss in case it would happen. Please list two to three strategies, including any positive consequences the loss might have for you.

Note: The text in italics was adapted to the condition.

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