Master's Thesis

Master of Psychology and Social Intervention at the University of Granada

Assessing the Sensitivity and Validity of the Berlin Emotional Responses to Risk Scale

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Abstract

Affect has been shown to influence our perceptions, thoughts, and behaviors, sometimes serving as a beneficial or harmful guide during risky decision making. Currently, there is no standardized instrument validated for the evaluation of affective reactions to risk-relevant information. This study sought to expand on the assessment of the psychometric sensitivity and predictive validity of a recently developed instrument, The Berlin Emotional Responses to Risk Scale (BERRS), a broad 6-item self-report of positive and negative affect that serves to provide an overall affective reaction to risk in one minute. We wanted to demonstrate that the scale would be sensitive to manipulations of risk severity and probability. Results from our online panel survey (N = 515) demonstrated that the BERRS was sensitive to subtle changes in risk severity and probability across diverse risk contexts (e.g., health, environmental, technological, etc.) and could predict behavioral intentions (i.e., willingness to engage in a risky behavior) in a variety of risk contexts and conditions.

Keywords: affect, risk perception, risk-taking, decision-making, emotions

Assessing the Sensitivity and Validity of the Berlin Emotional Responses to Risk Scale

While we may not always be aware of it, we are constantly making decisions in our daily lives, many of which carry a certain level of risk. We decide whether or not to take a prescription drug, wear a seatbelt, or invest money. But how do we arrive at these decisions? In recent decades, research on the science of emotion has revealed that our emotions can serve as "potent, pervasive, predictable, sometimes harmful and sometimes beneficial drivers of decision making" (Lerner, Li, Valdesolo, & Kassam, 2015, p. 799). When confronted with a decision to make, our emotions can guide us to choose a particular option in order to avoid negative feelings like regret or increase positive ones such as happiness, even though that choice may not be the most rational or beneficial (Lerner et al., 2015).

Researchers have developed numerous theoretical perspectives and models to describe the role of emotions in risk perception and decision making. Among them are the affect heuristic and risk-as-feelings hypothesis. The affect heuristic is a theoretical framework that describes how we rely on our affective responses and feelings to guide our judgments and decisions (Slovic, Finucane, Peters, & Macgregor, 2007). According to this framework, the images or representations of objects, people, and events in our minds are all marked to some degree with positive and negative affect. When forming an opinion or making a decision, we refer to these representations to form quick, efficient impressions about a subject. Thus, our affective feelings can be used as a *mental shortcut* to shape our judgments and decisions. For instance, how risky we perceive a particular hazard (e.g.,cancer, nuclear power) has been shown to be related to the degree of negative and positive affect it conjures (Fischhoff, Slovic, Lichtenstein, Read, & Combs, 1978; Alhakami&Slovic, 1994).The affect heuristic has also been shown to influence our judgments of numerical information and probabilities, which in turn can affect how we perceive

and interpret risks (Visschers et al., 2012; Peters, Lipkus, &Diefenbach, 2006).For instance, using relative frequencies (e.g., 1 in 10 people) rather than probabilities (e.g., 10% chance) has been shown to conjure greater affective reactions and greater perceptions of risk because the numerical information can be easier to imagine (Slovic, Monahan, & MacGregor, 2000; Slovic, Finucane, Peters, & Macgregor, 2007). Verbal probability terms (e.g., low probability), on the other hand, are easier to imagine than numerical formats for some people, but interpretations can vary drastically between individuals (Visschers et al., 2012). Thus, affect can influence how we interpret risk-relevant information and may be related to our cognitive abilities to evaluate probabilistic information (i.e., numeracy; Cokely, Galesic, Schulz, Ghazal, & Garcia-Retamero, 2012).Numeracy has been shown to predict our ability to understand risk and our decision making (Cokely et al., 2012).

Moreover, the risk-as-feelings hypothesis specifies that how we make decisions or respond to risky situations is influenced directly by both our emotions (e.g., feelings of worry or fear) and our cognitive assessment of the risky situation (Loewenstein, Weber, Hsee, & Welch, 2001; Slovic, Finucane, Peters, & MacGregor, 2004). Anticipated outcomes (e.g., severity of the consequence; anticipated emotions, or emotions we expect to experience in the future like regret) and subjective probabilities (i.e., our own assessments of the likelihood of a consequence occurring) can greatly influence our cognitive evaluations (Loewenstein et al, 2001). Factors that can influence our feelings include the perceived immediacy of the risk, the vividness with which we can imagine anticipated outcomes, personal past experience with risky outcomes, mood, and integral/anticipatory emotions (e.g., immediate visceral reactions such as worry of the risky situation or decision at hand). Our visceral, affective reactions to risk can be beneficial when theydeter us from making poor choices (e.g., choosing financially risky options), but can also mislead us when they cause us to perceive greater risks than actually present or skew our

judgments (Bechara, Damasio, H., Tranel, & Damasio, A. R., 1997; Lerner & Keltner, 2000; Johnson & Tversky, 1983; Gigerenzer, 2004).

While it is evident that our emotions play an important role in how we perceive risks and ultimately make decisions, there is currently no standardized scale that has been validated for the evaluation of affective reactions to risk-relevant information that may require important decision-making. The current study seeks to expand on the assessment of the psychometric sensitivity and validity of a scale that is currently being tested to measure such affective reactions. The Berlin Emotional Responses to Risk Scale (BERRS) is being developed by a team from the University of Granada and University of Oklahoma's National Institute for Risk and Resilience. It is a broad 6-item self-report of positive (i.e., assured, hopeful, relieved) and negative (i.e., anxious, afraid, worried) emotions that serves to provide an overall affective reaction in as little as one minute (Petrova, Cokely, Ramasubramanian, & Garcia-Retamero, n.d.). Depending on the aim of the research, it can be used as a global measure of affective reaction by averaging the negative and reverse-scored positive affect items or it can be used as a measure of negative and positive affect by computing negative and positive scores separately. Previous studies conducted to assess the scale's psychometric properties have demonstrated a high internal consistency for both positive (Cronbach's α = .87 to .88) and negative components (α = .92 to .93). They have also demonstrated the scale's predictive power and sensitivity to subtle affective manipulations of the context.Specifically, the BERRS has demonstrated predictive validity for risk perceptions, behavioral intentions, and decision-making with regards to health-related risk communications (see RiskLiteracy.org). The current study aims to expand on these findings by demonstrating the BERRS' i) sensitivity to variation in risk severity and probability and ii) predictive validity for behavioral intentions and decision-making in a variety of risk contexts and conditions. Given that previous research has shown that our decisions are influenced by probability and severity and

that ouremotional responses can predict behavior and decision making, a good instrument that assesses affective reactions to riskshould be able to capture these. Additionally, we have included several other measures (e.g., Domain-Specific Risk Taking Scale (*DOSPERT*), Ten-item Personality Inventory (*TIPI*), and The Berlin Numeracy Test (*BNT*)) to demonstrate convergent and divergent validity and conduct exploratory analyses.

Objective

The objective of the current study is to assess to what extent the Berlin Emotional Responses to Risk Scale (BERRS) is sensitive to subtle changes in risk severity and probability across diverse risk contexts (e.g., environmental, technological, etc.) and can predict behavioral intentions, allowing us to further our psychometric assessment of the BERRS' sensitivity and predictive validity. We also seek to test the instrument's convergent and divergent validity and assess the instrument's relationship to numeracy.

Hypotheses

We hypothesize that risk severity and probability will affect participants' scores on the BERRS, their willingness to engage in a risky behavior, and their willingness to pay to reduce their risk. We expect that as risks increase in severity and in their probability of occurrence, participants' negative affective reactions will increase and their positive affective reactions will decrease. In addition, we expect the global BERRS scores to be negatively correlated with participants' willingness to take the risk and positively correlated with the amount of money participants are willing to pay to avoid the risk. In other words, the higher participants score on the global BERRS, the less willing we expect them to be to take the risk and the greater amount of money we expect them to be willing to spend to avoid the risk.

Further, we expect global BERRS scores to be negatively correlated with scores on the DOSPERT (e.g., we expect participants who have a higher risk-taking propensity according to the DOSPERT to show weaker global affective reactions to risk), thusdemonstrating convergent validity. Wealso expect the global BERRS scoresto be correlated with the scores of the emotional stability domain of the TIPI, but not with the remaining personality dimensions, demonstrating divergent validity. Finally, we expect responses on the BERRS to be associated with numeracy skills, as measured by the BNT.

Ethics Statement

The study protocol was approved by the Norman Campus Institutional Review Board (OU-NC IRB) at the University of Oklahoma.

Experiment 1: Pilot Study

In order to assess the extent to which the BERRS is sensitive to subtle changes in risk severity and probability across diverse risk contexts, we first designed the risk scenarios with varying severity levels, making sure to devise a manipulation check for the risk severity levels via a pilot study. The purpose of the pilot study was to ascertain whether participants' perceived severity ofthe scenarios varied according to their risk severity level across all risk contexts, ensuring that thescenarios could be used in the main study.

Method

Participants. Fifty participants were recruited via an online post on Facebook[1] that advertised the need for volunteers to complete an anonymous, online survey. Three participants were excluded from the study due to a self-reported lack of English fluency, resulting in a total of

[1]Facebook is an American online social media and social networking website.

47 participants (15 males, 30 females, 2 other) between 20 and 77 years of age (*M*= 29.62, *SD*= 9.39). Participants represented 13 different nationalities with American (45%) and Bulgarian (11%) nationalities making up the majority. Participants did not receive compensation for their participation but were thanked for their contribution.

Design. The pilot study was a 6 x 3 within-subjects design with two independent variables, risk type (6 levels: technological, environmental, health, social, ethical, and financial) and risk severity (3 levels: mild, moderate, high), as the within-subjects factors. The dependent variable was participants' perceived severity, measured by their severity ratings of the outcomes of the risk scenarios.

Materials. The participants completed an online survey consisting of 18 different risk scenarios that varied in risk type (i.e., technological, environmental, health, social, ethical, and financial) and risk severity (i.e., mild, moderate, and high). All scenarios were designed for the purposes of this study. For example, the financial risk scenarios were the following: "Imagine you invested some money in a company… *mild:*whose stock values consistently remained stagnant for the past 5 years/ *moderate:*whose stock values consistently declined in value over the past 5 years/ *high:*that went bankrupt and caused you to lose your investment" (see Appendix A for more examples).The order in which the six risk types and their three severity levels were presented was randomized. Participants were asked to rate the severity of the outcome of each risk scenario on a Likert scale from 1 (not at all severe) to 7 (extremely severe). The end of the survey included four demographic questions.

Procedure. The study was advertised as a "Risk Perception" survey. Participants clicked on the link provided on the Facebook post advertising the online survey and were redirected to

the Qualtrics[2] platform to begin the survey. They read a brief introduction and the informed consent prior to participating. All participants 18 years of age or older were eligible. The entire survey took approximately five minutes to complete on average. Upon completion, participants were thanked for their participation.

Results

A repeated measures analysis of variance with a Greenhouse-Geisser correction was conducted with risk type and risk severity as independent variables and perceived severity as a dependent variable to determine if risk severity had an effect on perceived severity. Table B1 demonstrates that there was a significant main effect of risk severity on participants' perceived severity ratings for all six risk type scenario outcomes (see Appendix B). Post hoc tests using the Bonferroni correction revealed that participants rated the outcomes of the high-risk scenarios significantly higher in severity than the outcomes of moderate-risk scenarios (see Table B2 in Appendix B). In addition, both high-risk and moderate-risk scenario outcomes were rated significantly higher in severity than the mild-risk scenario outcomes. These results were consistent across all risk type scenarios.

Discussion

This pilot study served as a manipulation check for the mild, moderate, and high-risk severity scenarios that were created for use in the main study. Results revealed that participants' perceived severity differed significantly between scenarios with mild, moderate, and high-risk severity outcomes across all scenario categories (i.e., technological, health, social, financial, environmental, and ethical). These results indicate that the severity manipulations in all scenarios have the intended effects and are thus suitable for use in our main experiment.

[2] Qualtrics is a web-based tool for creating and distributing online surveys.

Experiment 2: Main Study

The purpose of the main experiment was to assess the extent to which the Berlin Emotional Responses to Risk Scale (BERRS) was sensitive to subtle changes in risk severity and probability across diverse risk contexts (e.g., environmental, technological, etc.) and could predict behavioral intentions, allowing us to further our psychometric assessment of the BERRS' sensitivity and predictive validity. We also aimed to assess the instrument's convergent and divergent validity and conduct exploratory analyses to assess the instrument's relationship to numeracy.

Method

Participants. The participants were 515 Amazon Mechanical Turk (MTurk)[3] workers (257 males, 257 females, 1 other) between 18 and 79 years of age (M = 35.67, SD = 12.72) that agreed to complete our anonymous survey that was advertised on the MTurk platform. They volunteered to be part of the research study in exchange for compensation according to the terms of Amazon's MTurk. Participants were eligible if they were MTurk workers residing in the United States, at least 18 years of age, and fluent in the English language. Participants were Caucasian (71%), African American (14%), Asian (6%), Hispanic (6%), and other (3%). They had completed high school or less (9%), had some college education (17%), had a 2-year college degree (11%), had a 4-year college degree (41%), or had a Master's degree or higher (22%). Participants were students (5%), employed (83%), unemployed (7%), or retired (5%).

Materials.

Risk scenarios. Six risk scenarios were developed for the purposes of this research on the basis of the pilot study. Each scenario pertained to a risk type category (i.e., technological,

[3]Amazon.com's Mechanical Turk is a crowdsourcing platform where tasks are distributed to anonymous workers online.

health, social, financial, ethical, and environmental) and included a brief description of a risk-relevant situation and its possible future outcome (see Appendix C). The outcomes varied in terms of risk severity (i.e., mild, moderate, high, identical to the pilot study) and probability of their occurrence (i.e., low, 5%; medium, 50%; high, 95%), leading to a total of 54 risk scenario variations. For instance, the health risk scenario was the following: "You have been having some really unpleasant allergies recently. Because of these allergies you haven´t been able to breathe and sleep properly, so they have really affected your quality of life. You went to the doctor and he prescribed you a medicine that is effective at reducing the allergy symptoms. You are considering buying the medicine and before you do, you consult its leaflet online." The possible future outcomes (nine severity*probability variations) were the following: "Imagine the leaflet says that as a side effect the medicine could cause *mild severity*: some mild stomach problems/ *moderate severity*: some quite unpleasant and persistent stomach problems/ *high severity*: some quite unpleasant and persistent stomach problems that even kept you at bedrest. It says that the risk of such side effect happening is quite *low*, about 5%/ *medium*, about 50%/ *high*, about 95%."

Berlin emotional responses to risk scale (BERRS). The BERRS was used to assess affective reactions to brief descriptions of the risk scenarios. Participants were asked to indicate how they would feel about engaging in a risky behavior. Specifically, they were instructed to indicate how assured, hopeful, relieved, anxious, afraid, worried they would feel on a scale from 1 (not at all) to 7 (extremely). The order in which the adjectives appeared was randomized. Participants' ratings across all negative adjectives (i.e., anxious, afraid, worried) were averaged to compute negative affect and their ratings across all positive adjectives (i.e., hopeful, relieved, assured) were averaged to compute positive affect. A global score on the BERRS was also calculated by averaging the ratings of negative and reverse-scored positive adjectives.

Intention criterion item. This item was created to measure participants' willingness to engage in each risky behavior, or willingness to take the risk (WTR). Participants were asked to rate how willing they would be to engage in the risky behavior in question on a scale from 1 (Not at all willing) to 7 (Extremely willing). For instance, for the health scenario participants were asked, "How willing would you be to take this medicine?"

Willingness to pay criterion item. This item was created to measure participants' willingness to pay to reduce one's risk (WTP). Participants were given a brief description of an alternative option to a given risky behavior (e.g., taking a medication with a fewer risk of side effects) and asked how much they would be willing to pay for this alternative by indicating an amount in U.S. dollars.

Berlin numeracy + Schwarz test (BNT). The adaptive version of the BNT in this study, consisting of three items from the Schwartz test and four items from the BNT, was used to assess statistical numeracy and risk literacy skills (Cokely et al., 2012; Schwartz, Woloshin, Black & Welch, 1997). Participants were instructed to solve a series of math-type problems without the use of a calculator. Sample items included, "Imagine that we flip a fair coin 1,000 times. What is your best guess about how many times the coin would come up heads in 1,000 flips?" and "Imagine we are throwing a five-sided die 50 times. On average, out of these 50 throws how many times would this five-sided die show an odd number (1, 3 or 5)?" Scores on the test were calculated by adding the total number of correct answers. This instrument has demonstrated to be a strong predictor of one's ability to comprehend everyday risks and make good decisions (Cokely et al., 2012).

Domain-specific risk taking scale (DOSPERT). The revised 30-item scale was used to assess risk-taking in five different domains: ethical, financial, health/safety, recreational, and

social decisions (Blais& Weber, 2006). Participants were instructed to rate the likelihood that they would engage in domain-specific risky activities on a 7-point rating scale ranging from 1 (Extremely unlikely) to 7 (Extremely likely). Sample items included "Engaging in unprotected sex" (health/safety), "Moving to a city far away from your extended family" (social), and "Investing 10% of your income in a new business venture" (financial). Overall risk-taking scores were calculated by adding item ratings across all 30 items. The higher the overall scale score, the greater the risk-taking propensity. Domain scores were calculated by adding item ratings across all items of a given subscale (e.g., ethical). This instrument's 30- item scale demonstrated high internal consistency reliability for risk-taking scores (mean $\alpha = .85$ across the five domains) in the current study.

Ten-item personality inventory (TIPI). This brief 10-item measure of the Big Five (or Five-Factor Model) personality dimensions was used to assess extraversion, agreeableness, conscientiousness, emotional stability, and openness to experience (Gosling, Rentfrow, & Swann, 2003). Participants were instructed to indicate the extent to which they agreed or disagreed with the statement, "I see myself as," followed by a pair of traits (e.g., anxious/easily upset, calm/emotionally stable) on a 7-point rating scale ranging from 1 (Disagree strongly) to 7 (Agree strongly). Scores on each of the five dimensions were calculated by averaging the participant's ratings on the corresponding items for each dimension. The TIPI has been shown to reach adequate levels of convergence with Big-Five measures and test-retest reliability (Gosling, Rentfrow, & Swann, 2003).

Design. This study employed a 6 x 3 x 3 within-subjects design with two independent variables, risk severity (three levels- mild, moderate, high) and probability (three levels- low, medium, high), as the within-subjects factors. Risk type (six levels- technological, health, social,

financial, ethical, environmental) was made a between-subjects factor to shorten the length of the survey for participants. The dependent variables were scores on the BERRS, willingness to take the risk (WTR), and willingness to pay (WTP).

Procedure. Once participants clicked on the link provided on the MTurk website to complete the advertised task, they were directed to the survey titled, "How do you feel about risk?" Participants read the introduction and informed consent for our anonymous, confidential, and completely voluntary survey which explained the purpose of the study, what they would be asked to do, how long the task would take, and provided compensation information as well as contact details for any inquiries or complaints. After consenting to their participation, the participants were randomly assigned to one of six risk type categories (e.g., health) and were given a brief text of a risk scenario to imagine (as aforementioned; also in Appendix C). Next, they were presented with nine variations of possible outcomes in random order, which varied in risk severity and probability. After each possibility, the participants had to indicate how they would feel about engaging in the risk-relevant behavior in question on the BERRS, how willing they would be to engage in the risk-relevant behavior, and how much they would be willing to pay to reduce their risk given an alternative option. After the risk scenario questions, the participants answered the seven items of the BNT, followed by the 30-item DOSPERT questionnaire. Next, they completed the ten items of the TIPI and seven demographic questions (e.g., age, sex, education). Upon completion, participants were thanked and awarded their compensation. The entire survey took approximately 20 minutes to complete on average.

Results

All analyses were conducted using the statistical software program SPSS 24. The criterion for statistical significance used was $p < .05$. Effect size was interpreted using partial eta-

squared (η_p^2) with values .01, .06, and .14 used as benchmarks for small, medium, and large effect sizes, respectively (Cohen, 1988). For Pearson's correlation coefficient (*r*), values between ± .50 and ± 1 denoted a strong correlation, values between ± .30 and ± .49 denoted a moderate correlation, values below ± .29 denoted a weak correlation, and values of zero denoted no correlation(Cohen, 1988).

Sensitivity of the global BERRS score. A repeated measures mixed analysis of variance with a Greenhouse-Geisser correction was conducted with risk severity and probability as the independent variables and within-subjects factors, risk type as a between-subjects factor, and global BERRS scores as the dependent variable. We sought to determine if risk severity and probability had an effect on affective reactions as indicated by participants' global BERRS scores. Results indicated that there was a significant main effect of risk severity on participants' global BERRS scores, $F(1.78, 904.02) = 91.23$, $p < .001$, $\eta_p^2 = .15$. In addition, there was a significant main effect of probability on their global BERRS scores, $F(1.36, 692.57) = 266.43$, $p < .001$, $\eta_p^2 = .34$. We also found there was a significant interaction between the severity of the risk and probability of the risk occurring,$F(3.62, 1844.29) = 2.62$, $p < .05$, however, with a much smaller effect size, $\eta_p^2 = .01$. Table 1 provides descriptive statistics and Figure 1(a) demonstrates mean global BERRS scores across risk severity and probability conditions, with affective reactions increasing with increases in risk severity and probability.

Sensitivity of the BERRS negative and positive components. To determine the extent to which risk severity and probability had an effect on positive and negative affect, we ran separate repeated measures ANOVAs. Results demonstrated main effects for severity and probability, similar to those with the global score. Negative affective reactions increased and positive affective reactions decreased with increasing risk severity and probability, as shown in figures

1(b) and 1(c), respectively. Descriptive statistics are shown in Table 1 and summaries of the ANOVAs are available in Table B3 (see Appendix B).

Predictive validity of the BERRS. We conducted Pearson correlations between participants'BERRS scores and WTR as well as WTP. Due to the right-skewed distribution of the WTP variable, we transformed the variable by computing its natural logarithm prior to conducting our analyses. In addition, one participant's responses were excluded from our analyses for not being within three standard deviations from the mean (logWTP> 9.65). Results revealed strong significant negative correlations between global BERRS scores and WTR across all conditions (r > - .5), and weaknegative correlations between global BERRS scores and WTP (see Table 2). With regards to the BERRS negative component, results revealed weak but significant negative correlations between negative BERRS scores and WTR and weak but significant positive correlations between negative BERRS scores and WTP. For the BERRS positive component, results indicated strong significant positive correlations between positive BERRS scores and WTR and weak to moderate significant positive correlations between positive BERRS scores and WTP (see Table 2).In summary, although there was variability between scenarios as is to be expected, responses on the BERRS were related to willingness to take risks and willingness to pay to avoid risks, and the positive BERRS component was a much stronger predictor of these outcome variables.

Convergent/divergent validity and exploratory analyses. For the subsequent analyses, we computed means for the global, positive, and negative BERRS scores (they were averaged for each participants across the nine severity*probability scenarios) and conducted these analyses using these mean scores.

Convergent validity.To test for convergent validity, we conducted Pearson correlations between the mean global, mean positive, and mean negative BERRS scores and overall DOSPERT scores. Results indicated a significant strong negative correlation between mean global BERRS scores and overall DOSPERT scores (r= -.50), a significant strong positive correlation between mean positive BERRS scores and overall DOSPERT scores (r= .65), and a significant but weak positive correlation between mean negative BERRS scores and overall DOSPERT scores (r= .19). We furthered our analyses by conducting Pearson correlations between the mean global BERRS scores and DOSPERT domain scores within the same scenario context (e.g., the correlation between scores on the DOSPERT health domain and the global BERRS for participants allocated to the health scenario; see Table 3). Results revealed strong significant negative correlations between global BERRS scores and ethical and financial domain scores, a moderate significant negative correlation between global BERRS scores and health domain scores, and a weak but significant negative correlation between global BERRS scores and social domain scores (see Table 3). Consequently, responses on the BERRS were related to scores on the DOSPERT (i.e., participants reporting stronger positive and weaker negative emotions on the BERRS also reported higher general risk-taking propensity), and the positive BERRS component was a much stronger predictor.

Divergent validity.To test for divergent validity, we conducted Pearson correlations between mean global BERRS scores (and its positive and negative components) and TIPI domain scores. As seen in Table 4, global and positive BERRS scores had significant weak (and both positive and negative) correlations with the majority of personality domains. The negative component of the BERRS did not have any correlations with the TIPI domains. Essentially, participants' reported positive emotions on the BERRS, but not their negative emotions, were related to scores on all five personality domains.

Exploratory analysis. We conducted Pearson correlations between mean global BERRS scores (and its positive and negative components) and overall BNT scores. Results revealed a significant moderate positive correlation between global BERRS scores and overall BNT scores (r = .33), a significant moderate negative correlation between positive BERRS scores and overall BNT scores (r = -.43), and a significant but weak negative correlation between negative BERRS scores and overall BNT scores (r = -.14).Responses on the BERRS were related to BNT scores (i.e., participants reporting stronger affective reactions on the BERRS also reported higher general numeracy skills) and those with higher numeracy skills were consistently less optimistic, or reported less strong positiveaffective reactions to risk.

Discussion

The results of our analyses supported our hypothesis that the BERRS would be sensitive to manipulations of risk severity and probability across diverse types of risk (i.e., technological, environmental, health, ethical, social, and financial). Results showed that risk severity (i.e., mild, moderate, high) and probability (i.e., low, medium, high) of the risk scenarios each had an effect on individuals' global BERRS scores (and both negative and positive components) across conditions and risk types. Like we expected, as the risk scenarios increased in risk severity as well as probability, participants' global affective reactions increased, or more specifically, their negative affective reactions increased and their positive affective reactions decreased. We also found a significant interaction between risk severity and probability on affective reactions. This tells us that participants' reported affective reactions across scenarios of different levels of risk severity were different for scenarios with low, medium, and high probabilities. Essentially, their affective reactions to risk were a function of both severity and probability, highlighting the BERRS' ability to capture these subtleties. These findings are in line with research showing that

the affective heuristic can guide our risk perceptions and inform our decision making (Alhakami&Slovic, 1994; Finucane, Alhakami, Slovic, & Johnson, 2000).

Furthermore, responses on the BERRS were related to willingness to take risks and willingness to pay to avoid risks, and the positive BERRS component was a much stronger predictor of these behavioral intentions. As expected, participants' global BERRS scores were negatively correlated with WTR. Participants who reported higher global affective reactions to risk (i.e., stronger negative and weaker positive affective reactions) also reported being less willing to take the proposed risk, or were more risk-averse, echoing results of previous research (Kuhnen& Knutson, 2005). It is interesting to note that of the negative and positive BERRS components, the positive component demonstrated to have a stronger relationship with willingness to take the risk, proving to be a better predictor of this behavioral intention.According to Lopes (1987), when facing a risky situation where we stand something to lose, our negative emotions (e.g., fear, worry) are more relevant since we are motivated to be safe. When facing a risky situation where we can improve our circumstances, our positive emotions (e.g., hope) are more important since we are motivated by the potential to gain something. Since participants in our study were always presented with an alternative option to mitigate their risk, or had the potential to improve their circumstances, perhaps their positive emotions were the primary drivers of their decision-making, resulting in the positive BERR component being a better predictor.With regards to willingness to pay, we hypothesized that the BERRS would bepositively correlated with WTP, or that the higher the global affective reactions of the participants (i.e., stronger negative and weaker positive affective reactions), the greater the amount of money they would be willing to pay to avoid the risk. While stronger negative affective reactions were in fact associated with greater amounts of money participants would be willing to pay, the same was true for positive affective reactions and the association for the

positive component was even stronger. Previous research has shown that participants induced to be in a positive mood have shown to be willing to pay more for a risk-relevant item than those induced to be in a negative mood (Peters, Västfjäll, &Starmer, 2004). Thus, it may just have been that participants who were in a more positive mood in general were also willing to pay more for the alternative.Consequently, the results did not support our hypothesis and showed that participants who reported higher global affective reactions to risk also reported lower amounts of money they would be willing to pay to avoid risks. It is important to note that although the negative correlation between global affective reactions and WTP was significant, it was also weak. In addition, prior to our analyses we observed that participants' WTP responses had a right-skewed distribution, begging the question as to why participants responded the way they did. A possible reason for these findings may be that participants' perceived immediacy of the proposed risks was not great enough to significantly influence their decision-making regarding how much money they were willing to pay across conditions, considering the hypothetical nature of the risk scenarios (Loewenstein et al, 2001). Another possibility is that the alternative options provided for this criterion item may not have sufficiently resonated with participants, possibly leading to apathy with regards to how much money they would be willing to spend.

With regards to convergent validity, our findingssupported our hypothesis that global affective reactions would be negatively correlated with overall DOSPERT scores.Results indicated that participants reporting lower affective reactions to risk (i.e., stronger positive and weaker negative emotions on the BERRS) also reported higher overall DOSPERT scores (i.e., higher general risk-taking propensity), and the positive BERRS component was a much stronger predictor. Further analyses of correlations between responses on the BERRS and scores on individual DOSPERT domains within the same scenario context yielded similar results. This speaks to the BERRS' ability to predict participants' risk-taking in a variety of contexts (i.e.,

ethical, financial, health, and social types of risk). Essentially, our test for convergent validity supports the idea that the BERRS and the DOSPERT (both measures for risk-taking) are actually related, and that this can be observed across a variety of contexts. The results are also in line with previous research showing that experiencing positive affect is associated with greater risk-taking while experiencing negative affect is associated with being more risk-averse (Isen, 1997; Mittal &Ross, 1998; Lerner & Keltner, 2000).

Contrary to our hypothesis that the responses on the BERRS would be related to emotional stability but not the other personality domains of the TIPI, results showed that global affective reactions were correlated (albeit only weakly) withall personality domainsexcept emotional stability (i.e., extraversion, agreeableness, conscientiousness, and openness to experience). Additionally, its positive affective component, but not the negative component, correlated with all personality domains. While these results were unexpected and did not support the BERRS' divergent validity, they serve to illustrate that our personalitiesmay be related to our affective reactions to risk-relevant information requiring decision-making. Such associations have been previously proposed, as inLerner et al.'s (2015) emotion-imbued choice (EIC) modelthat illustrates the ways in which emotion influences our decision-making processes. In this model, the characteristics of the decision maker (e.g., personality traits, preferences) are shown to have the ability to influence the emotions one feels at the time of decision-making, and in turn, our decision-making processes.Further, previous research has indeed shown associations between Big Five personality domains (e.g., extraversion) and affective reactions to emotional events and stimuli (Hoerger&Quirk, 2010; Lerner & Keltner, 2000; Zelenski& Larsen, 2001). Moreover, the TIPI may have also proven to be an inadequate test for the BERRS' divergent validity because research has shown personality domains to be related with risk-taking

propensity, which is also predicted by the BERRS (Nicholson, Soane, Fenton-O'Creevy,& Willman, 2005).

Finally, the exploratory analyses we conducted via correlations between BERRS scores and overall BNT scores revealed that responses on the BERRS were related to BNT scores, where participants reporting stronger affective reactions on the BERRS also reported higher general numeracy skills. We also found that people with higher numeracy skills were consistently less optimistic, or reported weaker positiveaffective reactions to risk. These results suggest that individual differences in numeracy skills may be associated with different affective reactions to risk. Previous research has indeed shown that such associations have been observed, albeit in a different direction than that in our study (Peters et al., 2006; Petrova, van der Pligt, & Garcia-Retamero, 2014). For instance, individuals with low numeracy have reported stronger negative and weaker positive affective reactions (e.g., more fear and less hope) than individuals with high numeracy when faced with a low probability of loss (Petrova et al., 2014).Essentially, one's ability to understand numerical information may drive one's preference for using different sources of information (e.g., numbers, text, visuals) to interpret a risk-relevant situationat hand.

Conclusion

Overall, the results of this study have yielded substantial support for the BERRS' sensitivity to subtle variations in risk severity and probability across a variety of risk contexts. The results have also demonstrated the BERRS predictive validity for behavioral intentions such as an individual's willingness to engage in a risky behavior. While the relationship between responses on the BERRS and participants' willingness to pay to reduce one's risk was tenuous at best, we do have more insight on what improvements we can make in future studies. For instance, we could conduct additional trials to confirm the reliability of our manipulation of risk

severity. We could also develop new risk scenarios and have participants rate the severity outcomes in terms of the vividness with which they could imagine anticipated outcomes and in terms of their perceived immediacy of the risk. In addition, we could develop new alternative options for the WTP criterion and run a pilot study to test that participants actually view them as both more appealing and less risky options.

The results of the study also supported the notion that the BERRS and the DOSPERT (both measures for risk-taking) were related, suggesting convergent validity. While divergent validity was not supported by our results, our unexpected findings pointed to a potential link between dimensions of personality and people's emotional reactions to risk. Finally, our results revealed that stronger affective reactions to risk were associated with higher numeracy skills and those with higher numeracy skills were generally less optimistic, providing a possible explanation for why individuals with higher numeracy make better risky decisions and attain better outcomes.These results serve to encourage future research to delve deeper into these associations and their possible repercussions in terms of people's decisions about risk.

Although brief, this study has important implications for risk communication and decision-making research. Since there are currently no standardized scales that have been validated for the evaluation of affective reactions to risk, expanding on the assessment of the psychometric sensitivity and predictive validity of the BERRS has allowed us to make progress in our pursuit of validating such a tool. This scale has the potential to become a powerful instrument for evaluating our affective reactions to everyday risks with the goal of helping us to make more informed and better decisions. Its brevity and simplicity makes the BERRS practical for use in real-life situations, such as in a healthcare setting when individuals are tasked to make critical decisions regarding a medical treatment. The BERRS can also be used as a tool to

evaluate the affective reactions that particular risk communications (e.g., visual aids and pamphlets) can induce in their audiences, thereby facilitating their development and improvementto ensure they meet their intended purposes (Visschers et al., 2012). The instrument could also be implemented in educational settings to help students understand how their emotional reactions to risk can influence their behaviors and decisions in numerous areas (e.g, ethics, sex education, and driving safety).The applications are numerous and vast in scope, transcending the area of psychology to other disciplines such as economics and sociology.

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Figures and Tables

Table 1

Descriptive Statistics for Global, Positive and Negative BERRS (N=515) in Experiment 2 (Main experiment)

				95% CI	
BERRS	Condition	Mean	Std. Error	Lower Bound	Upper Bound
Global	Mild severity	4.16*	0.04	4.08	4.24
	Moderate severity	4.44*	0.04	4.36	4.53
	High severity	4.59*	0.04	4.50	4.68
Global	Low probability	3.78*	0.05	3.69	3.87
	Medium probability	4.53*	0.04	4.44	4.61
	High probability	4.88*	0.05	4.78	4.98
Positive	Mild severity	11.50*	0.18	11.15	11.86
	Moderate severity	10.45*	0.19	10.07	10.82
	High severity	9.99*	0.20	9.60	10.38
Positive	Low probability	13.39*	0.19	13.03	13.76
	Medium probability	9.92*	0.21	9.51	10.33
	High probability	8.62*	0.24	8.16	9.08
Negative	Mild severity	13.13*	0.18	12.77	13.49
	Moderate severity	14.23*	0.17	13.90	14.57
	High severity	14.71*	0.18	14.37	15.06
Negative	Low probability	11.72*	0.21	11.30	12.14
	Medium probability	14.58*	0.18	14.23	14.94
	High probability	15.78*	0.19	15.40	16.14

Note. Std. = Standard. CI = Confidence Interval. *Bonferroni comparisons showed that means were significantly different from their respective severity and probability levels, $p < .05$.

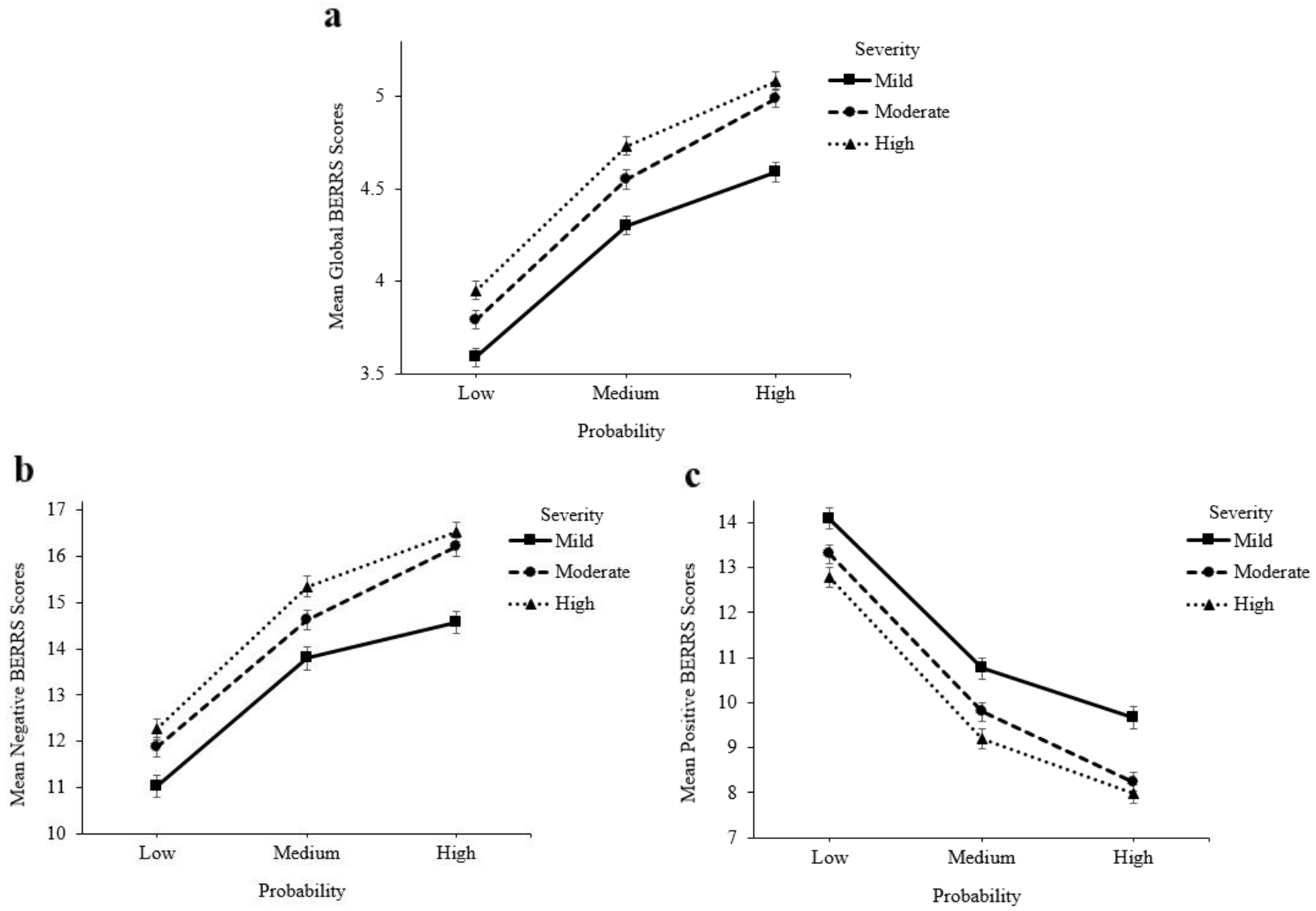

Figure 1. Mean global BERRS (a), mean negative BERRS (b), and mean positive BERRS scores (c) across risk severity and probability conditions in Experiment 2 (Main experiment). Standard errors of the means are represented in the figure by error bars.

Table 2
Pearson Correlations for Global BERRS Scores (Including Negative and Positive Components) and WTR/ WTP

Condition (risk severity-probability)	Global BERRS		Negative BERRS		Positive BERRS	
	WTR (*r*)	*WTP* (*r*)	*WTR* (*r*)	*WTP* (*r*)	*WTR* (*r*)	*WTP* (*r*)
1. Mild-Low	-.58**	-.38	-.25*	.24*	.74*	.21*
2. Mild-Medium	-.65**	-.16**	-.16*	.15*	.78*	.31*
3. Mild-High	-.70**	-.16**	-.24*	.09*	.81*	.28*
4. Moderate-Low	-.60**	-.02	-.27*	.23*	.77*	.21*
5. Moderate-Medium	-.74**	-.26**	-.17*	.11*	.84*	.38*
6. Moderate-High	-.74**	-.20**	-.22*	.04	.85*	.29*
7. High-Low	-.66**	-.14**	-.28*	.14*	.82*	.29*
8. High-Medium	-.75**	-.23**	-.21*	.08	.84*	.33*
9. High-High	-.76**	-.18**	-.24*	.07	.87*	.30*

Note. * $p < .05$ (two-tailed). ** $p < .01$ (two-tailed).

Table 3

Pearson Correlations for Mean Global BERRS Scores and DOSPERT Domain Scores of Matching Risk Context

Between-subjects condition (risk context)	Mean Global BERRS *(r)*
1. Ethical	-.68**
2. Financial	-.50**
3. Health	-.46**
4. Social	-.24*

Note. * $p < .05$ (two-tailed). ** $p < .01$ (two-tailed).

Table 4

Pearson Correlations for Mean BERRS Scores and TIPI Domain Scores

Mean BERRS Scores	Extraversion (*r*)	Agreeable-ness (*r*)	Conscientious-ness (*r*)	Emotional stability (*r*)	Openness (*r*)
1. Global	-.15*	.21*	.25*	.08	.18*
2. Positive	.20*	-.20*	-.24*	-.12*	-.17*
3. Negative	.06	.08	.09	-.04	.06

Note. *$p < .01$ (two-tailed).

Appendix A

"Risk Perception" Survey Scenarios

Below are the 18 different risk scenarios included in the risk perception survey (pilot study).

Technological

Imagine your computer has been infected with a new virus and it has infected a couple of computer files *mild severity*: but without serious consequences/ *moderate severity*: and caused permanent loss of these files/ *high severity*: caused permanent loss of these files, and wiped some of your hard drive irreversibly.

Health

Imagine your doctor prescribed you a medicine that had unwanted side effects, in particular, it *mild severity*: caused some mild stomach problems/ *moderate severity*: caused some quite unpleasant and persistent stomach problems/ *high severity*: caused some quite unpleasant and persistent stomach problems that even kept you at bedrest.

Social

Imagine you accepted a job offer at a start-up company; however, after a while the company was not doing very well and this led to *mild severity*: a small reduction in working hours that slightly decreased your pay/ *moderate severity*: a reduction to a part-time position that decreased your pay substantially/ *high severity*: you were fired at a moment's notice.

Financial

Imagine you invested some money in a company *mild severity*: whose stock values consistently remained stagnant for the past 5 years/ *moderate severity*: whose stock values consistently declined in value over the past 5 years/ *high severity*: that went bankrupt and caused you to lose your investment.

Ethical

Imagine you were caught making unapproved purchases using a company card and were *mild severity*: asked to reimburse the company for the spending/ *moderate severity*: given a week of suspension without pay/ high severity: fired from your job.

Environmental

Imagine you bought a new cleaning product that had unwanted side effects on the environment, in particular, it *mild severity*: decreased the food supply for fish in streams and lakes/ *moderate severity*: decreased the food supply for fish in streams and lakes and harmed their reproduction/ *high severity*: decreased the food supply for fish in streams and lakes, harmed their reproduction, and killed them.

Appendix B

Table B1
Repeated Measures ANOVA Summary for Perceived Severity Across Risk Type Scenarios in Experiment 1 (Pilot Study)

Risk Type	Source	Sum of Squares	*df*	Mean Square	F	Partial Eta Squared
Technological	Risk severity	203.59	1.47	138.75	130.53*	.74
	Error	71.75	67.50	1.06		
Health	Risk severity	144.06	1.74	82.62	85.02*	.65
	Error	77.94	80.21	0.97		
Social	Risk severity	91.76	1.49	61.61	52.60*	.53
	Error	80.24	68.51	1.17		
Financial	Risk severity	130.44	1.68	77.56	65.06*	.59
	Error	92.23	77.36	1.19		
Ethical	Risk severity	171.67	1.75	98.03	60.59*	.57
	Error	130.33	80.56	1.62		
Environmental	Risk severity	38.99	1.42	27.53	47.61*	.51
	Error	37.67	65.14	0.58		

Note. The Greenhouse-Geisser correction has been applied. *$p < 0.001$.

Table B2
Bonferroni Comparisons for Perceived Severity Across Risk Type Scenarios (N=47) in Experiment 1 (Pilot Study)

Risk Type	Comparisons	Mean Difference	Std. Error	95% CI Lower Bound	95% CI Upper Bound
Technological	Mild vs. Moderate	-2.36*	0.21	-2.88	-1.84
	High vs. Moderate	0.34*	0.12	0.06	0.63
	High vs. Mild	2.70*	0.21	2.19	3.21
Health	Mild vs. Moderate	-1.40*	0.15	-1.78	-1.03
	High vs. Moderate	1.06*	0.20	0.57	1.56
	High vs. Mild	2.47*	0.22	1.94	3.00
Social	Mild vs. Moderate	-1.21*	0.15	-1.58	-0.84
	High vs. Moderate	0.75*	0.18	0.31	1.18
	High vs. Mild	1.96*	0.24	1.36	2.56
Financial	Mild vs. Moderate	-1.40*	0.20	-1.89	-0.92
	High vs. Moderate	0.94*	0.17	0.51	1.36
	High vs. Mild	2.34*	0.25	1.73	2.95
Ethical	Mild vs. Moderate	-0.72*	0.24	-1.32	-0.13
	High vs. Moderate	1.89*	0.21	1.39	2.40
	High vs. Mild	2.62*	0.29	1.91	3.32
Environmental	Mild vs. Moderate	-0.79*	0.12	-1.08	-0.50
	High vs. Moderate	0.49*	0.10	0.24	0.74
	High vs. Mild	1.28*	0.17	0.86	1.70

Note. Std. = Standard. CI = Confidence Interval. *$p < .05$.

Table B3

Repeated Measures ANOVA Summaries for Positive and Negative Affect on the BERRS

Affect Type	Source	Sum of Squares	*df*	Mean Square	F	Partial Eta Squared
Positive	Severity	1865.68	1.76	1057.77	85.30**	.14
	Error	11132.27	897.76	12.40		
	Probability	18705.31	1.34	13924.54	322.62**	.39
	Error	29511.40	683.76	43.16		
	Severity*Probability	59.34	3.69	16.08	2.18	.00
	Error	13875.98	1878.07	7.39		
Negative	Severity	2033.11	1.72	1179.35	83.84*	.14
	Error	12342.78	877.48	14.07		
	Probability	13326.45	1.40	9496.57	241.60*	.32
	Error	28075.64	714.28	39.31		
	Severity*Probability	126.86	3.75	33.87	4.40*	.01
	Error	14672.73	1906.40	7.70		

Note. The Greenhouse-Geisser correction has been applied. *p< .01. **p< .001.

Appendix C

"How do you feel about risk?" Survey Scenario Example

Health

You have been having some really unpleasant allergies recently. Because of these allergies you haven´t been able to breathe and sleep properly, so they have really affected your quality of life. You went to the doctor and he prescribed you a medicine that is effective at reducing the allergy symptoms. You are considering buying the medicine and before you do, you consult its leaflet online.

Possibilities: Imagine the leaflet says that as a side effect the medicine could cause ***mild severity***: some mild stomach problems/ ***moderate severity***: some quite unpleasant and persistent stomach problems/ ***high severity***: some quite unpleasant and persistent stomach problems that even kept you at bedrest. It says that the risk of such side effect happening is quite ***low***, about 5%/ ***medium***, about 50%/ ***high***, about 95%.

1. How would you feel about taking this medicine?

	Not at all 1	2	3	4	5	6	Extremely 7
Assured	○	○	○	○	○	○	○
Hopeful	○	○	○	○	○	○	○
Relieved	○	○	○	○	○	○	○
Anxious	○	○	○	○	○	○	○
Afraid	○	○	○	○	○	○	○
Worried	○	○	○	○	○	○	○

2. How willing would you be to take this medicine?

	1	2	3	4	5	6	7	
Not at all willing	○	○	○	○	○	○	○	Extremely willing

3. There is an alternative medicine that could help you and does not expose you to the risk of such a side effect. However, it is not covered by your insurance. How much would you be willing to pay for this alternative medicine? Indicate amount of USD.