Attitudes toward risk and uncertainty:
The role of subjective knowledge and affect

Yiyun Shou and Joel Olney

The Australian National University

Author Note

Yiyun Shou and Joel Olney, Research School of Psychology, The Australian National University. This research was supported by the Australian Government through the Australian Research Council (Project number DE180100015). Correspondence concerning this article should be addressed to Yiyun Shou, Research School of Psychology, The Australian National University, Canberra, ACT 2601, Australia. Email: yiyun.shou@anu.edu.au.

This is a pre-print of the article. The citation and the published version is:

Shou, Y., & Olney, J. (2021). Attitudes toward risk and uncertainty: The role of subjective knowledge and affect. *Journal of Behavioral Decision Making*, *34*(3), 393-404. https://doi.org/10.1002/bdm.2217

Abstract

An individual's attitude toward risk is often measured by their behavioral tendency in risky situations. However, commonly used self-report measures of risk attitudes often do not explicitly specify "risk" in all the items, which results in an unsystematic mix of both perceived uncertainty and risk (as loss). Thus, an individual's endorsement of those items can vary as a function of not only the latent construct of attitudes toward risk, but also factors including prior knowledge and affective reaction to uncertainty. Two studies were carried out to examine the extent to which participants perceive behavioral tendency items as entailing uncertainty or risk (as loss), and how behavioral tendency can be influenced by prior knowledge. Results indicate that endorsement of behavioral tendency was significantly greater when "risk" information was implicit compared to items that had explicit information to contextualize the uncertainty or risk. Furthermore, prior knowledge had a significantly stronger influence on the endorsement of items in which risk information was implicit than on the explicit uncertainty/risk items. Finally, uncertainty and risk in the items appeared to influence behavioral tendency significantly via emotional responses to the items. This research highlights the need for researchers to more adequately control for different sources of variability when measuring the desired construct of attitude towards risk.

Keywords: risk-taking, uncertainty, behavioral tendency, domain specific risk-taking

Attitudes toward risk and uncertainty: The role of subjective knowledge and affect

People make judgments and decisions every day in situations where outcomes are uncertain and unpredictable. Individuals can vary in their choice tendency (whether to take a particular option or not) under these situations, and this tendency is often considered to be part of an individual's attitude towards risk (Weber & Johnson, 2009). Despite its wide use across various disciplines such as psychology, decision sciences, public health, and social sciences, the term "risk" is not conceptualized in the same way in all of these disciplines. Suppose one is facing a simple decision-making situation about whether or not to take a particular action, and the action has outcome states that include the presence/absence of a loss/gain. In fields like economics or decision sciences, the kind of uncertainty implied in a "risky" choice refers to the amount of variance in the outcomes (Schonberg, Fox, & Poldrack, 2011; Smithson, 2010) and risk manifests as a result of not knowing what outcome would occur in such a decision (Weber & Johnson, 2009).

On the other hand, in fields such as policy making, health, and clinical psychology, "risk" usually refers to situations that could involve "possible negative consequences", such as loss of money or suffering personal injuries – with a greater emphasis on losses than on gains (Schonberg et al., 2011). These "risky" situations involve both "loss" and "uncertainty", although the "uncertainty" itself may manifest in a number of different ways. According to the taxonomy of ignorance (Smithson, 2012), manifestations of uncertainty can involve known negative outcome probability (i.e., outcome variance, similar to risk as defined in fields such as economics), unknown negative outcome probability (i.e., ambiguity-uncertainty; e.g., the probability of a loss can be between 0% and 100%), or unknown negative outcomes (i.e., sample space ignorance, Smithson, 2012). Therefore, when speaking about "risk-taking" tendency, especially in psychology and health sciences, this usually rests

on an individual's tolerance of both uncertainty and loss, with a greater emphasis on tolerance of the perceived loss associated with a particular choice.

Unfortunately, in the measurements used to assess risk attitudes across various disciplines, especially those outside economics and the decision sciences, uncertainty and loss are usually not distinguished from each other. This is problematic because there is now sufficient behavioral and neurological evidence to demonstrate that human minds treat the two differently. To further complicate things, responses to uncertainty and loss can interact with other factors, such as prior knowledge and affective processing, differently (Smithson & Pushkarskaya, 2015). Thus, participants using these measurements of risk attitudes can vary in their interpretation and perception of uncertainty versus loss. This can lead to an increase in measurement errors, which, in turn, can substantially attenuate the results that are based on the measures.

The present research focuses on one of the most popular self-report measures of risk attitudes, the Domain-Specific Risk-Taking (DOSPERT) scale (Weber, Blais, & Betz, 2002). This scale is a quintessential measurement of "risk attitudes" where uncertainty and loss are not explicitly specified in the items of DOSPERT. Therefore, participants are left to interpret and perceive the uncertainty and loss within the items themselves. We aim to investigate how people interpret the DOSPERT items in terms of uncertainty and loss. We also examine how variation in people's interpretations can influence their endorsement of DOPSERT items through factors such as prior knowledge and affect.

Situational Based Risk Attitudes and the DOSPERT Scale

Weber and colleagues developed the Domain-Specific Risk-Taking (DOSPERT) scale to account for domain-specific traits that better reflected the complexity of everyday life decisions (Weber et al., 2002). Since its introduction, the DOSPERT has been popular in the literature attempting to understand and measure risk attitudes (Harrison, Young, Butow,

Salked, & Solomon, 2005). The theory underpinning the development of the DOSPERT was that decision makers can vary in their level of risk-taking across different decision domains, such as gambling, finance, or personal decisions (e.g., social, health, recreation, or ethical decisions), without these observations being somehow incongruent with one another.

Despite its popularity as a measurement tool, a recent meta-analysis on the reliability of the DOSPERT revealed that some of the domain subscales had substantially lower internal consistency than the commonly acceptable level (Cronbach's $\alpha s < 0.7$ versus the accepted value > 0.8), indicating potentially large measurement errors in the scale as a whole (Shou & Olney, 2020). The internal consistency reliability of the DOSPERT also varied substantially across different domain subscales, and results were affected by both scale and sample characteristics. Three major factors that may contribute to measurement errors in scales such as DOSPERT include the explicitness of risk, the influence of subjective experience, and the role of emotions.

When operationalizing "risk" in the measurement items, scales such as DOSPERT do not clarify the "risk" in the items. Many items are "risky behaviors" from the authors' perspective in the sense that there is a chance of loss. For example, "riding a motorcycle without a helmet" implies that the possible outcomes are becoming injured or being safe. "Taking some questionable deductions on your income tax return" implies that the possible outcomes are either being caught by the tax office and facing a penalty or getting away with it. Yechiam and Telpaz (2013) found that a higher preference for the choices with uncertain loss in behavioral tasks correlated significantly with the ethical, financial, health, and social domain subscales of DOSPERT. This suggests that risk attitudes, as measured by DOSPERT, could be a mixture of attitudes toward uncertainty and attitudes toward loss.

However, "uncertainty", inclusive of the different types previously mentioned, and "loss" may not be contained or mixed across items systematically, as neither is explicit in the

DOSPERT items. For example, based on the authors' own conceptualization of the DOSPERT (Weber et al., 2002), the behavioral tendency endorsement of the item "taking some questionable deductions on your income tax return" should be driven primarily by the perception of a chance-based loss outcome. However, individuals who are less experienced with tax returns may experience a greater level of uncertainty, such as being uncertain about the chance (ambiguity uncertainty) or being uncertain about all possible negative outcomes (sample space ignorance).

If participants in the target sample all have varying degrees of knowledge about a subset of items in a domain subscale, these items would exhibit poor discriminant abilities in differentiating the level of the latent trait – in this case, risk-taking. The problem of unsystematic inclusion and mixing of uncertainty and loss, thus, can result in additional sources of response error variance for scales such as DOSPERT. These error variances can be contributed to by the varying perception of uncertainty and loss (influenced by prior knowledge), as well as by affective reactions to the perceived uncertainty.

Interference of Prior Knowledge and Experience

There is an extensive literature that indicates risk-taking tendencies are essentially related to prior knowledge and previous experience (e.g., Campbell & Kirmani, 2000; Dodd, Laverie, Wilcox, & Duhan, 2005; Wang, 2009). Increasing levels of past experience has been found to be a significant predictor of behavioral intention in a range of situations (Ajzen, 2002; Norman, Conner, & Bell, 2000; Sommer, 2011). Knowledge and experience influence behavioral tendency by influencing the perceived uncertainty around a particular behavior (Lehto, O'leary & Morrison, 2004). That is to say, having greater experience in regard to a particular behavior increases one's knowledge of potential outcomes (benefits and losses) and their likelihood. This, in turn, results in there being a lower level of uncertainty associated with that behavior.

If it is given that all other variables are held constant, individuals who are less tolerant to uncertainty should have a lower likelihood of (or a higher delay in) endorsing a behavioral choice if they perceive more uncertainty in that choice (Jacoby, Abramowitz, Buck, & Fabricant, 2014; Koerner & Dugas, 2006; Thibodeau, Carleton, Gómez-Pérez, & Asmundson, 2013), as uncertainty in this situation is interpreted as negative and threatening. On the other hand, knowledge and experience influence behavioral tendencies by influencing the perceptions of benefit and loss for particular behavioral choices. For example, in the consumer and tourism literature, it has been found that higher prior knowledge is associated with a lower perceived risk of various recreational risk-taking behaviors (Sharifpour, Walters, Ritchie, & Winter, 2014). Rather than exhibiting a greater tendency for risk-taking, individuals who have greater knowledge and experience of a situation may demonstrate a greater endorsement of a particular behavioral item as a result of experiencing lower uncertainty. Investigating how prior knowledge and experience can moderate the endorsement of risk attitude items in DOSPERT may assist our understanding of how individuals perceive uncertainty and loss in those items.

The Role of Affect

The theory of attitude proposed by Rosenberg and Hovland (1960) suggests three main components of attitudinal responses: affective (feelings), cognitive (perception and belief), and behavioral (expression of intention or tendency to engage in that behavior). It has also been shown that one's behavioral tendency can be influenced by both affective and cognitive appraisals of a perceived situation (Ostrom, 1969). In general, a more positive affect about the behavior is associated with a greater behavioral tendency, while a more negative affect can be associated with behavioral aversion (Hu, Wang, Pang, Xu, & Guo, 2015). The unsystematic variation of different kinds of uncertainty experienced by subjects

across items in scales such as DOSPERT can introduce variability in the scale ratings via the items' influence on an individual's emotional state.

Greater levels of uncertainty are typically associated with greater negative emotions such as fear and anxiety, and uncertainty can be perceived as a "threat" (Beck & Clark, 1997; Budner, 1962; Freeston, Rhéaume, Letarte, Dugas, & Ladouceur, 1994; Macleod & Mathews, 2012). A greater perceived level of uncertainty would therefore result in a greater level of negative affect, which can, in turn, influence the behavioral tendency. This means that the variability in the level of uncertainty across scale items results in variability of anticipatory emotions associated with uncertainty. This can result in additional noise in the final endorsement of a behavioral tendency item.

The Current Research

The present research aimed to investigate how individuals may interpret behavioral tendency items like those endorsed in the DOSPERT, of which "uncertainty" and "loss" are not explicitly specified. In doing so, we compared ratings in items with unspecified outcomes with items in which either uncertainty or chance of loss was explicitly specified. We hypothesized that participant endorsement of unspecified items would be different from their endorsement of specified items. This would imply the existence of uncontrolled individual differences in the perception of "uncertainty" or "loss" in items such as those that comprise risk-taking scales like DOSPERT. We also investigated if participants' perceptions of uncertainty and loss can be explained by prior knowledge of the behavioral items. Finally, we aimed to investigate the role of affect in determining behavioral tendencies and the extent to which uncertainty would influence behavioral tendencies via affect.

Study 1

Study 1 presented participants with behavioral situation items that differed in their explicitness of uncertainty (variance of outcomes). In the implicit, or unspecified outcomes condition, all items contained only the description of the behavior (e.g., "Taking some questionable deductions on your income tax return"). The extent to which uncertainty was perceived by the participants depended on each participant's subjective interpretation of the situation. In the specified outcomes condition, all behavioral items were presented so that the outcomes were specified but the outcome probabilities were unknown. For example, "Taking some questionable deductions on your income tax return when you don't know whether or not you will be audited" specifies the outcome, however the probability of "being caught" and "getting away with it" can be highly variable if the likelihood of "being audited" is unknown. We examined participants' knowledge (i.e., experience and familiarity) of the subject matter (e.g., "reporting deductions in a tax return"), their likelihood of engaging in such behavior, and their feelings toward these behavioral situations. Participants may not have perceived uncertainty in all items presented in the unspecified outcomes condition, thus we expected that the overall uncertainty perceived in this condition would be lower than in the specified outcomes condition.[1]

First, we hypothesized that participants would have significantly higher behavioral tendency in the unspecified outcomes condition than they would in the uncertainty condition (Hypothesis 1). Next, based on previous research (e.g., Norman, Conner, & Bell, 2000; Sommer, 2011), we hypothesized that the greater familiarity/experience participants had with the item in context, the stronger their tendency would be to engage in those behaviors (Hypothesis 2). As the degree of uncertainty perceived by participants in the unspecified

[1] Based on the conceptualization and assumptions in most risk attitudes scales such as DOSPERT, we assumed participants would at least recognize a chance of loss in the unspecified outcomes items in Study 1.

outcomes condition would depend on subjective knowledge, the relationship between familiarity/experience and behavioral tendency would be stronger in the unspecified outcomes condition than in the specified outcomes condition (Hypothesis 3).

In terms of affect, based on recent literature (Hu, Wang, Pang, Xu, & Guo, 2015), we hypothesized that the more positive affect participants had towards a given behavioral situation, the stronger their tendency would be to engage in those behaviors (Hypothesis 4). As uncertainty can amplify unpleasant feelings, which, in turn, can influence behavioral tendency, we hypothesized that affect would mediate the effect of the specified outcomes condition on behavioral tendency (Hypothesis 5).

Method

Participants. The study was split into two parts to reduce participant burden. The study included demographic information (e.g., age, gender, highest education, first language), familiarity ratings, and behavioral tendency ratings. The second part included experience ratings and affect ratings. Participants who completed the first part of the study were invited to take part in the second part. A total of 173 participants were recruited via Prolific (an online crowdsourcing platform) to participate in the first part of the study. Of these participants, 155 completed the first part without failing the attention catch question and were included in subsequent analyses. The final 155 participants were invited to participate in the second half of the study, of which 144 participants responded and completed the second half of the study. Eight participants failed the attention catch question in the second part of the study and were excluded, which left a final sample of 136 participants that had completed both parts of the study. Participants (49.3% females) ranged in age from 18 to 67, with a mean age of 32.32 (SD = 10.45). Most participants listed English as their first language (94.8%), and all participants were fluent in English. Almost all participants (n = 134) had completed high school, and 66.4% (n = 89) of the sample had completed a tertiary education.

Materials. We used a range of situational items that described daily behaviors and decisions. A total of 90 items were generated from various sources, including the revised version of the DOSPERT (Blais & Weber, 2006), the Moralization of Everyday Life Scale (Lovett, Jordan & Wittermuth, 2012), the Physical Danger Scale (Sellbom, 2014), items generated by the study authors, and items generated by lay participants ($N = 50$) from a pilot open-ended questionnaire study. All items were worded using the same wording approach as the revised version of the DOSPERT (e.g., "speeding on an empty street" or "faking an injury to collect on insurance"). The items that described the behaviors/decisions were used for the unspecified outcomes condition where no further uncertainty or loss information was provided.

For the specified outcomes condition, each of the 90 items was combined with an uncertainty. For example, the uncertainty context for "speeding on an empty street" was "when you do not know whether or not there is a road safety camera", such that outcomes varied between "being caught" and "not being caught" with unknown probabilities.

Participants rated their affect and behavioral intention regarding each of the 90 items for both the unspecified outcomes and the specified outcomes conditions. The affective questions asked participants about their feelings toward each item on a seven-point scale, from "extremely unpleasant" to "extremely pleasant". The behavioral tendency questions asked participants the likelihood that they would engage in the behavior in each situation if faced with the opportunity on a seven-point scale from "extremely unlikely" to "extremely likely".

Participant knowledge of the situations was tested by their subjective familiarity and objective experience of the activity in each situation. For example, the activity in "speeding on an empty street" is "speeding", while the activity in "faking an injury to collect on insurance" is "filing an insurance claim". The subjective familiarity questions asked

participants to rate the extent to which they were familiar with each activity on a five-point scale, where “1= extremely unfamiliar” and “5 = extremely familiar”. The experience questions asked participants to rate their personal experience with each activity using one of the five categories: “1 = never heard of”, “2 = heard of this occasionally, but have had no personal experience”, “3 = heard of this frequently, but have had no personal experience”, “4 = heard of this and have personal experiences”, “5 = have frequent personal experiences”. While the familiarity questions focused more on participants’ confidence in their knowledge of each activity, the experience question asked about their first-hand experience with the activity.

Data analysis. We employed mixed-effects ordinal regression to assess the effects of different variables on behavioral tendency. The original regression coefficients indicate how changes in the value of a predictor would predict the change in odds of endorsing the higher category of the dependent variable, and the exponential of the coefficient can be interpreted as an odds ratio. A significantly positive coefficient (the exponential of the coefficient > 1) suggests that an increase in the value of a predictor would result in greater odds of endorsing the higher category (e.g. “likely” versus “unlikely”). Several regression models were estimated with different model sizes to address different hypotheses. The predictor variables were standardized when entered into a regression model and all models included the participant-level intercept as the random effect term. For Hypotheses 1, 2 and 3, the independent variables in the fixed effect models included the uncertainty context (specified or unspecified outcomes), familiarity, experience, and interaction terms between the uncertainty context and familiarity and the uncertainty context and experience. Affect and the interaction between the uncertainty context and affect were then used to test Hypothesis 4. These models were performed using the “ordinal” package (Christensen, 2019) in R program. Next, a mediation analysis was conducted to examine Hypothesis 5, that affect would mediate the

effect of uncertainty on behavioral tendency. Both the behavioral tendency and affect were treated as the ordered variables. Bootstrapping was applied to estimate the significance of the indirect (mediation) effect. The mediation models were performed using the "lavaan" package (Rosseel, 2012) in R program.

Results

Table 1 displays the descriptive statistics of the various variables in the current data. We also examined the convergence of the two versions of the items. The Spearman's correlation between two versions was 0.78, $p <. 001$ for behavioral tendency ratings, and was 0.70, $p <.001$ for affective ratings.

[TABLE 1]

Role of prior knowledge on behavioral tendency. A sequence of ordinal regression models was carried out to investigate how the variables of interest predicted behavioral tendency. Table 2 displays the results of the models and shows how variable coefficients changed with the inclusion of additional variables.

[TABLE 2]

The first model included the uncertainty context (unspecified vs. specified outcomes) as the fixed effect predictor. As expected in Hypothesis 1, the ratings on behavioral tendency were significantly lower overall when the uncertain context was specified as opposed to when it was unspecified (b = -0.31, $p < .001$, Model 1). The odds of being more likely to engage in the behavior in the specified outcomes condition was 26.7% (=1-exp(b) = 1 – (-0.31)) lower than in the unspecified condition. To examine whether the effect of uncertainty was homogenous across individuals, the model also included the uncertainty context as a random slope term nested with the individual level effect. The random slope of the uncertainty context at the individual level significantly contributed to the model fit ($\chi^2 = 42.73$, $df = 2$, p

< .001), indicating the strength of the effect of the specified outcomes condition varied significantly across individuals.

Subjective knowledge terms measured by familiarity and experience were entered into the model as the second step. Supporting Hypothesis 2, both subjective familiarity (b = 0. 80, p < .001, odds ratio = 2.23, Model 2) and experience (b = 0.49, p < .001, odds ratio = 1.23) had significantly positive associations with behavioral tendency. The significance of the coefficients in the model also suggested that familiarity and experience had independent contributions to the behavioral tendency.

We also predicted that familiarity and experience would have a stronger influence on behavioral tendency when the uncertainty context was implicit (i.e., the unspecified outcomes condition) (Hypothesis 3). The interactions between uncertainty context and the two knowledge variables were entered as the third step. There were significant interaction effects between the uncertainty context and familiarity and experience. As displayed in the Model 2 results section of Table 2, the association between familiarity, experience and behavioral tendency was significantly more positive in the unspecified outcomes condition (b = 0.80 + 0.10 = 0.90 for familiarity; b = 0.49 + 0.06 = 0.55 for experience) than in the specified outcomes condition in which the uncertain context was present (b =0.80 - 0.10 = 0.70 for familiarity; b = 0.49 - 0.06 = 0.43 for experience).

Role of affect on behavioral tendency. The results of Model 3 in Table 2, in which affect was entered into the model, indicated that a more positive affect toward the behavioral situations had a significantly positive association with behavioral tendency (Hypothesis 4; b = 1.33, p < .001, Model 3). For every one standard deviation increase in affective rating, the odds of being more likely to engage in the behavior was multiplied 3.78 times (= exp(b) = exp(1.33)). The association between affect and behavioral tendency did not differ significantly between the conditions of the uncertainty context (Model 4).

A mediation structural model was estimated to examine the indirect effect of the specified outcomes condition through affect. Figure 1 displays the final model. Results demonstrated that there were significant indirect effects of specified outcomes, familiarity, and experience on behavioral tendency through affect (b = -0.19, 0.11 and 0.12, ps < .001). Familiarity also significantly mediated the effect of experience on behavioral tendency, both alone (b = 0.13) and via affect (b = 0.07).

[FIGURE 1]

Across domains. Finally, we explored whether the links among variables were significantly different across domains. The 90 items were categorized into five domains based on both the initial DOSPERT classifications and the ratings of two independent raters. The five domains included ethical (illegal and immoral actions), health (health and medical decisions), financial (gambling and investment), social (social interactions and interpersonal relations), and recreational (recreational activities) domains. A total of 51 items had clear classifications agreed upon by the two raters, while 39 items either involved a mixture of domains, or did not fit into any of the aforementioned five domains. The 51 items were used to analyze domain-specific model effects.

Table 3 displays the means and *SD*s of the affect and behavioral ratings across the five domains. The reliability of each domain was assessed by Cronbach's α and McDonald's ω. The reliability was generally acceptable (α > 0.7 or ω > 0.7) for all domains except for the behavioral tendency ratings of the health domain.

[TABLE 3]

Within each domain, a mixed-effects ordinal regression was performed to predict behavioral tendency from the context condition, familiarity, experience, and affect. Table 4 shows that for all domains, familiarity, experience, and the affective component had significantly positive relationships with behavioral tendency, with the exception of

experience not having a significant influence on behavioral tendency in the ethical and social domains. The effect of the specified outcomes condition was significant in all domains before affect was entered in the model. With the inclusion of affect, the effect of the specified outcome context was no longer significant in the ethical, financial, and recreational domains, indicating a full mediation effect of emotion on the link between the specified outcomes condition and behavioral tendency.

[TABLE 4]

Discussion

The key finding lies in the differences found between the conditions in which uncertainty was either implicitly presented (unspecified outcomes) or explicitly presented (specified outcomes). Both behavioral tendency and affective ratings were significantly lower for the condition where uncertainty was explicitly specified than they were in the unspecified condition. This suggests that participants may attend less to the threatening cues of the uncertainty when reading the implicit items, at least those cues brought about by outcome variance uncertainty.

In addition, the magnitude of the effects of the uncertain context varied across participants, indicating individual differences in the interpretation of the items where uncertainty was implicit. When exploring these individual differences, the results demonstrated that participants' behavioral tendency ratings were influenced by their own prior knowledge and anticipatory affect in a given situation. We found that greater familiarity and previous experience significantly predicted stronger behavioral tendency and such relationships were observed across different decision domains. On one hand, having greater familiarity and past experience implies having greater knowledge of the potential outcomes of a given behavior, thus resulting in a greater perceived controllability in managing these different outcomes. On the other hand, familiarity and past experience may also be the result

of subjects having had more opportunities to encounter that behavioral choice as compared to those who had little prior experience or knowledge.

We also found that experience and familiarity had overlapping as well as independent contributions to behavioral tendency. The overlap between the two suggests that familiarity is partially derived from experience. The independent contributions of the two may also reflect the fact that experience is more objective and passively gained, while familiarity is a more subjective quality. Additionally, the results demonstrated that prior knowledge had a greater impact on ratings in the unspecified outcomes condition, suggesting that the ratings in this condition varied more as a function of prior knowledge. The significant indirect effect of the uncertainty context via affect further supports the idea that uncertainty is the source of an unpleasant affective feeling, which then negatively influences behavioral tendency. The effects of the uncertainty context, prior knowledge, and affect, as well as the mediation effects, were observed in all domains.

It could be argued that the condition in which uncertainty was explicit contains both the cue for outcome variability and the cue for potential loss. While we assumed that participants could, at the very least, recognize the presence of a loss in the unspecified outcomes condition, it is possible that participants may not have. As both the outcome variability cue and the potential loss cue were missing in the implicit condition, it is still unclear which cue led to the key differences between the specified and unspecified outcomes conditions. In addition, it is unclear if the individual differences found between the two conditions were driven by individual differences in recognition of loss or outcome variability. Study 2 furthered our exploration by examining the extent to which participants might have systematic perceptions of risk (as loss) in items when the risks are not specified explicitly.

Study 2

Study 2 included a condition where specific risk (a chance of negative outcomes) was stated within the item. If it was the case that not all participants would be able to recognize risk in the unspecified outcomes items, we expected an overall higher mean endorsement of these items than the items that had risk explicitly stated (specified risk outcomes) (Hypothesis 6). In addition to the replication of the relationships among familiarity, affect, and behavioral tendency shown in Study 1, the relationship between familiarity, experience, and behavioral tendency would be stronger in the unspecified outcomes condition than in the two specified outcomes conditions (risk and uncertainty) (Hypothesis 7). Finally, we expected that affect would mediate the effect of the uncertainty context on behavioral tendency (Hypothesis 8).

Method

Participants. A total of 165 participants (67.2% females) participated in the study. Participant ranged in age from 18 to 77, with a mean age of 35.07 (*SD* = 11.01). Most participants indicated English as their first language (98.79%). Approximately 50.3% of the participants had completed a tertiary education or higher, and 46% of the participants listed high school as their highest level of education. Participants were randomly assigned to one of the three conditions: specified uncertainty (n = 55), unspecified outcomes (n = 54), or specified risk (n = 56).

Materials. A total of 22 items were selected from the 90 items used in Study 1. The wording of the specified outcomes conditions and unspecified outcomes replicated that used in Study 1. For the specified risk condition, specific risk information was attached to each behavioral item. For example, the risk context for “speeding on an empty street” was “when there is a risk of being caught”. For each item situation, participants were asked to rate three things: their familiarity of the subject matter (0 = never heard of, 5 = extremely familiar), their feelings toward the situation (1 = extremely unpleasant, 7 = extremely pleasant), and

their likelihood of engaging in the behavior or action if faced with the opportunity to do so (1 = extremely unlikely, 7 = extremely likely).

Procedure. All questions were set up on the Qualtrics platform and participants were invited to participate in the study via Prolific. Participants were randomly assigned to one of the three conditions. Participants in each condition completed demographic information, as well as familiarity ratings, affective ratings, and behavioral tendency ratings for each of the items in their condition. Items were randomized for each type of the ratings.

Results and Discussion

Table 5 shows the means and standard deviations of the variables of interest. We first examined whether participants across different conditions had significantly different levels of familiarity. Results of a mixed-effects linear regression showed that the ratings were not significantly different between conditions ($\chi^2 = 3.76$, $df = 3$, $p = 0.289$). We then assessed the measurement noise by examining the internal consistency of the affective and behavioral ratings in the three conditions. The Cronbach's α and McDonald's ω are shown in Table 5. The specified risk condition had the highest internal consistency, followed by the specified uncertainty condition. The unspecified outcomes condition had poor internal consistency, indicating potentially high measurement noise.

[TABLE 5]

We then carried out mixed-effects ordinal regression to investigate the moderation effect of the conditions on the effect of familiarity. Due to multicollinearity between affect and behavioral tendency (Spearman $r = 0.74$, compared to $r = 0.61$ in Study 1), we performed the analyses for affect and behavioral tendency separately to avoid a suppression effect. Table 6 shows the final results. Consistent with Study 1, familiarity had a significantly positive relationship with both behavioral tendency and affect. Additionally, compared to the unspecified condition, the specified uncertainty condition significantly reduced affect (b = -

0.82) and behavioral tendency ratings (b = -0.34), while the specified risk condition reduced affect significantly (b = -1.02), but did not reduce behavioral tendency ratings. Finally, the specified uncertainty condition significantly reduced the association between familiarity and affect (b = 0.92 for the unspecified condition, b = 0.58 for the specified uncertainty condition), and between familiarity and behavioral tendency (b = 1.15 for the unspecified condition, b = 0.74 for the specified uncertainty condition). The specified risk condition also significantly reduced the associations between familiarity and affect (b = 0.61), and between familiarity and behavioral tendency (b = 0.8).

[TABLE 6]

To replicate the associations between condition, familiarity, affect, and behavioral tendency, as well as the mediation effects, we performed the mediation model presented in Study 1. Similar to Study 1, both familiarity and affect had significant direct effects on behavioral tendency (b = 0.18 for familiarity and b = 0.76 for affect, ps < .001 for both). Familiarity also had an indirect effect on behavioral tendency via affect (b = 0.27, p < .001). In terms of condition, using the unspecified condition as the base group, both the specified uncertainty and specified risk conditions had significant negative effects on affect (b = -0.45 for uncertainty and b = -0.43 for risk, ps < .001 for both). While the total effects of the risk/uncertainty manipulation on behavioral tendency were significantly negative (b = -0.14 for uncertainty and b = -0.21 for risk, ps < .001 for both), their direct effects became positive due to the multicollinearity between affect and behavioral tendency. The effects of the condition were fully mediated by affect (indirect effect b = -0.35 for uncertainty and b = -0.32 for risk, p <.001 for both).

General Discussion

The present paper describes two studies that attempt to explore issues that commonly used risk-taking scales face. Many popular risk-taking scales do not explicitly specify the

risks within the items of the scale. Indeed, it is common that while attempting to operationalize and measure risk-taking in their scales, many authors do not control for the effects of perceived uncertainty, separate to perceived risk, which may also be present in the items. This unclear specification of risk consequently results in more measurement noise when measuring participant responses to those scale items.

We investigated how individuals interpret items that do not explicitly specify the risk and compared this to items that did explicitly specify risk and uncertainty. The results of the current studies demonstrate that the endorsement of behavioral items in the implicit, or unspecified outcomes, condition was significantly higher than for items that either specified the risk as uncertainty or as a likelihood of having loss. This suggested that participants may not homogenously recognize risk and its type (uncertainty or loss) when responding to items in which these are implicit. Therefore, responses to items on commonly used risk-taking scales in the literature may also face this issue.

We argued that the experience of uncertainty and awareness of potential loss in one item could depend on one's prior experience or familiarity with a particular behavior or situation. As indicated in both studies, prior experience and subjective familiarity had stronger associations with the endorsement of behavior in the implicit condition than in the conditions that specified either uncertainty or loss explicitly. Thus, it is possible that individual differences in prior experience and familiarity with particular behavioral situations are generating greater measurement noise in existing risk-taking scales.

Furthermore, as demonstrated by the results in this paper, both the specification of uncertainty and the chance of negative outcomes negatively influenced affect toward risky behavior, which, in turn, influences the endorsement of the risky behavior items. Thus, heterogeneity in the recognition of risk subsequently results in heterogeneous interference of affect across behavioral tendency items.

When inspecting the results across decision domains, the heterogeneous effects of variables on behavioral tendency sheds light on the domain-specific characteristics of risk. It was found that the ethical, financial, and recreational items were perceived as being less ambiguous than those in the health and social domains, which had greater differences between the endorsement of behavioral tendency when risk was specified and when it was not. The ambiguity in health or social situations may stem from the fact that these decision domains are naturally more complex, both in terms of their outcomes and the influence of other considerations. For example, a situation in the social domain such as "speaking your mind about an unpopular issue in a meeting at work" can be relevant to one's career and future financial security risk rather than simple social risk. Likewise, situations in the health domain, such as "taking prescriptive medicine without medical advice", may invoke a variety of different and perhaps concurrent considerations, such as financial cost outcomes, as opposed to simple, one-dimensional health concerns.

Implications and future directions

Risk attitudes assessed by different measures may tap into different latent traits or cognitive processes due to the unclear conceptualization of "risk" in different measures. Commonly used self-report measures such as DOSPERT do not specify the risk and can mix "uncertainty" with "negative outcomes" in the items. However, the mix of the two components may not be systematic across items and can vary with an individual's prior knowledge of the situation. Thus, risk attitudes captured by DOSPERT are actually a function of several related but different constructs, including subjective knowledge, attitudes toward uncertainty, and attitudes toward loss. Rather than a measure of "attitudes toward risk", the DOSPERT scale may be best described as a measure of "behavioral tendency in situations that can be risky". Although the DOSPERT scale contains subscales of "risk perception" and "benefit perception" that may better capture knowledge of the risk, most studies

implementing the DOSPERT scale use only the risk-taking scale when measuring risk attitudes. Furthermore, these scales ("risk perception" and "benefit perception") are not useful when participants are wholly ignorant about the behavior in question.

At the theoretical level, the concept of "risk attitudes" is yet to be unified across disciplines when communicating the construct, drivers and consequences of "risk attitudes". That being said, increasing evidence from both behavioral science and neuroscience demonstrates that the human brain deals with loss, risk (known probability) and other kinds of uncertainty (e.g., unknown probability, unknown sample space) in different ways. The domain-specific framework of risk attitudes emphasizes on behaviors in real-life domain situations, most of which would present more than one single element of uncertainty (e.g., loss and known probability together). The continued development of the domain-specific framework may hinge on incorporating or extending to different kinds of uncertainty in order to account for this.

At the measurement level, the meta-analysis by Shou and Olney (2020) found that the internal consistency reliability of the DOSPERT was lower for some populations, such as non-English and student samples, than for others, such as English-speaking and community samples. Internal consistency reliability indicates whether a set of test items captures the latent level of ability precisely in a sample of test takers. Overly difficult or overly easy items would result in lower test precision. The sense of difficulty in the scale items of measures such as DOSPERT is essentially determined by subjective knowledge or experience of the activities indicated in the items. For example, the ethical domain of the DOSPERT scale contains individual tax return behaviors, however the use of such items is problematic with participants from East Asian countries where filing an individual tax return is uncommon (Schwartz et al., 2013). This, in turn, may result in higher measurement errors when the DOSPERT scale is applied to inappropriate populations. As such, low reliability or high

measurement errors threaten the validity of the results of studies that use the measure. Shou and Olney (2020) discussed several consequences of using the DOSPERT when its reliability was low. For example, the observed correlation coefficients between DOSPERT scales and criterion variables could be attenuated. On the other hand, if the errors are more systematic and may indicate another shared latent construct (e.g., prior belief), the association between the risk attitudes scale and criterion variables (e.g., other personality/attitudes scales) can be confounded by factors other than risk attitudes.

Thus, researchers should take care to control for different sources of variability when measuring the desired construct of "risk attitudes". One obvious approach, as described in the current study, is to explicitly define either uncertainty or risk in the items when assessing risk-taking behavioral tendency. Within the current DOSPERT framework, researchers should include the risk and benefit perceptions, in addition to the risk-taking tendency, to control for variability in the awareness of risks and benefits across different items. Alternatively, researchers could consider including an additional measure of prior knowledge or familiarity that participants have with the items and include this prior knowledge variable as a covariate when examining the relationship between risk-taking behavioral tendency items and variables of interest.

Familiarity of the situation also demonstrated that it had stronger associations with behavioral tendency than with affect. As most survey studies have restrictions on duration, it is sometimes difficult for researchers to gauge subjective experience of items together with behavioral tendency. Researchers could consider using affective responses as a better measure of attitudes toward risky behavior to minimize the effects of heterogeneity of knowledge among participants.

Limitations and Conclusion

One major limitation relates to the complexity of real-life situations, including those that were used in the present two studies. The classification of the items was based on the experimenters' interpretation of the main risk relating to the situation rather than based on empirical evidence (that is, participant perceptions). During the coding process, we found some items (especially those in the DOSPERT) had a mixture of two or more domains depending on how one would interpret the items. For example, the item "driving without seatbelt" in the DOSPERT was classified as related to the health/safety domain, however the action in this item also has clear ethical/legal risk in that this is against the law in many countries. Similarly, many ethical items, such those relating to law-binding behaviors, had strong financial risk implications. This domain contamination may help to explain previous findings regarding the moderate to high intercorrelations among the domains of the DOSPERT scale (e.g., Byrne, Dvorak, Peters, Ray, Howe & Sanchez, 2016; Zhang, Foster, & McKenna, 2018). We also focused on attitudes and relied on self-report measures, of which the generalizability to real-life behaviors is debatable (e.g., Ajzen & Finshbei, 2004; Ogden, 2003). Thus, future studies are needed to understand the extent to which the present findings can be a true reflection of the associations between uncertainty, loss, and real-life behaviors.

Second, we restricted our attention to the kind of uncertainty where outcome probabilities can be highly variable. While the inclusion of the uncertainty reduced the average behavioral tendency in Study 1, there was individual variability in the difference between the implicit and explicit conditions. This kind of uncertainty is similar to ambiguity uncertainty. Individuals may experience other kinds of uncertainty or ignorance in the unspecified outcomes condition. For example, if individuals hold error beliefs, which is another kind of ignorance (Smithson, 2010), they may overestimate the probability of the negative outcome (e.g., perceiving "being caught" as a certain loss outcome in the "tax return" behavioral situation). Such an error belief could reduce their behavioral tendency in

the unspecified outcomes condition when compared to a situation where they were told the negative outcomes are not certain.

Third, when standardizing the uncertainty and loss information into the behavioral situations, we also narrowed the loss outcomes being presented in the context. For example, by indicating "when you do not know if there is a road safety camera", we narrow the main outcome of "speeding" as "being caught". This has the effect of eliminating other possible outcomes people would recall when reading the behavioral situation, as well as eliminating the domains that we did not intend to include in the item. Thus, some items may differ in both the explicitness of uncertainty and risk information, but also in outcome and domain complexity between the implicit and explicit uncertainty/risk conditions. Nevertheless, the effects of the variables remained when we selected items that had clearer domain classifications. Future studies should investigate the role of outcome and domain complexity in influencing the individual differences in ratings of behavioral tendency items.

Finally, we relied on an overall and simplistic assessment of affect which does not entirely account for the complexity of the relationship between negatively valenced emotions and decision making (e.g., different kinds of emotions, and cognitive versus physiological expressions of emotions). In some situations, negative emotions such as acute stress can elicit a fight-or-flight response to uncertainty and risk to facilitate fast adaptive action (Phelps, Lempert & Sokol-Hessner, 2014). Thus, in real-life situations, some negative emotions may elicit the opposite behavioral tendency (e.g., a "fight" decision to take the risky choice) to the one emphasized in the current paper (i.e., flight). Future research should further investigate the effects of different kinds of emotions on decision making under conditions of uncertainty and should account for the potential differences between fast and slow decisions.

In summary, the results of the present studies suggest that measuring risk attitudes using self-report measures can be confounded by unclear definitions and inclusion of risk.

Furthermore, the endorsement of behavioral tendency items can be influenced by factors such as subjective familiarity and perceived uncertainty in the items that are independent from the construct of attitude towards risk. Controlling for these factors is crucial in order to increase the measurement precision of risk attitude scales in the future.

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Table 1
Descriptive Statistics for Study 1 Variables

Variable	Condition	Mean	SD	Skew	Of Means of 90 items	
					Range	Skew
Familiarity		3.01	1.44	0.03	1.28-4.88	-0.08
Experience		3.68	1.02	-0.73	2.32-4.93	-0.28
Affect	Uncertainty	2.89	1.53	0.46	1.30-5.32	0.73
	Implicit	3.44	1.75	0.22	1.43-6.06	0.44
Behavioral	Uncertainty	2.88	1.99	0.67	1.12-5.62	0.45
	Implicit	3.46	2.23	0.30	1.13-6.41	0.15

Notes. * Mean ratings for each of the 90 items averaged across all participants; Range = range of the means of the 90 items; Skew = skewness based on the 90 means. α is Cronbach's α, and ω is McDonald's ω.

Table 2

Regression Coefficients of Mixed Ordinal Regression for Study 1

Models	1	2	3	4
Random effects variance				
Subject: Intercept	0.20	0.22	0.20	0.20
Subject: UvI	0.07	0.06	0.10	0.10
Fixed effects				
Uncertainty Vs Implicit	-0.31**	-0.30**	-0.13**	-0.13**
Familiarity	0.80**	0.80**	0.65**	0.65**
Experience	0.49**	0.49**	0.29**	0.29**
UvI x Familiarity		-0.10**	-0.08**	-0.08**
UvI x Experience		-0.06**	-0.04*	-0.05*
Affect			1.33**	1.33**
UvI x Affect				0.00

Notes. UvI: Uncertainty vs Implicit condition coded as 1 = Uncertainty condition, -1 = Implicit condition. Affect, familiarity/experience were standardized. ** $p < .001$; * $p < .05$

Table 3

Means and SD*s of Affect and Behavioral Ratings across Domains*

	Uncertainty			Implicit			Convergent *r*
Domain	Mean(SD)	α	ω	Mean(SD)	α	ω	
Affect							
Ethical	2.31(1.21)	0.91	0.91	2.57(1.32)	0.89	0.90	0.69
Financial	2.35(1.36)	0.89	0.89	2.90(1.65)	0.86	0.87	0.53
Health	2.34(1.27)	0.78	0.78	2.73(1.48)	0.70	0.70	0.64
Recreation	2.66(1.67)	0.83	0.84	3.49(1.80)	0.82	0.83	0.71
Social	3.54(1.33)	0.78	0.79	4.04(1.43)	0.81	0.81	0.54
Behavior							
Ethical	1.92(1.47)	0.80	0.81	2.10(1.60)	0.81	0.81	0.74
Financial	1.79(1.36)	0.85	0.85	2.21(1.78)	0.82	0.82	0.69
Health	2.47(1.80)	0.66	0.67	3.14(2.13)	0.63	0.65	0.70
Recreation	2.18(1.71)	0.76	0.77	4.62(2.26)	0.78	0.78	0.77
Social	4.00(1.83)	0.76	0.77	2.56(1.94)	0.82	0.83	0.66

Note. α is Cronbach's α, and ω is McDonald's ω.

Table 4

Coefficients of the Variables on Behavioral Tendency across Domains

	Ethics	Financial	Health	Recreational	Social
Random Effects					
Subject: Intercept	0.76	1.05	0.24	1.09	0.80
Subject: UvI	0.01	0.19	0.01	0.13	0.01
Fixed effects					
Uncertainty vs	-0.05	-0.08	-0.26**	-0.01	-0.38**
Implicit	(-0.14*)	(-0.32*)	(-0.37**)	(-0.33**)	(-0.50**)
Familiarity	0.35**	0.56**	0.68**	1.05**	0.72**
Experience	0.13	0.29**	0.20**	0.28**	0.12
Affect	1.52**	1.73**	1.09**	1.42**	1.15**

Note. RS: recreational domain (safety related). Coefficient of UvI in the bracket is the coefficient before affect entered the model.
** $p < .001$, *$p <. 05$

Table 5

Means and SD*s of the Variables in Study 2*

			Means of item ratings		Reliability	
	Mean	*SD*	Range	Skew	α	ω
Implicit						
Familiarity	4.45	1.46	2.71-5.63	-0.36		
Affect	3.50	1.88	2.02-5.93	0.49	0.528	0.556
Behavior	3.29	2.15	1.57-6.15	0.48	0.520	0.568
Risk						
Familiarity	4.20	1.52	2.63-5.52	-0.25		
Affect	2.79	1.61	1.77-4.18	0.36	0.873	0.875
Behavior	2.94	1.94	1.57-4.86	0.29	0.868	0.872
Uncertainty						
Familiarity	4.42	1.50	2.85-5.55	-0.49		
Affect	2.80	1.57	1.62-4.87	0.82	0.864	0.868
Behavior	2.92	1.89	1.49-5.55	0.65	0.821	0.817

Table 6

Regression Coefficients of the Mixed Ordinal Regression for Study 2

	Affect	Behavioral
Random effects variance		
Subject: Intercept	0.50	0.47
Fixed effects		
Familiarity	0.92**	1.15**
Risk	-0.77**	-0.25
Uncertainty	-0.82**	-0.34*
Risk* Familiarity	-0.34**	-0.41**
Uncertainty* Familiarity	-0.31**	-0.35**

Note. We do not include the random slope of the condition nested with subject level as the condition is a between-subject design; ** $p < .001$, * $p < .05$.

Figure 1. Mediation structure model predicting behavioral tendency from affect, familiarity/experience and uncertainty conditions.