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Causes and Consequences of Uncertainty about Illness Risk Perceptions

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Abstract

We identified determinants of uncertainty about perceived risk judgments and demonstrated that uncertainty is associated with lower engagement in risk-reducing behavior. We found that people likely have metacognitive awareness of when their judgments are overly pessimistic, resulting in uncertainty and that question context (more constraints) and people's time orientation (future orientation) are associated with lower uncertainty. Uncertainty about conditioned risk judgments was associated with lower engagement in exercising and eating a healthy diet in order to reduce risk for heart disease. As a potential determinant of behavior, uncertainty about risk judgments merits further consideration for integration into theories of health behavior.

Public health professionals often try to educate people about why they may be at risk of developing an illness in hopes that they will take health protective actions. Most theories of health behavior, including the health belief model (Rosenstock, 1974), the transtheoretical model (Prochaska & Diclemente, 1983), the protection motivation theory (Rogers, 1983), and the extended parallel process model (Witte, 1992), assume that people engage in risk appraisals and that higher perceived risk is associated with greater likelihood of engaging in protective behavior. Empirical data supporting the role of perceived risk in health behavior are mixed, in part because of the challenge of testing whether perceptions of risk at one time point lead to protective behavior at a subsequent time point, although overall, in optimally designed studies there are reliable relationships between risk perception and behavior (Brewer et al., 2007; Sheeran, Harris, & Epton, 2014). Innovative thinking about how risk perceptions are assessed and presumed to relate to behavior might enhance understanding of the nature of perceived risk and potentially improve health behavior interventions.

Perceptions of illness risk and susceptibility are nearly always evaluated in terms of *level* of perceived risk (low to high) or the likelihood of an event occurring (unlikely to likely), and are typically operationalized as a numerical estimate or verbal anchor (i.e., somewhat unlikely). However, there may be meaningful variability in the degree of confidence people have in their risk judgments, or what Taber and Klein have called, “risk perception conviction” (Taber & Klein, 2016). Taber & Klein defined risk perception conviction as, “the subjective sense that one knows what one’s risk belief is, and confidence that this risk belief is accurate” (Taber & Klein, 2016, p.203). Confidence in one’s judgments may shape decision-making and behavior. How willing are people to engage in protective behaviors that can be unpleasant, costly, or time-consuming when they are uncertain that the threat is real? Over and above risk level, being uncertain about risk judgments may reduce motivation to take protective action, or, as hypothesized by Taber & Klein (2016), perceived risk may interact with uncertainty. Accordingly, when people hold their perceived risk beliefs with greater conviction, their level of perceived risk may be more predictive of behavior (Taber & Klein, 2016). The purpose of this study was to explore whether risk perception might have an important second dimension, namely uncertainty about perceived risk. We identify possible determinants and behavioral consequences of uncertainty about perceived risk.

One reason that people might be uncertain about their risk could be that they have metacognitive awareness of when their risk judgments are potentially incorrect. That is, people may know when they do not know their risk. For example, participants at average risk who perceive their risk as high and participants at elevated risk who perceive their risk as average may be more uncertain about their risk judgments. This may be the case when people make judgments with little or incomplete information, potentially inaccurate information, or even limited understanding of the nature of the judgment to be made (Han, Klein, & Arora, 2011). Uncertainty would represent an accurate metacognitive awareness of any of these conditions. There is evidence that uncertainty about perceived risk questions is partly attributable to lack of knowledge. Reporting that one does not know one’s risk for a common disease, presumably an extreme form of uncertainty, has been associated with lack of knowledge about the disease (Hay, Orom, Kiviniemi, & Waters, 2015). Over and above these situations involving quantity or quality of information, the nature of risk information may also induce uncertainty. Risk information is, by nature, probabilistic. Given this, for some individuals, the probabilistic nature of risk itself might induce uncertainty (Han, et al., 2011).

A second factor contributing to risk perception uncertainty may be the extent to which the risk perception question is constrained by information that narrows how the question can be interpreted. Time constraints, such as asking for perceptions of risk in the next 10 years rather than not mentioning a time frame, behavioral constraints, such as asking for judgments that are conditioned on preventive or risky behavior (sometimes called conditioned risk questions), and base-rate constraints, such as asking people to think about their risk relative to a group to which they belong (e.g., other college students your age) may help reduce uncertainty relative to questions that are more open to interpretation. The additional guidance on how to interpret the question may help people feel the judgment is more knowable.

A third possible determinant of uncertainty is individual differences. Beliefs about the influence of luck, fate, randomness (Davison, Smith, & Frankel, 1991), or divine will (Hayward, Krause, Ironson, & Pargament, 2016) in determining illness are common and likely increase uncertainty about risk judgments. There are also differences in how much time people have spent thinking about the consequences of their present circumstances and behaviors on potential future illness. Time orientation is a broad set of implicit cognitive structures for organizing experiences that determine whether people are focused on implications for the future, present, or past (Zimbardo & Boyd, 2015). Time orientation manifests in how much people contemplate and plan for future possibilities (i.e., future time orientation) (Lee, Liu, & Hu, 2017), and the priority they give to long-term rather than short-term consequences when they are making a decision (Kreuter, Lukwago, Bucholtz, Clark, & Sanders-Thompson, 2003; Lukwago, Kreuter, Bucholtz, Holt, & Clark, 2001). Time orientation is an individual (Zimbardo & Boyd, 2015), and possibly cultural difference (Lee, et al., 2017). We would expect that those who are future oriented, in that they routinely think about the consequences of present-day behavior for future risks and gains, including health consequences, might be more likely to have already formulated illness risk perceptions. We would also expect them to have resolved ambiguity about their risk perceptions in order to decide on how to reduce possible future threats. People who are more future oriented may feel more confident in their ability to predict future events. People who are more future oriented have been found to be more likely to engage in protective behavior, including quitting smoking or using condoms (Burns & Dillon, 2005; Hall, Fong, & Meng, 2014), suggesting they have previously engaged in risk appraisals. In contrast, being more present oriented has been shown to be associated with greater don't know responding to subjective probability questions, including questions about life expectancy (Lee, et al., 2017).

In this paper, we report two studies examining: a) potential underlying causes of uncertainty about perceptions of risk for common illnesses, and b) whether uncertainty about illness risk perceptions is associated with less engagement in risk-reducing behavior. In Study 1, we tested the hypothesis that uncertainty reflects metacognitive awareness that one's perceptions of risk may be inaccurate. In Study 2, we tested three additional hypotheses. First, we tested whether people are more uncertain about their responses when risk perception questions had fewer, rather than more constraints. Second, we tested whether individual differences in time orientation are associated with uncertainty about perceived risk judgments for illness. We reasoned that people who are more future oriented will be more likely to think about long-term health risk, and therefore be more likely to have formed, and have confidence in their risk perceptions. Third, we tested whether lower uncertainty about perceptions of risk is associated with engaging in more risk-protective behavior. Both studies were approved by the University at Buffalo IRB (#724662-1). As the study was conducted online, participants read an informational sheet and indicated whether or not they agreed to participate by clicking the appropriate response option.

Study 1: Are People Uncertain about Their Risk Judgment Because They Are Aware That Their Judgments May Be Inaccurate?

Overview

To investigate whether uncertainty reflects metacognitive awareness of possible inaccurate judgments, we tested whether uncertainty is highest among individuals whose actual and perceived risk is more discrepant, and lowest among individuals whose actual and perceived risk is less discrepant.

Methods

Participants and Procedure—Participants were 188 participants recruited through Amazon Inc.’s Mechanical Turk (mTurk) online crowdsourcing marketplace. Mechanical Turk workers were invited to participate in a survey about diabetes and diabetes risk, personal beliefs, and thoughts about health. They were screened out if they reported having diabetes or did not live in the U.S.

The original purpose of the study was to pilot a self-affirmation manipulation.; however, all constructs used in the present analyses with the exception of objective diabetes risk were assessed prior to the manipulation. Participants completed demographic questions and then were asked to judge their perceived risk for diabetes and their level of certainty/uncertainty about their risk judgment.

Measures—*Perceived absolute diabetes risk* was a single item adapted from the second Health Information National Trends Survey (HINTS 2)(National Cancer Institute, 2005) in which people were asked to indicate “how likely are you to get type 2 diabetes in your lifetime” on a scale from 1 (very unlikely) to 5 (very likely) or “don’t know”.

Objective diabetes risk was calculated using the American Diabetes Association’s (ADA) Type 2 Diabetes Risk Test (American Diabetes Association, 2017). Scores can range from 0 to 11 and, per ADA instructions, participants were classified as average (score < 5) or elevated risk (score ≥ 5).

Diabetes risk uncertainty: participants who chose a risk perception response other than “don’t know” were asked to indicate their certainty about their judgment. For example, someone who had indicated they were very unlikely to get diabetes were asked, “How certain are you that you are very unlikely to develop type 2 diabetes?” The uncertainty response options ranged from 1 (very uncertain) to 5 (very certain). The item was reverse scored so that higher scores indicated greater uncertainty.

Covariates were self-reported age, gender, marital status (married/cohabitating vs. not married/cohabitating), years of education, household income, White vs. not White race, Hispanic vs. non-Hispanic ethnicity, and whether or not the participant had been born in the US. In previous research we found that these demographic characteristics (except income, which was not analyzed due to a high level of missing responses) were associated with don’t know responding to perceived risk questions {Waters, 2013 #5454}. As don’t know responding may, in part, reflect uncertainty, we anticipated that these responses might also

be related to uncertainty among those who select a valid risk response option (i.e., not “don’t know”). We were able to include income as a covariate in the present study because we had few missing responses. Given that other demographic characteristics associated with disadvantage had been associated with don’t know responding, we thought it appropriate to do so.

Analyses—To investigate whether uncertainty was highest among individuals whose actual and perceived risk were discrepant, we tested whether objective risk and perceived risk interacted to predict uncertainty among those who chose a valid risk response option. We conducted a multivariable linear regression with the interaction between perceived and actual risk as the main predictor, and uncertainty as the outcome, while controlling for age, gender, marital status, years of education, income, race, ethnicity, and nativity.

Results

Sample characteristics are reported in Table 1—Although we did not use null hypothesis significance testing for the comparisons, they can be compared to the U.S. general population characteristics also presented in Table 1. Our sample included more males than the general population (59% vs. 48.6%) and was younger (35.3 vs. 47.3 years). On average, participants had more formal education than the general population. In the Study 1 sample, only 15.1% had a high school education or less, compared to 40.4% of the general population. Participants had, on average, somewhat lower household incomes compared to the general population. The sample was somewhat less racially and ethnically diverse in the general population (85.0% White vs. 73.6% White).

Over 40% of the sample reported some degree of uncertainty (Table 2)—26% said that they did not know their risk, and an additional 16% rated their perceived risk but said they were “somewhat uncertain” or “very uncertain” about their risk judgment. The interaction between perceived risk and actual risk was significant ($B = -0.69$, 95 % Confidence Interval (CI) $= -1.20, -0.18$, $p = .008$, see Figure). The majority of individuals ($n = 165$; 87.8%) were at average risk for diabetes. Among individuals at average risk, higher perceived risk was associated with greater uncertainty about their risk ($B = 0.56$, 95% CI $= 0.39, 0.73$, $p < .001$), indicating that individuals who were more inaccurate about their judgment were also more uncertain. Greater uncertainty was also associated with a higher continuous score on the objective risk tool ($B = 0.17$, 95% CI $= 0.01, 0.32$, $p = .035$). Among the much smaller group with elevated objective risk ($n = 23$; 12.2%), perceived risk was not associated with uncertainty ($B = -0.23$, 95% CI $= -0.95, 0.49$, $p = .507$). Objective risk score was also not associated with uncertainty for this group ($B = -0.30$, 95% CI $= -0.81, 0.21$, $p = .227$). Uncertainty was relatively high at all levels of risk perception among those at elevated risk for diabetes. Results were identical when analyses were performed without the addition of covariates or if objective risk was treated as a continuous variable.

Discussion

Individuals at average risk for diabetes who mistakenly judge their risk as high (pessimistic bias) appear to have a metacognitive awareness that they may be misjudging their risk. We can also think of this group as including individuals who know they have one or more risk

factors, suspect their risk is higher and therefore rate their risk as high, but are less confident about the judgment than others with many risk factors. This explanation is consistent with there having been a positive association between continuous objective risk scores and uncertainty for the average risk group, but not the elevated risk group. An alternative explanation is that people are generally unaware of their risk, and those who rate their risk as high engage in defensive hedging to protect against perceived threat. However, if this were the case we would expect to find that all individuals who rate their risk as high say they are relatively more uncertain about their risk. This was not the case. Among participants at elevated risk, those who rated their risk as higher were not more uncertain about their risk than those who rated their risk as lower. The discrepancy between actual and perceived risk was not significantly associated with uncertainty in the subgroup who mistakenly judged their risk as low (optimistic bias), but this group was very small. It would be important to study a larger sample of individuals with optimistic bias to understand the causes of uncertainty in this group.

Study 1 only tested one possible explanation of uncertainty -- that people might be aware when there is a discrepancy between their perceived and actual risk -- and that this makes people uncertain about their risk judgments. As uncertainty about perceived risk is likely multiply determined, we conducted a second study to test two additional possible explanations for uncertainty about perceived risk judgments.

Study 2: Are Question Context and Future Orientation Associated with Perceived Risk Uncertainty, and is Perceived Risk Uncertainty Associated with Risk Reduction Behavior?

Overview

The first purpose of Study 2 was to identify contextual and person factors associated with uncertainty about perceived risk. We tested whether the degree to which a risk perception question is unconstrained (by time, behavior, or reference group) is associated with higher uncertainty, and for the second, whether being more future oriented was associated with lower uncertainty about perceived risk. The second purpose of Study 2 was to test whether perceived risk uncertainty was associated with prevention behavior or interacted with level of perceived risk to predict behavior. In contrast to Study 1, in Study 2, we analyzed two uncertainty variables: don't know responding to risk perception questions and uncertainty about the accuracy of any responses to perceived risk questions other than "don't know".

Methods

Participants and Procedure—Study 2 was conducted with a second sample of mTurk workers (N= 280). Participants were invited to complete a survey about beliefs about diabetes, colon cancer, and heart disease. Participants were excluded if they reported having any of these diagnoses or did not live in the U.S. We report on findings for heart disease as this is the only condition for which we fully manipulated the degree to which the risk perception questions were constrained.

Measures—Uncertainty about risk judgments likely falls along a continuum. We assessed uncertainty in two ways. First, we included a don't know option for all the perceived risk questions. Whether the don't know option was placed before or after the Likert responses was counterbalanced. We reasoned that participants with the most uncertainty about their illness risk would choose the don't know option. Second, among those who used the Likert anchors, we asked a follow-up question about how certain they were about the level of risk they selected, as we had in study 1. We also asked four questions about perceived risk for heart disease: unconditioned absolute and comparative and conditioned absolute and comparative. To assess *unconditioned absolute risk*, participants were asked, "how likely are you to get heart disease in your lifetime? (not at all likely/somewhat likely/fairly likely/very likely/don't know)". To assess *unconditioned comparative risk*, participants were asked, "compared to the average man/woman your age, would you say that you are less likely to get heart disease, about as likely, or more likely?" Given that engaging in protective behavior can lead people to report lower perceived risk (Brewer, et al., 2007; Brewer, Weinstein, Cuite, & Herrington, 2004), we asked people what their risk would be if they had not engaged in a protective behavior, exercising. For the *conditioned absolute risk* item, participants were asked, "If you don't exercise, how likely are you to get heart disease in your lifetime? (unlikely/somewhat likely/fairly likely/very likely/don't know)". For the *conditioned comparative risk* item, participants were asked, "If you don't exercise, compared to the average man/woman your age, would you say that you are less likely to get heart disease, about as likely, or more likely?"

The perceived risk questions were coded two ways—Participants who used the valid Likert-type response options were assigned a perceived risk score. All participants were assigned a value for the dichotomous *don't know responding* variables, for which responders are classified as having chosen the Likert-type option or the "don't know" option for each of the four risk perception questions.

Perceived risk uncertainty was assessed for each perceived risk question. As in study 1, participants who used the Likert-type response options were asked a follow-up question about how certain they were that their risk was the chosen level. Again, the uncertainty response options ranged from 1 (very uncertain) to 4 (very certain) and the item was reverse scored so that higher scores indicate greater uncertainty.

Future and present time orientation were assessed with five validated items that assess present orientation (e.g., "There's no sense in thinking about the future before it gets here") ($\alpha=0.73$) and five that assess future orientation (e.g., "I have a plan for what I want to do in the next 5 years of my life.") ($\alpha=0.68$) (Kreuter, et al., 2003; Lukwago, et al., 2001, possible range 5–20). Present and future orientation are typically treated as distinct dimensions (Lukwago, et al., 2001; Zimbardo & Boyd, 2015); however, they are moderately correlated ($r=-0.47$, $p<.001$).

To assess *health behavior change*, participants were asked if, during the past 12 months, they had increased their exercise in order to reduce their risk for heart disease and if they had changed their diet to reduce their risk of heart disease.

Covariates included self-reported *age*, *gender*, *education* (years of education), *household income*, *race* (which was collapsed into the binary variable White vs. other race), *Hispanic ethnicity*, and whether they were *foreign born* or had been born in the United States.

Analyses—We compared the percent of participants who responded don’t know and the mean uncertainty for the four risk perception items with using two sample z-tests and within-subjects analysis of variance (ANOVAs), respectively. To test whether present and future time orientation predicted don’t know responding and uncertainty, we tested eight separate models in which we regressed each of the eight uncertainty variables on the two time orientation dimensions, controlling for age, gender, education, household income, and race using logistic or linear regression, as appropriate. To test whether uncertainty predicted risk reduction behavior, we regressed exercise and diet change on each of the eight uncertainty predictors using multivariable logistic regression, controlling for perceived risk and the same covariates described above (8 models total). We also tested whether interactions between uncertainty about perceived risk and perceived risk were associated with risk reduction behavior. We tested eight multivariable models where exercise and diet change were regressed on the product of uncertainty and perceived risk as well as our standard covariates.

Results

Sample Characteristics—The second mTurk sample had similar characteristics to the first (Table 1). Again, it was younger, had slightly more education, had somewhat lower incomes and was somewhat less racially and ethnically diverse than the nation as a whole (tests of significance not performed). The proportion of the sample who reported being uncertain, whether they responded don’t know or indicated they were somewhat uncertain or very uncertain about their risk judgment, depended on the type of risk question asked. The highest proportion was 73.57% for absolute unconditioned risk and the lowest was 35.35% for conditioned comparative risk (Table 2). Participants’ mean future orientation score was 14.16 (SD=2.83) and mean present time orientation score was 8.47 (SD=2.54).

Question context contributed to uncertainty about risk judgments—Levels of uncertainty followed a consistent pattern that was a function of the degree of constraint placed on people’s risk judgments. The perceived absolute risk questions yielded higher proportions of don’t know responses than comparative risk questions (21.43% vs. 11.43% for unconditioned risk and 11.43% vs. 8.57% for conditioned risk). The difference was significant for unconditioned risk questions, but not for conditioned risk questions ($z=3.19$ $p<.002$ and $z=1.13$, $p=.130$, respectively). Conditioning also contributed to lower rates of don’t know responding for absolute risk questions ($z=3.19$, $p<.002$), although not for conditioned risk questions ($z=1.13$, $p=.130$).

After excluding those who selecting “don’t know”, we also analyzed participants’ ratings of uncertainty about their risk judgment. Uncertainty ratings followed a similar pattern (Table 2). Mean uncertainty ratings, for those who rated their risk, ranged from a high of 2.67 (SD=0.64) for unconditioned absolute risk to a low of 2.15 (SD=0.76) for conditioned comparative risk. The mean ratings were all significantly different from one another

($p < .001$), with the exception that uncertainty for conditioned absolute and conditioned comparative risk did not differ ($t(268) = -1.78, p = .075$). Both asking the question as a comparative risk question and a conditioned risk question contributed to reduction in uncertainty.

Future orientation was associated with greater uncertainty—Time orientation was associated with uncertainty ratings about risk judgments and in some instances, it was associated with responding don't know to risk perception questions (Table 3). Being more future oriented was significantly associated with being less likely to respond don't know to the absolute risk question ($OR = 0.83, 95\% CI = 0.74, 0.94, p = .003$) and marginally significantly associated with lower likelihood of responding don't know to the comparative risk question ($B = 0.88, 95\% CI = 0.76, 1.01, p = .074$). Being more present oriented was associated with higher odds of responding don't know to the conditioned comparative risk question ($OR = 1.28, 95\% CI = 1.06, 1.55, p = .010$), but not any of the other risk questions. For participants who rated their level of risk perception, there was a consistent relationship between being more future oriented and also being more certain about their judgment for all risk questions except absolute perceived risk (Table 3). Being more present oriented was not associated with uncertainty ratings for any of the perceived risk items ($p > .267$).

Uncertainty about risk perception and risk reduction behavior—When asked about their behavior in the past 12 months, 28.9% reported changing their diet to reduce their risk of heart disease and 25.7% had increased their exercise to reduce their heart disease risk. When perceived risk and rating of uncertainty about perceived risk were both entered into a regression with our standard covariates, greater uncertainty about conditioned risk was associated with lower odds of having changed one's diet or exercise to reduce heart disease risk in 3 out of 4 models (see Table 4). We had also hypothesized that level of perceived risk would be more strongly associated with behavior change to the degree that participants were certain about their level of risk. This was not the case. Uncertainty about perceived risk did not interact with level of perceived risk to predict behavior change ($ps > .494$).

Discussion

The way researchers ask risk perception questions likely influences the degree to which people feel confident judging their susceptibility for an illness. Many participants were uncertain about absolute perceived risk appraisals, but fewer were uncertain when the question was more constrained, such as when participants were asked to compare themselves to the average man or woman one's own age or when asked to think about their risk for heart disease if they had not engaged in protective behavior. The fewer the constraints, the more complex and multiply determined the event. People may take this into account when assessing how certain they are about their risk judgments.

In addition to characteristics of the question, uncertainty about illness risk judgments may be due, in part, to enduring beliefs and behavioral tendencies. We found that the extent to which a person was future oriented was associated with being certain about judgments about perceived risk. Future oriented individuals may be more certain about their risk judgments if

they engage in risk judgments on a routine basis when making decisions and plans. They may have been more likely to have spent time appraising their heart disease risk and thinking about risk mitigation strategies.

Levels of uncertainty about perceived risk in the population would likely vary as a function of familiarity with a given illness, although we would predict that uncertainty would still shift as a function of the factors identified in this study. If people use the availability heuristic as a basis for judging disease rates, uncertainty may vary in a curvilinear fashion as a function of disease familiarity. People may believe that extremely familiar diseases are common and unfamiliar diseases are rare and be the least certain about risk judgments for illnesses that have moderate levels of familiarity.

Uncertainty about conditioned perceived risk was consistently associated with lower odds of reporting having engaged in either protective dietary or physical activity behavior in the last 12 months, regardless of level of perceived risk. Uncertainty about unconditioned perceived risk was not associated with behavior change to reduce heart disease, although effect directions and magnitude were similar to that for conditioned risk. A larger sample might have resulted in significant effects for these risk questions as well. It is not surprising that effects were more likely to be in the expected direction and more likely to be significant when conditioned risk questions were used. Unconditioned risk questions are more likely to be affected by risk reappraisal, which happens when people rate their risk as lower because they are already engaging in protective behavior. The unconditioned items may also introduce more error variance into the statistical models because they allow people greater flexibility in their interpretations of the question; some participants may reappraise their risk because they changed their behavior and others may not.

Contrary to Taber & Klein's (2016) hypothesis, we did not find that uncertainty moderated relations between perceived risk and behavior. This may be because of the difficulty of demonstrating that perceived risk is associated with behavior, especially when studies are not prospective (Brewer, et al., 2007). In the present study, out of eight models, perceived risk was only associated with behavior change in two.

General Discussion and Conclusions

Uncertainty about perceived risk judgments was common and, as hypothesized, appears to be multiply determined. Potential explanations include metacognitive awareness of the possibility of being incorrect about one's judgments. In addition, the degree to which the risk questions were constrained and the extent to which participants were future oriented were associated with certainty about one's risk judgments. We expect that these are some but not all of the possible explanations for uncertainty about risk perception judgments. Future work might examine whether beliefs in divine control, luck, fate, and randomness or unpredictability also uniquely contribute to uncertainty.

Our study was not without limitations

One drawback was that we were not able to test our metacognition, questions framing, and time orientation hypotheses concurrently. Additional research is needed to confirm whether

all three independently contribute to uncertainty about risk judgments. Another shortcoming is that we did not randomly vary the order in which participants received the different risk perception questions in Study 2. It is possible that uncertainty was reduced because participants practiced making risk judgments and not because the questions became more constrained. Similarly, it is always possible that an unassessed third variable accounts for the association between time orientation and risk perception uncertainty. In addition, our samples, while more representative of the general population than a sample of college students or community members recruited through flyers or personal contacts, were younger, more likely to be male than female, and likely more technologically savvy than the general population given that they responded through an online crowd sourcing site. It would be important to study uncertainty about risk perceptions in a general population sample. Using a larger sample would also be important as our Study 1 subgroup of individuals with elevated risk for diabetes was small and we were likely underpowered to test the metacognition hypothesis. It will also be necessary to test whether uncertainty about risk perception predicts behavior when studied prospectively.

Our findings demonstrate that people are often uncertain about their illness risk perceptions and that this uncertainty is associated with lower prevention behavior. We argue that these findings indicate that it may be helpful to reconceptualize perceived risk. As noted by others, perceived risk may be multi-dimensional (Slovic 1987). We hypothesize that one dimension may be confidence in one's risk appraisal. In the present work, uncertainty about risk perception judgments were more predictive of not engaging in risk-reducing behavior than level of perceived risk. Integrating the notion of uncertainty about risk perception judgments into models of health behavior and assessments of health behavior may improve our ability to predict and intervene in health behavior. Doing so would be consistent with science in domains where judgments, appraisals, and attitudes have been conceptualized as having multiple dimensions (Bandura, 1997; Fazio & Zanna, 1978). Future research should investigate whether adding uncertainty to health behavior change models improves the ability to predict future behavior.

Whether we should attempt to reduce perceived risk uncertainty in our interventions is a complex issue. One might encounter legitimate resistance in attempting to completely reduce uncertainty. At the height of the movement in the 1980s and early 1990s to persuade populations that lifestyle change was imperative to avoid heart disease, Davison and colleagues argued that since people's experience indicates that there is not necessarily a one-to-one correspondence between lifestyle and health outcomes, trying to argue otherwise is disingenuous and inconsistent with people's lay epidemiologies (Davison, et al., 1992). Messages that make too strong, deterministic claims about risk factors, including lifestyle, genetic or demographic risk factors might be viewed as suspect, incorrect, or irrelevant if people can generate counterexamples. While there may still be value in helping people understand their risk factors for common illnesses, complete reduction of uncertainty is probably not realistic or even laudable. Intervention might be focused on reaching the many individuals who have not yet applied what they know about illness risk factors to formulate a risk perception and those individuals who have yet to be reached by messaging about chronic disease prevention.

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Figure.
Association between perceived risk and uncertainty about perceived risk for participants at average and elevated risk

Table 1**Study 1 and Study 2 Participant Characteristics**

Characteristic	N (%) or Mean (SD)		% or Mean (SD)
	Study 1 (N = 186)	Study 2 (N=280)	US General Population ^a
Age	35.25 (10.3)	33.57 (9.4)	47.32 (18.47)
Gender			
Female	77 (41.4)	123 (43.9)	51.4
Male	109 (58.6)	157 (56.1)	48.6
Marital Status			
Not married/cohabitating	89 (47.9)	—	52.5
Married/cohabitating	97 (52.2)	—	47.5
Education			
High School	28 (15.1)	30 (10.7)	40.4
Some College/Trade	64 (34.4)	111 (39.6)	28.9
College	69 (37.1)	110 (39.3)	19.0
College	25 (13.4)	29 (10.4)	11.6
Household Income			
< \$25,000	55 (29.6)	60 (21.4)	23.1
\$25,000 – \$49,999	58 (31.2)	96 (34.3)	23.5
\$50,000 – \$74,999	33 (17.7)	62 (22.1)	17.8
\$75,000 – \$99,999	18 (9.7)	34 (12.1)	12.1
\$100,000	22 (11.8)	28 (10.0)	23.5
Race			
White	158 (85.0)	223 (79.6)	73.6
Other	28 (15.1)	56 (20.0)	26.4
Hispanic Ethnicity	9 (4.8)	—	17.1
Foreign born	6 (3.2)	—	13.2

Note: Percentages may not equal 100% due to rounding. Income and education were continuous variables in the multivariable models.

^aU.S. general population estimates are from the U.S. Census Bureau, American FactFinder, https://factfinder.census.gov/faces/nav/jsf/pages/guided_search.xhtml. Age is from the 2016 estimate for data of ages 18 and over; gender, marital status, and education are from the 2015 American Community Survey 1-Year Estimates; household income, race, and nativity are from 2011–2015 American Community Survey 5-year estimates.

Table 2

Levels of uncertainty about perceived risk in Study 1 and 2

Study 1: Perceived absolute risk for diabetes [N (%)]				
Don't Know %	65 (25.69)			
Level of uncertainty %				
Very certain	22 (8.70)			
Somewhat certain	84 (33.20)			
Neither certain nor uncertain	41 (16.21)			
Somewhat uncertain	34 (13.44)			
Very uncertain	7 (2.77)			
Mean uncertainty (SD)	2.58 (1.03)			
Study 2: Perceived risk for heart disease [N (%)]				
	Absolute risk	Comparative risk	Conditioned absolute risk	Conditioned comparative risk
Don't Know %	60 (21.43)	32 (11.43)	32 (11.43)	24 (8.57)
Level of uncertainty %				
Very certain	10 (3.57)	14 (5.00)	37 (13.21)	47 (16.79)
Certain	64 (22.86)	124 (44.29)	133 (47.50)	134 (47.86)
Uncertain	135 (48.21)	97 (34.64)	67 (23.93)	65 (23.21)
Very Uncertain	11 (3.93)	13 (4.64)	11 (3.93)	10 (3.57)
Mean uncertainty (SD) among valid responders out of 4	2.67 (0.64)	2.44 (0.68)	2.21 (0.75)	2.15 (0.76)

Table 3

Associations between future or present orientation and uncertainty

Outcome	Absolute risk	Comparative risk	Conditioned absolute risk	Conditioned comparative risk
Odds of responding don't know [OR (95% CI)]				
Future orientation	0.83 (0.74, 0.94) **	0.88 (0.76, 1.01)	0.92 (0.79, 1.06)	0.94 (0.79, 1.12)
Present orientation	0.89 (0.78, 1.02)	1.03 (0.8, 1.21)	1.08 (0.92, 1.27)	1.28 (1.06, 1.55) *
Uncertainty among valid responders [B (95% CI)]				
Future orientation	-0.00 (-0.04, 0.03)	-0.04 (-0.08, -0.01) *	-0.04 (-0.08, -0.00) *	-0.04 (-0.08, -0.00) *
Present orientation	0.01 (-0.03, 0.05)	0.02 (-0.02, 0.06)	0.02 (-0.02, 0.06)	0.02 (-0.2, 0.07)

Note. Future and present orientation were entered into the same model along with age, gender, income, education, and race/ethnicity (White vs. other); the pattern of significant and non-significant findings were the same when models were tested without covariates

*
p<.05,

**
p<.01

Table 4

Associations between perceived risk and dietary or exercise change

Predictor	Dietary change			Exercise change		
	OR	95% CI	p-value	OR	95% CI	p-value
Absolute risk uncertainty	0.69	0.43, 1.11	.124	0.84	0.52, 1.35	.475
Absolute risk	1.57	1.08, 2.28	.018	1.34	0.92, 1.96	.127
Comparative risk uncertainty	0.69	0.46, 1.06	.088	0.71	0.46, 1.09	.115
Comparative risk	1.15	0.78, 1.70	.486	1.00	0.67, 1.49	.991
Absolute conditioned risk uncertainty	0.61	0.39, 0.96	.034	0.72	0.46, 1.12	.145
Absolute conditioned risk	1.56	1.04, 2.33	.031	1.35	0.90, 2.02	.146
Comparative conditioned risk uncertainty	0.63	0.42, 0.94	0.025	0.65	0.43, 0.99	.044
Comparative conditioned risk	1.74	0.89, 3.40	0.105	1.02	0.56, 1.87	.955

Note. The pattern of significant and non-significant findings were the same when models were tested without covariates.