Available online at www.sciencedirect.com
ScienceDirect
Behavior Therapy 42 (2011) 378–386
Behavior Therapy
www.elsevier.com/locate/bt

Intolerance of Uncertainty and Decisions About Delayed, Probabilistic Rewards

Christian C. Luhmann
Kanako Ishida
Greg Hajcak
Stony Brook University

Worry is the inflated concern about potential future threats and is a hallmark feature of generalized anxiety disorder. Previous theoretical work has suggested that worry may be a consequence of intolerance of uncertainty (IU). The current study seeks to explore the behavioral consequences of IU. Specifically, we examine how IU might be associated with aspects of reward-based decision making. We utilized a simple laboratory gambling task in which participants chose between small, low-probability rewards available immediately at the beginning of each trial and large, high-probability rewards only available after some variable delay. Results demonstrate that higher levels of intolerance of uncertainty were associated with a tendency to select the immediately available, but less valuable and less probable rewards. IU also predicted decision-makers' sensitivity to outcomes. We discuss the cognitive and affective mechanisms that are likely to underlie the observed decision-making behavior and the implications for anxiety disorders.

Worry, or concern regarding uncertain future events, is a hallmark of generalized anxiety disorder (GAD) and associated with anxiety disorders more broadly. A prominent, cognitive model of GAD (Dugas, Gagnon, Ladouceur, & Freeston, 1998) proposes that intolerance of uncertainty (IU) is a central mechanism underlying the disorder and plays a causal role in producing worry. IU refers to the negative cognitive, affective, and behavioral reactions to information that is uncertain or ambiguous situations. In particular, IU is believed to lead to fear and discomfort in the face of uncertain events and situations, regardless of the actual probability of aversive outcomes and consequences (Ladouceur, Gosselin, & Dugas, 2000).

Higher IU has been associated both with greater recall and threatening interpretations of ambiguous information (Dugas et al., 2005). In the face of uncertainty, individuals who are high in IU perceive greater aversive likelihood and are more prone to worry (Ladouceur et al., 2000). Indeed, IU is thought to play a central role in the development and maintenance of pathological worry itself: Ladouceur and colleagues (2000) speculate that IU leads to “What if?” thinking that in turn leads to more persistent and uncontrollable worry. In support of this possibility, increasing IU has been shown to result in greater worry, even when the objective probability of good versus bad outcomes remains unchanged (Ladouceur et al., 2000). Moreover, reducing IU has been shown to precede reductions in worry during cognitive–behavioral treatment for GAD (Dugas & Ladouceur, 1998, 2000). Taken together, this body of research supports the idea that IU underlies many of the cognitive, emotional, and behavioral disturbances associated with GAD.

Though IU has been related to a variety of cognitive and emotional constructs (e.g., worry), we

Portions of this manuscript form the basis of the second author’s honors project and have been presented at the Annual Convention of the Association for Psychological Science.

Address correspondence to Christian C. Luhmann, Department of Psychology, Stony Brook University, Stony Brook, NY 11794-2500; e-mail: christian.luhmann@stonybrook.edu.

0005-7894/11/378–386/$1.00/0

know relatively little about the behavioral consequences of IU. What little we do know is related to the idea that IU is associated with differences in problem orientation—that is, how individuals feel about their ability to solve problems (Dugas, Letarte, Rhéaume, Freeston, & Ladouceur, 1995; Ladouceur, Blais, Freeston, & Dugas, 1998, Stöber, Tepperwien, & Staak, 2000). For example, Ladouceur, Talbot, and Dugas (1997) had participants make inferences about the ratio of black marbles and white marbles hidden in a bag. High-IU participants sampled significantly more marbles before reaching a conclusion than did low-IU participants. The authors suggest that rendering a judgment while in a moderate state of uncertainty was particularly unacceptable to individuals high on IU and that sampling additional information likely reflected an attempt to reduce the uncertainty participants were facing. Others (e.g., Metzger, Miller, Cohen, Sofka, & Borkovec, 1990; Tallis, Eysenck, & Matthews, 1991) have similarly reported that worriers take longer to make category judgments than nonworriers, particularly when confronted with ambiguous stimuli.

Importantly, whereas these previous studies demonstrate that individuals with clinical and subclinical GAD symptoms differ in their decision-making tendencies, they have not reported deficits in these individuals' problem-solving *abilities*. For example, the studies reviewed above have shown that IU, and worry more generally, are associated with a desire for more information that, arguably, would only act to increase the accuracy of participants' judgments. However, the worry associated with clinical levels of IU clearly leads to behavioral impairments. In particular, some theories of anxiety (Barlow, 2000; Barlow, Allen, & Choate, 2004; Moses & Barlow, 2006) have emphasized "emotion-driven behaviors"—behaviors that act to reduce distress. For example, an anxious individual might repeatedly call to check on a loved one, in order to reduce uncertainty about a potential negative outcome. Although reinforcing in the short term, these emotion-driven behaviors can be maladaptive and can actually maintain anxiety in the long term (Barlow, 2000; Barlow et al., 2004; Foa & Kozak, 1986; Moses & Barlow, 2006). Indeed, tolerating progressively increasing amounts of fear and anxiety for progressively longer periods of time is a core feature of effective treatments for anxiety disorders (Moses & Barlow, 2006). Though these emotion-driven behaviors are likely to have diffuse influences on behavior, the current study seeks to examine their influence on decision-making behavior.

Decision Making

The role of emotions in decision making has been discussed in a number of literatures (e.g., Connolly & Zeelenberg, 2002; Damasio, 1994; Dolan, 2002; Gutnik, Hakimzada, Yoskowitz, & Patel, 2006; Loewenstein & Lerner, 2003; Loewenstein, Weber, Hsee, & Welch, 2001; Naqvi, Shiv, & Bechara, 2006; Sanfey, Rilling, Aronson, Nystrom, & Cohen, 2003). This may explain why researchers (e.g., Maner & Schmidt, 2006) have suggested that decision making may play an important role in the development and maintenance of anxiety. In particular, relative to nonanxious controls, anxious individuals appear to exhibit a preference for low-risk options (Maner & Schmidt, 2006; Maner et al., 2007; Mitte, 2007; Raghunathan & Pham, 1999). For example, Raghunathan and Pham (1999) had participants choose between high-probability, small reward and low-probability, large reward monetary options. Relative to controls, the anxious decision makers tended to prefer the "safe" high-probability, small reward options. Maner and colleagues (Maner et al., 2007) found similar results using the balloon analogue risk task (BART; Lejuez et al., 2002). In the BART, participants earn monetary rewards as they "pump up" a balloon but can lose their earnings if the balloon is pumped too many times. Results indicate that anxious participants made significantly fewer pumps than nonanxious participants, again suggesting a preference for smaller rewards available with higher probabilities over larger rewards available with smaller probabilities. These results support what we refer to as the risk-aversion hypothesis: Anxious individuals tend to make decisions so as to avoid uncertain or risky consequences. For an individual with GAD, even a promotion may be viewed in terms of uncertainty and potential risk of failure.

The current study seeks to challenge the idea that anxious individuals have a simple preference for lower risk. We do so by considering decisions that involve both risk and time. Work in behavioral economics has suggested that temporal delays may be particularly associated with emotional factors (Loewenstein et al., 2001; Wu, 1999). For example, people exhibit strong anticipatory responses as decision outcomes approach in time (Berns et al., 2006; Loewenstein, 1987; Roth, Breivik, Jorgensen, & Hofmann, 1996). Conversely, other work (Gray, 1999) has demonstrated that experiencing threat-related emotions (e.g., stress) may bias decision-makers' thinking by emphasizing short- over long-term benefits. We have previously speculated (Luhmann, Chun, Yi, Lee, & Wang, 2008) that decision makers may find temporally extended periods of uncertainty to be aversive and consequently make decisions in an attempt to avoid unpleasant emotion. We would further suggest that intolerance of uncertainty should predict decision-makers' susceptibility to such effects. Thus, our proposal is that anxious decision makers, specifically those high on IU, will not simply avoid high-risk choices. Instead, we expect that the temporal duration of uncertainty should play a critical role in magnifying the negative emotional consequences of uncertainty.

One particularly relevant experiment was conducted by Newman, Kosson, and Patterson (1992). Their study examined the relationship between psychopathy, anxiety, and decision making among male prison inmates. In one version of their decision-making task, participants had to choose between two monetary rewards: a 40% chance of winning 5 cents (60% chance of winning nothing) that was available as soon as the trial began and an 80% chance of winning a 5-cent reward (20% chance of winning nothing) that could only be selected 10 seconds after the beginning of the trial. Thus, in order to select the more probable reward, participants were required to wait for 10 seconds on each trial. Newman et al. found that high-anxious psychopaths were less likely to wait for the delayed reward than low-anxious psychopaths. They did not report similar effects of anxiety in the nonpsychopathic sample. This result appears to be partially consistent with our speculation; however, the authors interpret choices for the first, less probable reward in their task as resulting from failures of inhibitory processes rather than intentional avoidance of the delayed rewards. Furthermore, given these authors' focus on psychopathy, the nonpsychopaths' data were not thoroughly investigated.

The current study utilizes a modified version of the Newman et al. (1992) decision-making task in order to investigate the relationship between intolerance of uncertainty and decision making in a nonclinical sample. One key modification made to the task was to associate all of the available rewards with some amount of uncertainty. We feel this presents a more conducive context in which to observe decision-related correlates of intolerance of uncertainty and better corresponds to real-world decision-making situations. For example, imagine an individual waiting to receive the results of some important test (e.g., the SATs or a diagnostic biopsy) and being given the choice between waiting several days for the results to arrive in the mail or driving some long distance to receive the results in person. If waiting in a state of uncertainty is undesirable enough, the individual has the opportunity to eliminate the uncertainty at personal cost.

Given that waiting in a state of uncertainty is particularly aversive for individuals who are intolerant of uncertainty we propose that, despite monetary incentives, those high on IU may exhibit seemingly irrational decision-making behavior. Specifically, we predict that decision makers high on IU will be particularly unwilling to wait for uncertain monetary rewards. Additionally, and contrary to the risk-aversion hypothesis, we expect that the aversion to waiting may be strong enough so that *decision-makers high on IU may actually exhibit preferences for more risky options*. The decision task is designed such that preferences for maximum rewards and preferences for low risk both act to encourage participants to endure periods of uncertainty. Thus, this task provides a strong test of our proposal.

Method

PARTICIPANTS

Fifty Stony Brook University undergraduates (mean age = 22.5, *SD* = 2.57) participated for partial course credit and monetary rewards earned during the decision-making task itself. The sample was 42% Caucasian, 32% Asian, 8% African American (remaining participants fell into either multiple categories or the "Other" category). One participant was excluded for completing several of the questionnaires significantly faster (0.425 seconds per item) than the group average.

MEASURES

Decision Task

The decision task had participants make simple choices between real monetary rewards that varied in magnitude, probability, and in how long participants had to wait before learning the outcome of their chosen option. Each trial began with the presentation of information about a single reward. This first reward was always a 50% chance of receiving 4 cents. The probability was explicitly depicted as shown in Figure 1 (e.g., the first rectangle was 50% green and 50% red). As soon as this reward appeared, it could be selected by pressing the appropriate key on the computer keyboard. If selected, participants were immediately told whether the chosen reward was actually obtained (which occurred 50% of the time). Alternatively, participants could wait for the appearance of a second reward, which was always a 70% chance of receiving 6 cents. If participants

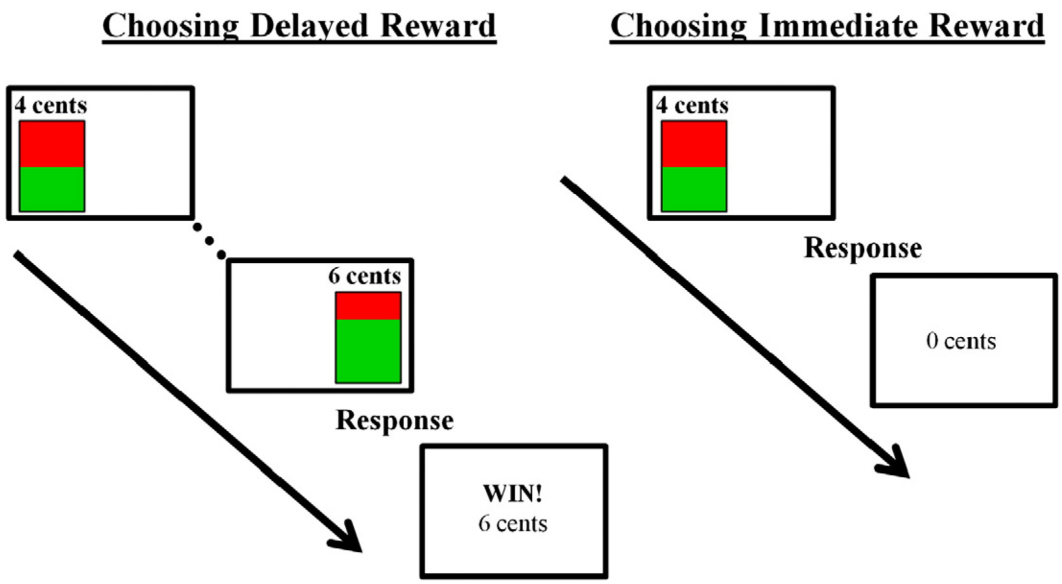

FIGURE 1 Depicted are two example trials illustrating the task sequence that occurred on each trial. At left is a trial on which the larger, delayed reward is selected and won. At right is a trial on which the smaller, immediate reward is selected but not won.

waited and selected this second reward, they were then immediately told whether the reward was actually obtained (which occurred 70% of the time). Reaction times were recorded for all responses.

There are two important methodological details to be noted. First, the delay between the appearance of the first and second rewards varied (5–20 seconds) according to a truncated exponential distribution. That is, on 50% of trials, the delay was 5 seconds, on 25% of trials the delay was 8 seconds, on 13% of trials the delay was 11 seconds, and so on. This prevented participants from knowing how long they would have to wait. For example, at the beginning of each trial, there is a 50% chance that the second reward will appear 5 seconds into the trial and a 50% chance that it will appear after 5 seconds. If the reward did not appear within 5 seconds, there was a 50% chance that it would appear 8 seconds into the trial and a 50% chance that it would appear after 8 seconds. This means that the probability of the second reward appearing in the next few seconds was constant (at 50%) throughout the waiting period and thus, the passage of time did not provide information about how much longer the participant might have to wait.

Also critical to the design was the fact that participants could not reach the next trial any sooner by choosing the smaller reward; choosing the smaller reward simply extended the following intertrial interval. Participants were explicitly told this ahead of time and were further told that they would be completing exactly 100 trials (regardless of what choices they made) and that the entire decision task would last for approximately 25 minutes (again, regardless of what choices they made). Thus, choices for the smaller reward could not reflect (a) a desire to complete more trials, (b) a desire to acquire rewards at a faster rate, or (c) a desire to complete the task more quickly. This also meant that choices for the smaller, more immediate reward could not reflect an aversion to waiting per se. Participants had no control over how long they waited on each trial. They only had control over the relative amount of time spent waiting in a state of uncertainty (before the presentation of the outcome) and the amount of time spent waiting in a state of certainty (after the presentation of the outcome). Thus, choices for the first, less valuable reward can only be seen as an aversion to waiting in a state of uncertainty.

The critical dependent measure in this task was simply how frequently participants waited to choose the second reward. Note that, because the second reward was always both larger and more probable, it was always in the participant's best financial interest to wait and select the second reward. Furthermore, the second, larger reward was also more certain (i.e., predictable 70% of the time) than the first reward (i.e., predictable only 50% of the time).

Intolerance of Uncertainty

The Intolerance of Uncertainty Scale (Buhr & Dugas, 2002) includes 27 items that measure the degree to which the participant finds uncertainty to be unacceptable and associated with emotionally negative reactions. Within our sample, this measure exhibited a high degree of internal consistency, α = .88. This measure has also been shown to exhibit test–retest reliability over 5 weeks, *r* = .74 (Buhr & Dugas). Each of the 27 items can be rated on a 1–5 scale. Thus, overall IU scores can range from 27 to 135 with higher scores indicating greater intolerance of uncertainty.

Trait Anxiety

Trait anxiety was measured using the trait version of the State Trait Anxiety Inventory, Form Y (STAI; Spielberger, Gorsuch, & Lushene, 1970). Within our sample, this measure exhibited a high degree of internal consistency, α = .87. This measure has also been shown to exhibit good reliability (Barnes, Harp, & Jung, 2002). Overall STAI scores can range from 20 to 80 with higher scores indicating greater trait anxiety. A cutoff score of 44 (which is approximately one standard deviation above the mean for healthy adult scores on the trait version of the STAI) was used to identify participants with elevated trait anxiety (Spielberger, 1983). Approximately one third of our sample (17 participants) met this criterion.

Delay Discounting

Delay discounting was measured using Kirby and Marakovic's (1996) 21-item monetary choice questionnaire. Each item on the questionnaire asks the participant to choose between two hypothetical amounts of money: a smaller amount available immediately or a larger amount available at some time in the future. The 21 items are constructed so as to each imply a specific degree of discounting and to cover the plausible range of discounting preferences exhibited by even extremely impulsive clinical populations (e.g., Kirby & Petry, 2004; Kirby, Petry, & Bickel, 1999). By determining which items elicited patient choices and which items elicited impatient choices (see Kirby & Marakovic, 1996, for the scoring procedure), we were able to estimate the rate at which delayed rewards lose value (referred to as the discount rate, or *k*). Kirby (2009) recently found that this questionnaire provides good 5-week, 12-month, and 57-week test–retest reliability (*r* = .77, .71, and .63, respectively). Higher values of *k* suggest greater discounting, meaning that rewards rapidly lose value as they are delayed. Because distributions of *k* values tend to be highly skewed and nonlinear, the results of this measure are presented as discount factors (see Takahasi, Sakaguchi, Oki, & Hasegawa, 2008), which is simply 1 / (1 + *k*) and represents the value of a reward that is delayed a single day (i.e., a discount factor of .8 would imply that today's value of a dollar promised tomorrow is 80 cents). Thus, smaller discount factors represent greater discounting.

PROCEDURE

After completing consent paperwork, participants completed the four measures in a counterbalanced order. Each measure began with instructions that were read to the participant by the experimenter. For the questionnaire tasks, these instructions simply explained the rating scales. The instructions for the decision task explained all aspects of the task including the size of the rewards, the depiction of probability, and the variable delay between the availability of the two rewards. For this task, participants also completed 10 practice trails. These trials were exactly like those in the actual task except that participants were instructed to make specific choices. On half of the practice trials, participants were directed to select the first, smaller reward. On the other half, they were directed to select the second, larger reward. This ensured that participants were exposed to the full range of possible outcomes.

Results

As a preliminary analysis we computed zero-order correlations between study variables. As expected, STAI and IU were significantly related, $R = .66$, $p < .0001$. Furthermore, participants' willingness to wait was significantly correlated with their discount factor, $R = .43$, $p < .005$. No other zero-order correlations were significant. Below we utilize multiple regression to more fully examine the relationships between these variables.

WILLINGNESS TO WAIT

Within our sample, willingness to wait varied quite dramatically (ranging from 0.0 to 1.0, *Mdn* = 0.58; see Table 1 for descriptive statistics of the study variables). The observed distribution of this measure across participants is illustrated in Figure 2. To explore this variation, we constructed a multiple regression model using our three measures (IU, STAI, and discount factor) as predictor variables. Results indicate that the model provided a good fit to

Table 1
Descriptive Statistics for Study Variables

	M	*SD*	*SEM*
Probability of waiting for larger reward	0.6	0.27	0.04
Intolerance of uncertainty	61.12	14.32	2.05
STAI	43.08	8.85	1.26
Discount factor	0.95	0.05	0.01

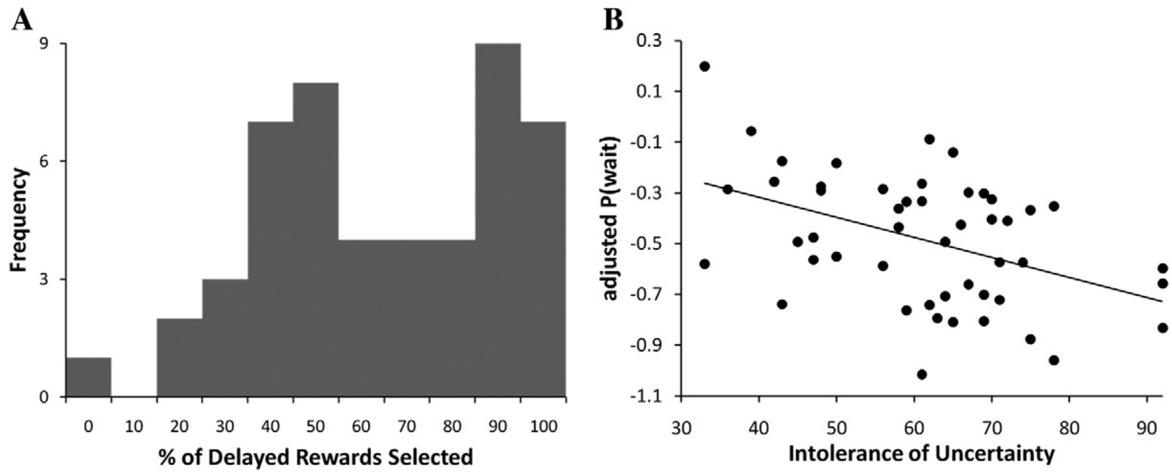

FIGURE 2 (A) Distribution illustrating the tendency to wait (or not) across participants. (B) Participants' tendency to wait for the more valuable reward was predicted by their intolerance of uncertainty (IU) scores with higher IU associated with a decreased tendency to wait.

participants' behavioral data, $R^2 = .22$, $F(3, 45) = 4.2$, $p < .05$. Furthermore, willingness to wait was predicted by both IU, $\beta = -.49$, $t(45) = 3.69$, $p < .001$, and delay discounting, $\beta = -.42$, $t(45) = 2.42$, $p < .05$, but not by trait anxiety, $t(45) = 1.65$, $p > .1$. A partial residual plot (Figure 2) depicts the relationship between participants' willingness to wait and IU. The directions of these relationships are as predicted: Participants high on IU waited on a smaller proportion of trials than participants low on IU. Similarly, stronger delay discounting was associated with waiting on fewer trials. This former finding suggests that high-IU individuals were willing to give up monetary gains (2.2 cents per trial) simply to avoid waiting in a state of uncertainty.

To create a more specific assessment of the influence of IU, we also compared the full regression model described above to a reduced model in which IU was removed as a predictor. The reduced model provided a significant fit to the behavioral data, $R^2 = .13$, $F(2, 46) = 3.51$, $p < .05$, but the full model explained a significant amount of additional variance, $R^2_{\text{diff}} = .09$, $F(1, 45) = 4.97$, $p < .05$. This finding strongly suggests that IU is playing a critical role in accounting for our decision-makers' choices.

To further asses our participants' preferences, we computed median wait times (e.g., reaction times) using only trials on which the first, less valuable reward was selected. This is a coarse measure of willingness to wait on occasions when that waiting did not last long enough for the second, more valuable reward to appear. We constructed the same, full regression model used above, this time using the wait times as the dependent measure. Four subjects were excluded from this analysis; two because they never chose the first item (and thus didn't have any eligible wait times), and two because a computer error prevented the recording of reaction times. Results suggest that IU was marginally predictive, $\beta = -.40$, $t(41) = 1.90$, $p = .064$, whereas trait anxiety and delay discounting were not, ts $< .4$, ps $> .7$. This suggests that participants low on IU were attempting to wait for the larger reward even on trials where they ultimately gave in and chose the smaller reward. In contrast, high-IU participants may have been resigned to choosing the immediate option even before trials began.

OUTCOME SENSITIVITY

We next investigated the degree to which participants were sensitive to the outcome of their choices (winning vs. not winning). Given that participants presumably preferred winning to not winning and that many of them preferred not to wait for the more valuable reward, we expected that nonwins would be particularly undesirable after waiting for and selecting the larger, delayed reward. To evaluate this possibility, we computed two probabilities for each participant. First, we computed the probability of waiting when the larger, delayed reward was selected but not won on the preceding trial. Second, we computed the probability of waiting under all other circumstances (i.e., after waiting and winning, after not waiting and winning, and after not waiting and not winning). Across our sample, the probability of selecting the larger, delayed reward after a delayed nonwin, $M = .47$, $SD = .28$, was significantly smaller than after other types of trials, $M = .56$, $SD = .22$; $t(44) = 3.25$, $p < .005$. Thus, if participants waited for the larger delayed reward and did not win, they were less likely to wait on the following trial. We further explored this tendency by computing the difference between the two computed probabilities. This difference represents the degree to which each participant was sensitive to delayed losses while controlling for that participant's general tendency to wait. This difference was found to be correlated with IU across subjects, $R = -.30$, $p < .05$, with higher IU predicting a greater tendency to select the smaller, immediate reward after not winning the delayed reward (neither STAI nor delay discounting were related to this behavior; Rs $< .21$, ps $> .14$).

Discussion

The current study was designed to explore how intolerance of uncertainty might be related to decision-making behavior. Our decision-making task involved two monetary rewards, one of which was both more valuable and less risky. However, selecting this more valuable reward required decision makers to endure a prolonged period of uncertainty (not knowing whether they would actually obtain the chosen reward). Our results suggest that IU was related to multiple facets of behavior in this task. For example, high IU predicted shorter wait times and more frequent selection of the immediate, less valuable (and riskier) reward. We take this tendency as evidence that IU was associated with an aversion to waiting in a state of uncertainty. One might argue that choices for the more immediate, less valuable reward might reflect an aversion to waiting per se, however, participants in the task had no control over how long they waited. They only had control over how long they waited in a state of uncertainty. Furthermore, our results show that high IU predicted greater sensitivity to unfavorable outcomes: High-IU participants more frequently chose the immediate, less valuable reward after selecting but not winning the more valuable, delayed reward. This suggests that IU partially determined how participants reacted to various outcomes and suggests that learning may play an important role in the development and maintenance of avoidant behavior.

Perhaps most straightforwardly, our results also provide some of the first directly observed evidence that IU is associated with maladaptive patterns of actual behavior. As mentioned above, previous work has linked IU to either cognitive tendencies (e.g., increased worry, positive beliefs about worry) or to arguably benign behavioral consequences (e.g., increased need for evidence, problem orientation). Because of the design of the decision task used in the current study, the pattern of behavior associated with high IU is unarguably maladaptive. Additionally, because of the nature of the decision task, current results can be taken as strong validation results for the self-report IU scale developed by Buhr and Dugas (2002).

Previous work (Maner & Schmidt, 2006; Maner et al., 2007; Mitte, 2007; Raghunathan & Pham, 1999) has shown that anxious individuals are risk averse, preferring more certain monetary rewards even if there are larger, high-risk rewards available. In contrast to these previous results, however, participants in the current study exhibited the opposite pattern; higher IU was associated with more frequent selection of the riskier, more immediate option. Consistent with our earlier proposal (Luhmann et al., 2008), the delay associated with the more valuable reward in the current study appears to have magnified the unpleasant affective responses to uncertainty, particularly for those participants high on IU. As Ladouceur and colleagues (2000) have theorized, IU may have led decision makers to worry about waiting for the delayed reward, to second-guess choices to wait, and to ask "What if?" questions such as "What if I wait all this time only to win nothing?" Together, these affective factors could have diminished the subjective value of the delayed reward enough to make the less valuable but more immediate reward more attractive. Indeed, for risk-avoidant decision makers, these affective factors would have to have been strong enough to overcome both the loss in value and the strong preference for low-risk choices. Such a process would be consistent with previous suggestions (e.g., Berns et al., 2006; Loewenstein et al., 2001; Sanfey et al., 2003) that waiting, and particularly waiting in a state of uncertainty, is associated with strong affective influences on decision making even in healthy individuals. IU, it appears, exaggerates the contribution of these emotional factors.

Furthermore, if delay is provoking unpleasant affective responses, choices for the smaller, immediate reward can be seen as avoidance of distress. For decision makers who find themselves uncomfortable while they attempt to wait for the more valuable reward, the immediate reward represents an effortless but financially costly "escape route." Consistent with previous reports (e.g., Maner et al., 2007; Raghunathan & Pham, 1999), high IU was associated with this avoidant behavior. More generally, our results lead us to speculate that the previous reports of risk-avoidant behavior in anxious individuals might better be understood in terms of emotional avoidance (Borkovec, Alcaine, & Behar, 2004). That is, the affective consequences of uncertainty may play a more central role in determining behavior than uncertainty itself. Indeed, the current data suggest that decision-making tendencies among those high in IU may be maintained through negative reinforcement—the preference for smaller, immediate rewards might be maintained insofar as these choices reduce or eliminate affectively unpleasant circumstances that accompany waiting in uncertainty.

Avoidant behavior was also seen on those occasions when high-IU participants endured extended uncertainty only to experience undesirable consequences; following these trials, high-IU participants were even more likely to prefer the smaller, immediate reward. This behavioral pattern suggests that decision making among high-IU individuals may be characterized by two processes: first, high-IU individuals may choose more immediate rewards that are smaller in magnitude and riskier in order to avoid distress associated with waiting in uncertainty; and, second, this tendency may become exaggerated following those instances when waiting in uncertainty is not rewarded. It is easy to imagine how IU could create obstacles for positive behavior change—particularly when such change requires waiting in the face of uncertainty. Indeed, exposure-based cognitive–behavioral therapies encourage anxious participants to experience and tolerate distress, particularly in situations when feared outcomes are possible and require waiting in a state of uncertainty (i.e., tolerating distress associated with concerns about a loved one and *not* calling to check on him or her).

Lastly, we note that the current study has several limitations. First, our participants consisted of an unselected, undergraduate population. Second, given that the sample was unselected, it is unclear what proportion met criteria for clinical levels for anxiety. Though we had both reasonable variability on our measures and moderately high levels of IU for a nonclinical sample, stronger conclusions could be drawn with a selected sample, perhaps including those meeting criteria for GAD. Third, the trade-off between risk and delay cannot be thoroughly evaluated in the current results because risk was held constant. Future studies are needed to fully address the relationship between these variables. For example, it remains unclear how much delay is required before high-IU decision makers begin to prefer risky alternatives. Finally, we note that IU has been associated with several other anxiety-related constructs that were not included in the current study. For example, IU has been highly related to measures of worry (e.g., Dugas, Gosselin, & Ladouceur, 2000). Future work could be designed to evaluate whether IU and worry account for similar aspects of decision-making behavior or whether there are separable influences.

References

Barlow, D. H. (2000). Unraveling the mysteries of anxiety and its disorders from the perspective of emotion theory. *American Psychologist*, *55*, 1247–1263.

Barlow, D. H., Allen, L. B., & Choate, M. L. (2004). Toward a unified treatment for emotional disorders. *Behavior Therapy*, *35*, 205–230.

Barnes, L. B., Harp, D., & Jung, W. S. (2002). Reliability generalization of scores on the Spielberger state trait anxiety inventory. *Educational and Psychological Measurement*, *62*, 603–618.

Berns, G. S., Chappelow, J., Cekic, M., Zink, C. F., Pagnoni, G., & Martin-Skurski, M. E. (2006). Neurobiological substrates of dread. *Science*, *312*, 754–758.

Borkovec, T. D., Alcaine, O., & Behar, E. (2004). Avoidance theory of worry and generalized anxiety disorder. In R. G. Heimberg, C. L. Turk, & D. S. Mennin (Eds.), *Generalized anxiety disorder: Advances in research and practice* (pp. 77–108). New York: Guilford Press.

Buhr, K., & Dugas, M. J. (2002). The intolerance of uncertainty scale: Psychometric properties of the English version. *Behaviour Research and Therapy*, *40*, 931–945.

Connolly, T., & Zeelenberg, M. (2002). Regret in decision making. *Current Directions in Psychological Science*, *11*, 212–216.

Damasio, A. R. (1994). *Descartes' error*. New York: Putnam's Sons.

Dolan, R. J. (2002). Emotion, cognition, and behavior. *Science*, *298*, 1191–1194.

Dugas, M. J., Gagnon, F., Ladouceur, R., & Freeston, M. H. (1998). Generalized anxiety disorder: A preliminary test of a conceptual model. *Behaviour Research and Therapy*, *36*, 215–226.

Dugas, M. J., Gosselin, P., & Ladouceur, R. (2000). Intolerance of uncertainty and worry: Investigating specificity in a nonclinical sample. *Cognitive Therapy and Research*, *25*, 551–558.

Dugas, M. J., Hedayati, M., Karavidas, A., Buhr, K., Francis, K., & Phillips, N. A. (2005). Intolerance of uncertainty and information processing: Evidence of biased recall and interpretations. *Cognitive Therapy and Research*, *29*, 57–70.

Dugas, M. J., & Ladouceur, R. (1998). Analysis and treatment of generalized anxiety disorder. In V. E. Caballo (Ed.), *International handbook of cognitive–behavioural treatments of psychological disorders* (pp. 197–225). Oxford: Pergamon Press.

Dugas, M. J., & Ladouceur, R. (2000). Treatment of GAD: Targeting intolerance of uncertainty in two types of worry. *Behavior Modification*, *24*, 635–657.

Dugas, M. J., Letarte, H., Rhéaume, J., Freeston, M. H., & Ladouceur, R. (1995). Worry and problem solving: Evidence of a specific relationship. *Cognitive Therapy and Research*, *19*, 109–120.

Foa, E. B., & Kozak, M. J. (1986). Emotional processing of fear: Exposure to corrective information. *Psychological Bulletin*, *99*, 20–35.

Gray, J. R. (1999). A bias toward short-term thinking in threat-related negative emotional states. *Personality and Social Psychology Bulletin*, *25*, 65–75.

Gutnik, L. A., Hakimzada, A. F., Yoskowitz, N. A., & Patel, V. L. (2006). The role of emotion in decision-making: A cognitive neuroeconomic approach towards understanding sexual risk behavior. *Journal of Biomedical Informatics*, *39*, 720–736.

Kirby, K. N. (2009). One-year temporal stability of delay-discount rates. *Psychonomic Bulletin and Review*, *16*, 457–462.

Kirby, K. N., & Marakovic, N. N. (1996). Delay-discounting probabilistic rewards: Rates decrease as amounts increase. *Psychonomic Bulletin and Review*, *3*, 100–104.

Kirby, K. N., & Petry, N. M. (2004). Heroin and cocaine abusers have higher discount rates for delayed rewards than alcoholics or non-drug-using controls. *Addiction*, *99*, 461–471.

Kirby, K. N., Petry, N. M., & Bickel, W. K. (1999). Heroin addicts discount delayed rewards at higher rates than non-drug using controls. *Journal of Experimental Psychology: General*, *128*, 78–87.

Ladouceur, R., Blais, F., Freeston, M. H., & Dugas, M. J. (1998). Problem solving and problem orientation in generalized anxiety disorder. *Journal of Anxiety Disorders*, *12*, 139–152.

Ladouceur, R., Gosselin, P., & Dugas, M. J. (2000). Experimental manipulation of intolerance of uncertainty: A study of a theoretical model of worry. *Behaviour Research and Therapy*, *38*, 933–941.

Ladouceur, R., Talbot, F., & Dugas, M. J. (1997). Behavioral expressions of intolerance of uncertainty in worry: Experimental findings. *Behavior Modification*, *21*, 355–371.

Lejuez, C. W., Read, J. P., Kahler, C. W., Richards, J. R., Ramsey, S. E., Stuart, G. L., Strong, D. R., et al. (2002). Evaluation of a behavioral measure of risk-taking: The balloon analogue risk task (BART). *Journal of Experimental Psychology: Applied*, *6*, 75–84.

Loewenstein, G. (1987). Anticipation and the valuation of delayed consumption. *Economic Journal*, *97*, 666–684.

Loewenstein, G., & Lerner, J. S. (2003). The role of affect in decision making. In R. Davidson, K. Scherer, & H. Goldsmith (Eds.), *Handbook of affective sciences* (pp. 619–642). New York: Oxford University Press.

Loewenstein, G. F., Weber, E. U., Hsee, C. K., & Welch, N. (2001). Risk as feelings. *Psychological Bulletin*, *127*, 267–286.

Luhmann, C. C., Chun, M. M., Yi, D., Lee, D., & Wang, X. (2008). Neural dissociation of delay and uncertainty in inter-temporal choice. *Journal of Neuroscience*, *28*, 14459–14466.

Maner, J. K., Richey, J. A., Cromer, K., Mallott, M., Lejuez, C., Joiner, T. E., & Schmidt, N. B. (2007). Dispositional anxiety and risk-avoidant decision making. *Personality and Individual Differences*, *42*, 665–675.

Maner, J. K., & Schmidt, N. B. (2006). The role of risk-avoidance in anxiety. *Behavior Therapy*, *37*, 181–189.

Metzger, R. L., Miller, M. L., Cohen, M., Sofka, M., & Borkovec, T. D. (1990). Worry changes decision-making: The effect of negative thoughts on cognitive processing. *Journal of Clinical Psychology*, *48*, 76–88.

Mitte, K. (2007). Anxiety and risky decision-making: The role of subjective probability and subjective costs of negative events. *Personality and Individual Differences*, *43*, 243–253.

Moses, E. B., & Barlow, D. H. (2006). A new unified treatment approach for emotional disorders based on emotion science. *Current Directions in Psychological Science*, *15*, 146–150.

Naqvi, N., Shiv, B., & Bechara, A. (2006). The role of emotion in decision making: A cognitive neuroscience perspective. *Current Directions in Psychological Science*, *15*, 260–264.

Newman, J. P., Kosson, D. S., & Patterson, C. M. (1992). Delay of gratification in psychopathic and nonpsychopathic offenders. *Journal of Abnormal Psychology*, *101*, 630–636.

Raghunathan, R., & Pham, M. T. (1999). All negative moods are not equal: Motivational influences of anxiety and sadness on decision making. *Organizational Behavior and Human Decision Processes*, *79*, 56–77.

Roth, W. T., Breivik, G., Jorgensen, P. E., & Hofmann, S. (1996). Activation in novice and expert parachutists while jumping. *Psychophysiology*, *33*, 63–72.

Sanfey, A. G., Rilling, J. K., Aronson, J. A., Nystrom, L. E., & Cohen, J. D. (2003). The neural basis of economic decision-making in the ultimatum game. *Science*, *300*, 1755–1758.

Spielberger, C. D. (1983). *Manual for the state–trait anxiety inventory STAI (form Y)*. Palo Alto, CA: Mind Garden.

Spielberger, C. D., Gorsuch, R. L., & Lushene, R. (1970). *STAI manual*. Palo Alto, CA: Consulting Psychologists Press.

Stöber, J., Tepperwien, S., & Staak, M. (2000). Worrying leads to reduced concreteness of problem elaborations: Evidence for the avoidance theory of worry. *Anxiety, Stress, and Coping*, *13*, 217–227.

Takahashi, T., Sakaguchi, K., Oki, M., & Hasegawa, T. (2008). Sex hormonal modulation of hyperbolic discount factor in men. *Journal of Neuroscience, Psychology, and Economics*, *1*, 7–16.

Tallis, F., Eysenck, M. W., & Matthews, A. (1991). Elevated evidence requirements and worry. *Personality and Individual Differences*, *12*, 21–27.

Wu, G. (1999). Anxiety and decision making with delayed resolution of uncertainty. *Theory and Decision*, *46*, 159–199.

Received: April 27, 2010
Accepted: September 28, 2010
Available online 3 March 2011