J. Behav. Ther. & Exp. Psychiat. 51 (2016) 58–65

Contents lists available at ScienceDirect

Journal of Behavior Therapy and Experimental Psychiatry

journal homepage: www.elsevier.com/locate/jbtep

Self-reported intolerance of uncertainty and behavioural decisions

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A R T I C L E I N F O

Article history:
Received 6 October 2015
Received in revised form
4 December 2015
Accepted 21 December 2015
Available online 28 December 2015

Keywords:
Intolerance of uncertainty
Behavior
Wisconsin Card Sorting Task
Risky Gains Task
Modified Iowa Gambling Task

A B S T R A C T

Intolerance of Uncertainty (IU) appears to be a robust transdiagnostic risk factor related to anxiety and depression. Most transdiagnostic IU research has used the self-report Intolerance of Uncertainty Scale-Short Form; however, there is comparatively little research exploring presumed behavioral correlates of IU. The current study was designed to assess relationships between self-reported IU and decisions in uncertainty-based behavioral tasks (specifically, the Wisconsin Card Sorting Task, the Risky Gains Task, and the Modified Iowa Gambling Task). Participants comprised compensated community members ($n = 108$; 69% women) and undergraduates ($n = 98$; 78% women). Community member compensation was not contingent on performance, but undergraduate compensation was partially contingent on performance. Results replicated prior research, with both samples producing small ($r = .19$) to moderate ($r = -.29$) correlations ($ps < .05$) between self-reported IU and outcome variables from each of the behavioral tasks. The relationships were larger in the undergraduate sample, likely due to the compensation incentive. In general, the results suggest that increasing IU is associated with increasingly risk adverse behaviors; however, the relationship appears complex and in need of substantial additional research to understand how clinically-significant IU would impact pathology-related behaviours.

1. Introduction

Almost every choice or decision made by an organism involves some consideration of uncertainty, where uncertainty describes imperfect or unknown information relevant to a decision. Decision-making under uncertainty has been (and continues to be) a key topic of inquiry in the behavioral sciences, especially biology, economics, and psychology, and has inspired a vast literature of thousands of studies (reviewed in Plous, 1993; see for recent examples, Pleskac, Diederich, & Wallsten, 2015; Starcke & Brand, 2012). Despite the interest, surprisingly little of this vast literature has addressed whether or not there are stable individual differences in how organisms make decisions under uncertainty until recently.

Intolerance of Uncertainty (IU) is a dispositional characteristic resulting from negative beliefs about uncertainty and its implications (Dugas & Robichaud, 2007), the core of which is appears to be fear of the unknown (Carleton, 2012), wherein the possibility of a negative event occurring is considered threatening irrespective of the probability of its occurrence (Carleton, Sharpe, & Asmundson, 2007). IU is an uncertainty-specific lower-order construct that is the most prominent factor underlying the broader higher-order construct that is distress tolerance (Bardeen, Fergus, & Orcutt, 2013; Zvolensky, Vujanovic, Bernstein, & Leyro, 2010). Because of the central importance of sensitivity to uncertainty in decision-making, the development of IU as an index of behaviors and responses to uncertainty is a key step forward, and has broad implications for understanding decision-making in multiple domains.

IU is particularly relevant to understanding psychopathology. Fearing the unknown and difficulties associated with tolerating uncertainty have been posited as transdiagnostic vulnerability factors for the development and maintenance of anxiety and depression symptoms e.g., (Carleton, Mulvogue, et al., 2012; Gentes & Ruscio, 2011; Hong & Cheung, 2015). There is now substantial evidence that IU accounts for variance in several anxiety- and

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http://dx.doi.org/10.1016/j.jbtep.2015.12.004
0005-7916/

mood-related disorders (see for review Carleton, 2012; Hong & Cheung, 2015) and appears consistently higher for clinical samples relative to undergraduate and community samples (Carleton, Mulvogue, et al., 2012). The evidence implicates IU as a potentially critical transdiagnostic vulnerability factor (Carleton, 2012). There is also evidence that uncertainty automatically activates the fight or flight response (Thayer, Ahs, Fredrikson, Sollers, & Wager, 2012) and the behavioural inhibition system (Gray & McNaughton, 2003), implicating IU in the development of psychopathology and decision-making processes. Most research e.g., (Hong & Lee, 2015) has supported two robust dimensions of IU measurement, a more immediate behaviorally focused dimension (i.e., Inhibitory IU) and a more future-oriented cognitively focused dimension (i.e., Prospective IU).

Current theories (Carleton, 2012) and models e.g., (Dugas, Buhr, & Ladouceur, 2004; Einstein, 2014; Grupe & Nitschke, 2013) of IU implicate a potentially significant transdiagnostic role for uncertainty in decision making for clinical and non-clinical populations. Most of the research supporting such models has used self-report measures, such as the Intolerance of Uncertainty Scale (IUS; Freeston, Rhéaume, Letarte, Dugas, & Ladouceur, 1994), the 12-item short form (IUS-12; Carleton, Norton, & Asmundson, 2007), and the Intolerance of Uncertainty Index (IUI; Carleton, Gosselin, & Asmundson, 2010) to assess IU; however, there is relatively limited research explicitly assessing behavioural correlates of IU. Understanding the relationship between IU as a cognitive construct and behaviour appears to be an important aspect of demonstrating broad utility (Carleton, 2012). In the following, we summarize some studies that have examined IU as a behavioral outcome.

Ladouceur and colleagues (Ladouceur, Talbot, & Dugas, 1997) demonstrated that behavior associated with reducing uncertainty (as measured by the Beads Task) was positively associated with self-reported trait IU. The Beads Task has participants draw a series of beads (with replacement) from a container and then choose the ratio of black and white beads from a set of presented options. The results indicated a positive relationship between IU and number of draws before choosing, $rs = .32$ to .43, with the relationship falling as the ambiguity increased (i.e., as participants were given more potential ratios), $rs = .26$ to .32. Ladouceur et al. (1997) suggested that too much uncertainty produced a ceiling effect (i.e., a range restriction) that removed the relationship between IU and task performance.

Jacoby and colleagues (Jacoby, Abramowitz, Buck, & Fabricant, 2014) replicated and extended Ladouceur et al. (1997) results with the Beads Task using an undergraduate sample and a clinical sample with anxiety disorders. They used two self-report measures to assess IU; specifically, the IUS-12 and the Perfectionism/Certainty subscale of the Obsessive Beliefs Questionnaire (Obsessive Compulsive Cognitions Working Group, 2001, 2003). Correlations were used to assess relationships between self-reported IU and the time participants took to decide the ratio of beads in a container. The results indicated a statistically significant positive relationship between the Perfectionism/Certainty subscale and the number of bead draws before a participant decided, $r = .36$; in contrast, the relationship with the IUS-12 total and subscale scores (i.e., Prospective IU and Inhibitory IU) was not significant. There was no statistically significant relationship identified between IU and the time taken to reach a decision.

Rosen and colleagues (Rosen et al., 2010) found a positive association between self-reported trait IU (measured as a total score) and behaviors associated with the reduction of uncertainty. In an experimental design, they manipulated health-related uncertainty in a sample of undergraduates and then assessed subsequent health seeking behaviours, which may be more ecologically valid than the beads task. The results indicated a positive relationship between IU and behaviours designed to reduce uncertainty, $r = .26$ (i.e., taking health brochures and requesting information packages).

Luhmann and colleagues (Luhmann, Ishida, & Hajcak, 2011) found that self-reported trait IU (measured as a total score) was associated with greater delay discounting behavior—that is, preference for smaller immediate rewards over larger distal rewards. Specifically, the results indicated an inverse relationship ($R = -.30$) between IU and delay discounting. There was also an inverse relationship ($\beta = -.49$) between IU and willingness to wait. In other words, the desire to end the uncertainty appeared to outweigh the desire for specific gains; moreover, trait anxiety was not related to the behavioural measures, even though IU and trait anxiety were correlated ($r = .66$).

Thibodeau and colleagues (Thibodeau, Carleton, Gomez-Perez, & Asmundson, 2013) found an inverse relationship between both of the IU subscale scores (i.e., Prospective IU and Inhibitory IU) and typing speed ($r = -.54$), which was higher after controlling for other psychological and physiological variables (*part* $r = -.68$); however, neither IU nor the reduced speed were related to fewer typographic errors. Higher IU may have produced intentional or unintentional visual or haptic checking before key strikes in an attempt to maximize certainty and minimize errors. Such slight hesitancies over hundreds of keystrokes would have aggregated to an overall slower typing speed. van Horen and Mussweiler (van Horen & Mussweiler, 2014) may have investigated the most subtle relationship between IU and behaviour by assessing the desirability of soft (i.e., comforting) haptic sensations under uncertainty. Participants primed to consider the world as uncertain demonstrated greater desire for softer rewards, Cramer's $V = .28$ to .45; however, van Horen and Mussweiler did not assess for a relationship with self-reported IU.

The current research was designed to further explore the relationship between self-reported IU and behaviours related to decision-making under uncertainty. The current research extends previous work in several important ways. First, we use multiple well-established behavioral measures involving decision-making under uncertainty, which have not been examined in concert with a transdiagnostically robust measure of trait IU in undergraduate, community, or clinical samples. The behavioral measures include the Wisconsin Card Sorting Task (WCST; Grant & Berg, 1948), the Risky Gains Task (RGT; Paulus, Rogalsky, Simmons, Feinstein, & Stein, 2003), and the Modified Iowa Gambling Task (MIGT; Cauffman et al., 2010).

The WCST, RGT, and MIGT behavioural tasks were selected because each has been used broadly in the decision-making literature to measure decision-making under uncertainty. Second, each of these tasks taps into different cognitive elements of decision-making e.g., the WCST has been associated with executive functioning; the MIGT is associated with implicit cognitive processes; e.g., (Bechara, Damasio, Tranel, & Damasio, 2005; Miyake, Friedman, Emerson, Witzki, & Howerter, 2000), although each involves decision-making under uncertainty (our key behavioral outcome of interest). Third, the ecological validity of behavioral measures of uncertainty avoidance have been highly variable. As a consequence, it is unclear whether associations between self-reported trait IU and behavioral decision-making under uncertainty are confounded by the ecological validity of the tasks used. The ecological validity of the behavioral tasks we use in this study range from relatively low (e.g., the WCST) to relatively high (e.g., the MIGT). Finally, we use both undergraduate and community participants. This approach allows for the initial examination of the trait-behavioral IU relationship in a much more variable sample than has been used in previous studies (e.g., solely undergraduate or clinical samples); moreover, clinical samples typically exhibit ceiling effects for self-reported trait IU (Carleton, Mulvogue, et al., 2012), are resource intensive, making them difficult to justify without prior task-specific evidence, and clinical would be better supported if compared to non-clinical samples.

We predicted that self-reported IU would be positively associated with prolonged decision-making/the selection of immediate safe rewards rather than delayed, risky, but potentially more advantageous rewards; specifically, we hypothesized that self-reported IU would be 1) positively associated with response latency on the WCST and the MIGT (both subscales, greater for Inhibitory IU); 2) negatively associated with the number of trials needed to complete the first WCST category (both subscales, but greater for Inhibitory IU); and 3) negatively associated with total scores on the MIGT (i.e., the net of the percentage of plays on advantageous decks minus the percentage of plays on disadvantageous decks; both subscales, but greater for Prospective IU) and 4) positively associated with the RGT total score because higher IU was expected to result in less risky, more certain, and less advantageous choices (both subscales, but greater for Prospective IU). Finally, in line with Cauffman et al. (2010) analytic recommendations for the MIGT, IU was expected to be associated with higher sensitivity to negative outcomes.

2. Methods

2.1. Participants

Participants included community members ($n = 164$; 69% women) from across North America and undergraduate students ($n = 98$; 79% women) from the University of Regina. Community members were recruited by means of CrowdFlower, a crowd-sourcing Internet marketplace. The CrowdFlower platform allows users (e.g., researchers) to access an online workforce of millions of people to help collect data. Community members were compensated $4.00 for their participation. Only 115 community participants (69% women) completed at least one of the behavioural tasks. Most community participants ($n = 115$) completed at least some post-secondary education (81%), were single (38%) or married (57%), Caucasian (81%), and employed full-time (38%) or part-time (10%).

Undergraduate students were recruited through the University of Regina Psychology Participant Pool. Undergraduate students were awarded one credit towards their psychology course of choice for their participation. In order to enhance participant involvement from the undergraduate students, they were offered an additional bonus credit for excellent performance on the behavioural tasks; however, all participants received the additional credit. Most undergraduate participants ($n = 98$) were single (80%), Caucasian (69%) or Asian (14%), and employed part-time (55%). The university research ethics board approved the current research project.

2.2. Measures

Intolerance of Uncertainty Scale, Short Form (IUS-12; Carleton, Norton, et al., 2007). The IUS-12 is a 12-item short-form of the original 27-item Intolerance of Uncertainty Scale (Freeston et al., 1994) that measures reactions to uncertainty, ambiguous situations, and the future. Items are scored on a 5-point Likert scale ranging from 1 (*not at all characteristic of me*) to 5 (*entirely characteristic of me*). The measure assesses trait IU (i.e., trans-situational IU), rather than situation specific IU (Mahoney & McEvoy, 2012). The IUS-12 has been shown to have two distinct factors (Carleton, Norton, et al., 2007; Khawaja & Yu, 2010; McEvoy & Mahoney, 2011), prospective IU (e.g., "Unforeseen events upset me greatly") and inhibitory IU (e.g., "The smallest doubt can stop me from acting"), assessed as subscales, each with comparable internal consistencies of $\alpha = .85$ (Carleton, Norton, et al., 2007). IU appears to have has a continuous latent structure (Carleton, Weeks, et al., 2012) supporting its use in correlation research (Field, 2005). The IUS-12 is psychometrically comparable to the longer original 27-item Intolerance of Uncertainty Scale (Khawaja & Yu, 2010). The IUS-12 and the two related subscales (i.e., prospective and inhibitory IU) have demonstrated substantial transdiagnostic psychometric support (Carleton, Mulvogue, et al., 2012; Helsen, Van den Bussche, Vlaeyen, & Goubert, 2013; Jacoby, Fabricant, Leonard, Riemann, & Abramowitz, 2013; McEvoy & Mahoney, 2011). Internal consistencies and average inter-item correlations (*iir*) for the total score (community, $\alpha = .91$, $iir = .45$; undergraduate, $\alpha = .88$, $iir = .39$), the prospective IU subscale score (community, $\alpha = .84$, $iir = .43$; undergraduate, $\alpha = .79$, $iir = .35$), and the inhibitory IU subscale score (community, $\alpha = .91$, $iir = .68$; undergraduate, $\alpha = .86$, $iir = .54$), were all acceptable.

2.3. Tasks

Wisconsin Card Sorting Test (WCST; Grant & Berg, 1948). The WCST developed by Grant and Berg (1948) is one of the most widely used measures of executive functioning. The WCST assesses abstract reasoning and the ability to shift between cognitive strategies (Grant & Berg, 1948). Participants are asked to sort cards into four different "categories" (i.e., by color, form, or number), and are informed "The goal is to get as many cards into the 'right' pile as quickly as possible". No instructions are given in regards to the categorization rules. There are four decks of cards that serve as the reference cards, and another deck of cards that serves as the response cards. The participant is instructed to place each response card in front of one of the four reference cards. After each response, the participant is told whether the response was "right" or "wrong," but they are not told where the card should have gone. The goal for the subject is to get as many "right" responses as possible. As the test progresses, there are unannounced shifts in the sorting principle which require the client to alter his or her approach (Grant & Berg, 1948). Participants receive the equivalent of two decks of cards. Each deck contains 64 different cards, with the maximum number of trials/cards being 128.

Risky-Gains Task (RGT; Paulus et al., 2003). The Risky-Gains Task was developed to probe the neural circuitry underlying risky decisions (Paulus et al., 2003). In the computerized RGT, participants are told "The goal of the game is to gain as many points as possible" and they are presented with three numbers of 20, 40, and 80 (Paulus et al., 2003). Each trial begins with an opportunity to gain 20 points. Participants can accept the gain of 20 points or wait until the next number is presented, which will be either a gain or loss of 40 points. Once the 40 is presented participants can again accept the gain or loss of 40 points, or wait until the next number is presented, which will be either a gain or loss of 80 points. The RGT consists of three trial types (up to 96 trials in total), which are presented in randomized order. The trials are non-punished ($n = 54$), a trial punished with a loss of 40 ($n = 24$), and a trial punished with a loss of 80 ($n = 18$). Unbeknownst to the participant, there is no inherent advantage to waiting for the risky response (+/−40 or $\pm$ 80) over selecting the safe response (+20). The RGT has been used to assess decision-making processes and the evaluation of risk in regards to these decision-making processes e.g., (Kruschwitz, Simmons, Flagan, & Paulus, 2012).

Modified Iowa Gambling Task (MGT; Cauffman et al., 2010). A variation of the original Iowa Gambling Task (Bechara, Damasio, Damasio, & Anderson, 1994), the MIGT is an established neuropsychological decision-making task that was used to examine affective decision-making under conditions of uncertainty (Bechara et al., 1994; Bechara, Damasio, & Damasio, 2000). The IGT has been used to examine the relationship of intolerance of uncertainty in decision-making e.g., (Mueller, Nguyen, Ray, & Borkovec, 2010). Like the original task, the MIGT requires participants to earn pretend money by passing or playing on four decks of cards. Participants are instructed that "The goal is to win as much money as possible" and presented with four decks of cards (Cauffman et al., 2010). Two decks (i.e., decks A and B) are statistically *disadvantageous* and probabilistically result in monetary net loss. The other two decks (i.e., decks C and D) are statistically *advantageous* and probabilistically result in monetary net gains. In the MIGT, participants choose to play or pass on one of the four decks randomly selected on each trial rather than choosing from any of the four decks (Cauffman et al., 2010). The modification allows for the separate tracking of sensitivity to reward (i.e., selecting advantageous decks) and sensitivity to cost (i.e., avoiding disadvantageous decks; Peters & Slovic, 2000). The computerized MIGT is set up to play 6 blocks of 20 trials (5 trials per deck) with 30 trials per deck total.

2.4. Analyses

A series of independent *t*-tests were used to compare participant responses to self-reported IU across completers and non-completers to assess for a potential confounding bias with self-selection. Descriptive statistics were calculated for all variables of interest for all completers. A series of independent *t*-tests were used to compare participant responses to key variables of interest across the two groups (i.e., the community sample and the undergraduate sample). Finally, zero-order correlations were used to evaluate relationships between IU and the task variables, testing the hypotheses for each sample.

Additional analyses were conducted for the MIGT per Cauffman et al. (2010). To assess the degree to which participants learned to play (rather than pass) when presented with a card from a good deck, and to pass (rather than play) when presented with a card from a bad deck, latent growth curve modeling was used (with M*plus* v7.2, using full information maximum likelihood estimation to handle missing data). Linear latent growth models were estimated separately for percentage of plays (versus passes) on good decks, percentage of plays (versus passes) on bad decks, the difference between the two (net score), and the average of the two (total score) across the six blocks of the task. For each outcome variable (good decks, bad decks, net score, and total score), the latent intercept (average performance on the final block of the task) and latent slope (average rate of change across the 6 blocks of the task) was regressed on IU, sample (student = 0, community = 1), IU × sample (to detect whether the effect differed for students and community members), and control variables—age and whether the participant was female. IU inhibitory and IU prospective were highly correlated ($r = .71$); as such, each subscale was tested separately.

3. Results

All of the participants who elected to discontinue without completing at least one of the behavioural tasks were from the community sample. All but one of the undergraduate participants completed all three behavioural tasks. The exception was the result of a single technical error with the MIGT. Assuming unequal variances, community participants who discontinued without completing at least one of the behavioural tasks were significantly younger, $t(88.75) = -1.17$, $p = .245$, $r^2 = .01$, as well as having higher levels of prospective IU, $t(73.62) = 2.47$, $p = .02$, $r^2 = .04$, inhibitory IU, $t(82.40) = 2.26$, $p = .03$, $r^2 = .03$, and total IU, $t(74.66) = 2.52$, $p = .01$, $r^2 = .04$.

Participants in the community sample were older, but reported comparable scores on self-reported IU. There were several statistically significant differences between the community and undergraduate scores related to the behavioural tasks (see Table 1); among those differences, "total completed categories" on the WCST and "total percent 'good' play decisions" on the MIGT were no long statistically significant after controlling for age. On the WCST, community participants completed fewer categories, took less time to complete the first category, and took less time to complete the task overall. On the MIGT community participants selected slightly more good and bad play decisions than the undergraduate participants. In addition, relative to the undergraduate participants, the community participants produced lower Total Current Scores, but comparable Total Net Scores, and took less time to complete the task. On the RGT community participants produced comparable scores to the undergraduate participants. Community participant age was significantly inversely correlated with inhibitory IU (see Table 2). In contrast, undergraduate participant age was not significantly correlated with self-reported IU.

There was support for some, but not all, of the hypothesized relationships between self-reported IU and the behavioural tasks (see Table 3); that said, in line with previous research pairing self-reported IU with behavioural tasks e.g., (Jacoby et al., 2014; Ladouceur et al., 1997; Luhmann et al., 2011; Rosen et al., 2010) the relationships had small to modest absolute values ranging from $r = .001$ to $r = .290$. Contrasting the first hypothesis (see Table 4), there was no significant relationship between IU and response latency for the WCST in either the community sample or the undergraduate sample. There was a single positive, statistically significant relationship between prospective IU and response latency for the MIGT in the undergraduate sample.

Supporting the second hypothesis (see Table 3), there was a statistically significant inverse relationship between the trials required to complete the first category for the WCST, but only for inhibitory IU and the community sample. In contrast, the undergraduate sample demonstrated a stronger positive correlation between prospective IU and the trials required to complete the first category for the WCST.

Supporting the third hypothesis (see Table 3), in the community sample the total current score was inversely associated with prospective IU and inhibitory IU. In addition, the total net score was inversely associated with prospective IU. Contrasting the third hypothesis, in the undergraduate sample the total current score was positively associated prospective IU; however, no other relationships were statistically significant. Similarly, the total score for the RGT was statistically significantly positively associated with inhibitory IU, but only for the undergraduate sample.

The unconditional growth models (those estimated without any predictors of the slope or intercept) showed no evidence that participants learned to play from good decks ($b_{slope} = -.06$, $SE = .35$, $\beta = -.02$, $p = .851$). The models did indicate participants learned to stop playing from bad decks over the course of the task ($b_{slope} = -.99$, $SE = .34$, $\beta = -.27$, $p = .004$). Also, participant net scores increased on average over the course of the task ($b_{slope} = .85$, $SE = .34$, $\beta = .43$, $p = .012$). The results of the conditional models, reported in Table 4, found no evidence that inhibitory IU or prospective IU was associated with performance on block 6 (the intercept), or with the rate of change (the slope) in passing or playing on good or bad decks. Furthermore, the models did not indicate any relationship between IU and the intercept or slope for net score.

4. Discussion

There has been a recent surge in research exploring the impact

Table 1
Group descriptive statistics and comparisons.

Group statistics	Community		Undergraduate				
	M	*SD*	*M*	*SD*	*t*	*p*	r^2
Self-report community *n* = 115 and undergraduate *n* = 98							
Age	35.70	10.20	22.08	4.94	12.684	<.001	.43
IUS-12 prospective IU	19.10	5.27	18.48	4.99	.887	.376	<.01
IUS-12 inhibitory IU	10.23	4.60	9.84	4.09	.654	.514	<.01
IUS-12 total	29.33	8.97	28.32	8.37	.853	.395	<.01
WCST – community *n* = 115 and undergraduate *n* = 98							
Total correct responses	70.84	13.01	72.91	10.50	−1.259	.209	.01
Total incorrect responses	33.81	23.86	30.30	19.67	1.156	.249	.01
Total completed categories[a]	4.73	1.89	5.29	1.36	−2.432	.016	.03
Trials to complete first category	19.42	22.56	17.11	15.48	.861	.390	<.01
Latency, first category mean (msec)	1482	981	1810	753	−2.707	.007	.04
Latency, total mean (msec)	1338	445	1582	443	−3.943	<.001	.08
MIGT – community *n* = 115 and undergraduate *n* = 98							
Total percent "good" play decisions[a]	76.91	19.09	72.29	14.51	2.002	.047	.02
Total percent "bad" play decisions	72.96	17.38	68.53	13.43	2.089	.038	.02
Total current score	3836.30	536.03	4617.27	423.75	−11.841	<.001	.71
Total net score	3.96	9.52	172.67	1497.93	−1.109	.270	.01
Latency, total mean	650.21	263.66	881.95	258.81	−6.44	<.001	.20
RGT – community *n* = 115 and undergraduate *n* = 98							
Total score	1957.48	275.15	1919.39	289.82	.955	.341	<.01

Notes: All 2-tailed tests; IUS-12 – Intolerance of Uncertainty Scale, Short Form; WCST – Wisconsin Card Sorting Task; MIGT – Modified Iowa Gambling Task; RGT – Risky Gains Task.
[a] Group differences were no long statistically significant after controlling for age.

Table 2
Zero-order correlations, self-report variables.

	IUS-12			
	Age	Prospective	Inhibitory	Total
Age	–	.016	−.083	−.031
IUS-12 Prospective IU Subscale	−.165	–	.694**	.936**
IUS-12 Inhibitory IU Subscale	−.251**	.649**	–	.903**
IUS-12 Total Score	−.226*	.921**	.894**	–

Notes: Undergraduate (*n* = 98) correlations above the diagonal and Community (*n* = 115) correlations below the diagonal; all 2-tailed tests; $^*p < .05$; $^{**}p < .01$; IUS-12 – Intolerance of Uncertainty Scale, Short Form.

Table 3
Zero-order correlations, self-report and behavioural task variables.

	IUS-12		
	Prospective IU	Inhibitory IU	Total
WCST – undergraduate			
Latency, first category mean[1]	−.011	.065	.025
Latency, total mean[1]	.009	.054	.032
Trials to complete first category[2]	.253*	.153	.226*
Total correct responses[2]	−.282**	−.137	−.236*
Total incorrect responses[2]	.248*	.113	.203*
Total completed categories[2]	−.290**	−.180	−.261**
WCST – community			
Latency, first category mean[1]	−.058	.038	−.014
Latency, total mean[1]	−.002	−.007	−.005
Trials to complete first category[1]	−.119	−.189*	−.167
Total correct responses[2]	−.046	−.061	−.058
Total incorrect responses[2]	−.001	−.052	−.027
Total Completed Categories[2]	−.033	−.054	−.047
MIGT – undergraduate			
Latency, total mean[1]	.172*	.108	.156
Total current score[1]	.197*	.122	.177*
Total net score[1]	.080	.025	.060
Total percent good play decisions[2]	.201*	.124	.181*
Total percent bad play decisions[2]	.051	.084	.072
MIGT – community			
Latency, total mean[1]	.072	−.071	.006
Total current score[1]	−.176*	−.103	−.156
Total net score[1]	−.247**	−.190*	−.243**
Total percent good play decisions[2]	−.080	−.048	−.071
Total percent bad play decisions[2]	.048	.052	.055
RGT – undergraduate total score[1]	.090	.198*	.151
RGT – community total score[1]	.064	.131	.106

Notes: 1 – 1-tailed test; 2 – 2-tailed test; $^*p < .05$; $^{**}p < .01$; IUS-12 – Intolerance of Uncertainty Scale, Short Form; WCST – Wisconsin Card Sorting Task; MIGT – Modified Iowa Gambling Task; RGT – Risky Gains Task.

of IU on a variety of anxiety and related disorders (see for review Carleton, 2012; Hong & Cheung, 2015); however, there have been relatively few investigations of the relationships between current self-report measures of trait IU (e.g., the IUS, the IUS-12, the IUI) and behavioral tasks. The available research results have indicated a wide range of predictive relationships, from .26 to .68 (Jacoby et al., 2014; Ladouceur et al., 1997; Luhmann et al., 2011; Rosen et al., 2010; Thibodeau et al., 2013). The current research was designed to further explore the relationship between self-reported IU and behaviours related to decision-making under uncertainty using several common tasks; specifically, the WCST, the RGT, and the MIGT. The resulting effect sizes were consistent with effect size estimates from previous research linking self-reported IU and behaviors regarding decision-making under uncertainty.

A positive relationship was expected between IU and response latency on the WCST and the MIGT, premised on the task uncertainty increasing time spent trying to decipher the task before making a decision. There was no such relationship for the WCST in either sample, which indicates that IU has relatively little impact on processing time for the task decisions. The WSCT may also be more ambiguous (i.e., characterized by equivocal features) than uncertain, per se (Carleton, 2012), which may have masked the relationship with IU. Decision-making within the MIGT is less ambiguous and involves more familiar variables (e.g., money) than the WCST, which may partially explain the small positive relationship between prospective IU and response latency for the MIGT in the undergraduate sample. The undergraduates may also have been more motivated because of the perceived threat of losing a potential second bonus mark, whereas no such risk existed for the community sample.

Participants with higher IU were expected to spend more time evaluating WCST feedback (i.e., information or evidence) in order to

Table 4
Conditional models.

Intercept ON	Good decks				Bad decks				Net score			
	Inhibitory IU		Prospective IU		Inhibitory IU		Prospective IU		Inhibitory IU		Prospective IU	
	b (SE)	β	*b (SE)*	β	*b (SE)*	β	*b (SE)*	β	*b (SE)*	β	*b (SE)*	β
IU Subscale	.43 (.57)	.10	.86 (.46)	.24†	.70 (.57)	.16	.54 (.47)	.15	−.29 (.35)	−.78	.31 (.29)	1.13
Sample[1]	.08 (4.17)	.00	.16 (4.10)	.00	.88 (4.81)	.02	1.48 (4.15)	.04	−.78 (2.60)	−.23	−1.28 (2.57)	−.41
Sample × IU Subscale	−.17 (.74)	−.03	−.78 (.62)	−.18	−.21 (.74)	−.04	−.43 (.63)	−.10	.04 (.46)	.09	−.35 (.39)	−1.09
Age	.04 (.20)	.02	.01 (.19)	.01	.09 (.20)	.05	.04 (.20)	.02	−.03 (.12)	−.21	−.01 (.12)	−.09
Female	−4.83 (3.60)	−.11	−5.08 (3.58)	−.11	−6.54 (3.62)	−.14†	−6.88 (3.63)	−.15†	1.94 (2.24)	.51	2.05 (.2.24)	.60
Intercept *M*	79.88 (3.95)	3.96**	8.18 (3.92)	3.98**	74.48 (3.96)	3.61**	74.51 (3.97)	3.61**	5.29 (2.46)	3.15*	5.53 (2.46)	3.66*
Intercept RV	399.31 (51.53)	.98**	393.23 (5.96)	.97**	408.49 (51.02)	.96**	411.20 (51.28)	.97**	–	–	–	–
Slope ON	*b (SE)*	β	*b (SE)*	β	*b (SE)*	β	*b (SE)*	β	*b (SE)*	β	*b (SE)*	β
IU Subscale	.04 (.12)	.06	.12 (.10)	.20	.16 (.12)	.19	.10 (.10)	.16	−.12 (.12)	−.31	.02 (.10)	.05
Sample	.20 (.89)	.03	.25 (.88)	.04	.10 (.90)	.01	.28 (.90)	.04	.11 (.89)	.03	−.03 (.88)	−.01
Sample × IU Subscale	.11 (.16)	.12	.02 (.13)	.03	−.02 (.16)	−.02	−.09 (14)	−.11	.13 (.16)	.30	.11 (.13)	.31
Age	−.05 (.04)	−.14	−.05 (.04)	−.16	−.01 (.04)	−.03	−.02 (.04)	−.07	−.03 (.04)	−.22	−.03 (.04)	−.16
Female	−1.20 (.77)	−.15	−1.22 (.77)	−.16	−1.22 (.78)	−.15	−1.30 (.78)	−.16†	.13 (.76)	.03	.19 (.76)	.05
Slope *M*	.65 (.85)	.19	.67 (.84)	.19	−.15 (.86)	−.04	−.17 (.86)	−.05	.74 (.84)	.43	.77 (.84)	.45
Slope RV	11.02 (2.48)	.92**	1.83 (2.46)	.90**	12.86 (2.51)	.94**	13.12 (2.53)	.97**	2.70 (.97)	.93**	2.45 (.95)	.84*
Intercept-Slope correlation		.66**		.66**		.75**		.75**				
Intercept R^2		.02		.03		.04		.03		–		–
Slope R^2		.08		.10		.06		.04		.07		.16

Notes: $^{*}p < .05$; $^{**}p < .01$; $\dagger p < .10$; all other *p*-values associated with β were >.10; RV – Residual Variance (Block 6); In the net score models, the intercept was treated as a fixed variable across participants to aid model convergence, so there was no residual variance; 1 – The undergraduates were coded as the reference group, making the presented effects those of the community sample.

increase certainty regarding category rules, therein requiring more time, but fewer trials, to complete the first category; as such, an inverse relationship was expected between IU and the number of trials needed to complete the first WCST category. The expectation held for community participants, wherein inhibitory IU was inversely related with trials to complete the first category. In contrast, for undergraduate participants, prospective IU was *positively* related with trials to complete the first category. The divergent relationship pattern may be the result of several factors (e.g., motivation, education), but warrants exploration in future studies because community participants used more trials overall to complete the first category than undergraduate participants. For the undergraduate participants, relatively increased threat (i.e., risk of potentially losing a bonus grade) coupled with increasing IU may have expedited a trial-and-error seeking of, and adherence to, any perceived rule to end the uncertainty in line with (Luhmann, Chun, Yi, Lee, & Wang, 2008; Luhmann et al., 2011); if that supposition is correct, it would explain the positive relationship between prospective IU and number of trials to learn the first rule, but also the unpredicted inverse relationship between prospective IU and correct responses. The community sample demonstrated no such pattern, suggesting perceived threat may be a necessary factor for elucidating the relationship.

Participants with higher IU were expected to score lower on the MIGT because they would select options that appeared more certain despite being less advantageous. The expectation was upheld, for community participants who demonstrated an inverse relationship between Total Net Score and IU; however, the undergraduates demonstrated the reverse relationship, possibly due to the slight elevation of perceived threat.

A positive relationship was expected on the MIGT between IU and sensitivity to negative outcomes using the unconditional growth models. All participants learned to stop playing from bad decks, increasing their net scores, but they did not learn to play good decks preferentially. There was no evidence of a robust relationship between play performance (i.e., sensitivity to negative outcomes) and either inhibitory IU or prospective IU. As with the WCST, the level of perceived risk may have been insufficient for IU to influence decision-making.

A positive relationship was expected between IU and RGT total scores because higher IU was expected to result in participants being more likely to take the immediate safe reward rather than waiting and taking the more risky rewards that appear potentially more advantageous. Both samples demonstrated the positive relationship, but the relationship was only statistically significant for the undergraduates. The increased effect size seems to further underscore the importance of perceived threat to demonstrating behavioural change associated with IU.

The inconsistent associations between self-reported IU (as measured with the IUS-12) and the behavioral tasks may be due to a lack of common method variance reviewed in (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). Previous research examining risk-propensity, for example, has shown that personality traits associated with risk (i.e., impulsivity, low self-control, sensation-seeking) show surprisingly inconsistent associations with behavioral measures of risk-taking that involve active choice (Mishra & Lalumiere, 2011). From a clinical perspective, the previous and current results suggest IU is significantly impacting behaviour. The intensity of that impact may be substantially increased in situations of perceived risk (e.g., social encounters for persons with social anxiety disorder). At minimum, in line with recommendations from Mahoney and McEvoy (2012), the current results suggest that further research into associations between self-report measures of trait IU and behavioral measures of state IU is necessary; however, the current results already further support notions that IU should be specifically targeted for persons anxiety-related disorders in order to facilitate cognitive and behavioural changes (Boswell, Thompson-Hollands, Farchione, & Barlow, 2013; Carleton, 2012; Einstein, 2014).

There are several limitations to the current study that provide direction for future research. Our samples were relatively homogenous with respect to most demographic variables (e.g., ethnicity, education), limiting generalizability and suggesting future research should include more diverse participants. Our samples were also non-clinical, which allows for an exploratory assessment of the relationship without ceiling effects or intense resource requirements, as well as providing a justification and a comparative baseline for subsequent results with clinical samples; that said, the current results demonstrate impact of IU on behaviour in non-clinical samples, supporting subsequent research with clinical samples wherein the impact may be even greater. Future researchers should consider using the same self-report measures and the same tasks, but with one or more clinical samples (e.g., patients with generalized anxiety disorder or depression). Future researchers might also consider using non-clinical or clinical samples, but including a biological measure as a manipulation check for assessing task-specific stress (e.g., galvanic skin response) as an index of perceived risk.

The current measures varied in ecological validity (from relatively low in the WCST to relatively high in the MIGT); as such, there are ways to enhance ecological validity further. In our study, there was no risk associated with community participant decisions and, despite the potential for an additional bonus, the perceived risk to undergraduate participants would also have been low. The impact of potentially gaining an additional bonus grade also was likely less than would have been the impact of potentially losing the existing bonus grade (Cauffman et al., 2010; Mueller et al., 2010). Others have used domain-specific decision-making tasks with real-world implications (e.g., measurement of health seeking behaviors; Rosen et al., 2010). Future research designs should consider increasing perceived risk and utilizing decision-making tasks with "real world" implications (e.g., larger potential rewards; perceptions of actual risk) to further improve ecological validity.

Online administration may have reduced the perceived threat by removing the social interaction and potential for negative evaluation by the experimenter inherent in some of the previous studies e.g., (Jacoby et al., 2014; Ladouceur et al., 1997; Thibodeau et al., 2013); moreover, the online administration may have reduced cognitive engagement. Future research should use comparable samples and then compare results across online and observed in-lab administrations.

The tasks may have better approximated intolerance of ambiguity than IU, per recent distinguishing definitions (e.g., Carleton, 2012); moreover, the tasks would have had difficult delineating whether decisions were made based on appraisals of expected value, risk sensitivity, trait anxiety, or other cognitive processes related to, but not specific to, IU. Future research designs should attempt to better distinguish such processes.

There is initial evidence that higher levels of IU can lead to very different patterns of decision-making. For example, some persons with high IU may perseverate, worry, and become anxious but not act, while others may act quickly, even accepting negative consequences, in order to resolve the uncertainty (Luhmann et al., 2008, 2011). Future research designs should attempt to account for such individual differences in coping with IU, perhaps including post-play analyses to identify differences in strategies.

The current results suggest relationships between self-reported IU and subsequent behaviours may require perceptions of threat. Alternatively, the current results may stem from challenges with ecological validity, insufficiently sensitive measurement methods, insufficient threat, or because IU only has a substantial influence on behaviour at levels of clinical significance. In any case, the relationship between IU and behaviour warrants dedicated research in transdiagnostic clinical and non-clinical samples to facilitate behavioural correlates for the self-report measures.

Acknowledgments

R. N. Carleton's research is supported by the Canadian Institutes of Health Research through a New Investigator Salary Award (FRN: 13666). Sophie Duranceau was supported by a Fond de recherche du Québec – société et culture bourse de doctorat en recherche B2 (FRN: 181214) and is currently supported by a Social Sciences and Humanities Research Council Vanier Scholarship (FRN: 347406).

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