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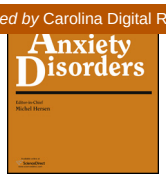

Enhancing the ecological validity of the Beads Task as a behavioral measure of intolerance of uncertainty

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ABSTRACT

To broaden the measurement of intolerance of uncertainty (IU) beyond self-report methods, recent research has examined the Beads Task as a behavioral measure of IU. In the present study, we enhanced this task to increase its ecological validity by maximizing decisional uncertainty and the importance of a correct response. Undergraduate participants ($n = 102$) completed the Beads Task with instructions that they would complete the Cold Pressor Task (CPT) if they answered incorrectly. As hypothesized, baseline CPT endurance time and self-reported pain level were weakly associated with later Beads Task distress during the decision-making process. Furthermore, *in vivo* Beads Task distress was associated with self-report inhibitory IU, which measures avoidance and paralysis in the face of uncertainty, but not with prospective IU, perfectionism, or general psychological distress after making statistical adjustments for multiple comparisons. Comparisons to previous work using the Beads Task, clinical implications, and avenues for future research are discussed.

1. Introduction

Intolerance of uncertainty (IU) is a cognitive bias that affects how a person experiences, interprets, and responds to situations that are ambiguous or have indefinite outcomes (Dugas, Schwartz, & Francis, 2004; Obsessive Compulsive Cognitions Working Group [OCCWG], 1997). IU involves both *prospective* (*i.e.*, discomfort due to future unknowns) and *inhibitory* (*i.e.*, avoidance and paralysis in the face of ambiguity) components (Birrell, Meares, Wilkinson, & Freeston, 2011; Carleton, Norton, & Asmundson, 2007; McEvoy & Mahoney, 2011). Individuals who are high in IU tend to (a) have a lower perceptual threshold of ambiguity, (b) make threatening interpretations of ambiguous information, (c) find uncertainty to be distressing, unmanageable, and something that should be avoided, and (d) have difficulty functioning in uncertain or ambiguous situations (Bredemeier & Berenbaum, 2008; Buhr & Dugas, 2002; Krohne, 1993; Ladouceur, Talbot, & Dugas, 1997).

IU is also a transdiagnostic vulnerability factor for the development of anxiety and related disorders (Boswell, Thompson-Hollands, Farchione, & Barlow, 2013; Carleton, 2012; Carleton, Mulvogue et al., 2012; Einstein, 2014). It is associated with symptoms of OCD (*e.g.*, Tolin, Abramowitz, Brigidi, & Foa, 2003), GAD (*e.g.*, Buhr & Dugas, 2006), panic disorder (*e.g.*, Carleton et al., 2014), health anxiety (*e.g.*, Fergus & Valentiner, 2011), and social phobia (*e.g.*, Boelen & Reijntjes, 2009). In fact, IU predicts anxiety symptoms above and beyond other cognitive vulnerability factors such as anxiety sensitivity, distress tolerance, and trait anxiety (Norr et al., 2013). Indeed, many behaviors observed in these conditions (*e.g.*, safety behaviors, reassurance seeking, rumination, compulsions, avoidance) can be conceptualized as attempts to obtain certainty and reduce anxious arousal (*e.g.*, Behar, DiMarco, Hekler, Mohlman, & Staples, 2009; Einstein, 2014; Holaway, Heimberg, & Coles, 2006).

An important limitation of the existing research on IU, however, is that studies rely almost exclusively on self-report measures, such as the Intolerance of Uncertainty Scale (IUS-12; Carleton et al., 2007) and the Perfectionism/Certainty subscale of the Obsessive Beliefs Questionnaire (OBQ-PC; OCCWG, 2005). Although there is strong evidence for the construct validity of these instruments, the literature would benefit from methodologically varied measurement of this cognitive bias. Specifically, these questionnaires are limited in that they are trait measures, which merely capture participants' self-reported stable beliefs about uncertainty. They do not, however, lend themselves well to use as dependent variables in studies seeking to examine predictors and moderators of *state* IU (*i.e.*, feelings of IU-related distress captured in the moment). Some research, however, has evaluated laboratory paradigms as *in vivo*

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measures of IU, by quantifying the relationship between self-report IU and performance on behavioral tasks involving uncertainty or ambiguity (*e.g.*, decisions made during a laboratory gambling task; Luhmann, Ishida, & Hajcak, 2011). These tasks have the advantage of experimentally inducing uncertainty in the laboratory and capturing participants' cognitive, emotional, and behavioral responses to actual ambiguous scenarios.

One such behavioral measure is the Beads Task (Huq, Garety, & Hemsley, 1988; Phillips & Edwards, 1966), utilized by three studies to date to examine how performance on this task may be related to IU. The Beads Task is a probabilistic inference task in which participants are shown two jars on a computer screen. Each jar contains 100 beads of two different colors in a particular ratio (*e.g.*, 85:15 red beads to blue beads *vs.* 85:15 blue to red). Participants are told that beads will be drawn one by one with replacement from one of the jars (the sequence of beads is predetermined using a random number generator), and that each jar is equally likely to be chosen. The participant's task is to determine from which jar the beads are being drawn (*e.g.*, the mostly red jar or the mostly blue jar). Participants are told that they can request as many beads as necessary to correctly decide. Outcome measures include: (a) the number of beads requested before feeling "certain" about making a decision (*i.e.*, draws to decision; DTD), (b) the time taken to decide, and (c) self-reported distress during the task. IU is expected to be associated with greater DTD, time to decision, and distress.

Ladouceur et al. (1997) found a positive association between scores on the IUS and DTD using a non-clinical sample; yet a separate team was unable to replicate this finding in a sample of participants with eating disorders (Sternheim, Startup, & Schmidt, 2011). Neither study, however, assessed relationships between self-reported IU and time to decision or *in vivo* distress. Thus, using a sample of individuals diagnosed with anxiety disorders, Jacoby, Abramowitz, Buck, and Fabricant (2014) found that self-reported IU as measured by the OBQ-PC was correlated with DTD and distress during the Beads Task. Furthermore, the distress variable distinguished individuals with anxiety disorders from healthy controls.

Jacoby et al. (2014) also raised two issues necessitating further investigation of the Beads Task as a viable paradigm for studying IU. First, IU, in the context of anxiety disorders, typically focuses on the possibility of a feared negative consequence (Nelson & Shankman, 2011). However, the ecological validity of the Beads Task was limited in that there were no meaningful negative consequences for an incorrect response. Accordingly, this may explain why participants self-reported relatively little distress while completing the task. Second, because the OBQ-PC, used in Jacoby et al. (2014), assesses both IU and perfectionism, it is important to clarify the extent to which each construct might be uniquely associated with outcomes on the Beads Task.

Accordingly, the present study aimed to enhance the ecological validity of the Beads Task as an analog for how individuals with anxiety disorders manage uncertainty. Specifically, we sought to heighten the importance of a correct response (and corresponding *in vivo* distress) by introducing the threat of an aversive outcome—the Cold Pressor Task (CPT; submerging one's dominant hand in a cooler of ice water for as long as is tolerable; described in Section 2.3). All participants completed the CPT prior to the Beads Task, and were informed they would have to repeat the CPT if they guessed the incorrect jar. We also maximized uncertainty of the decision by using a completely ambiguous version of the Beads Task with 50/50 probabilistic ratios. We hypothesized that: (a) lower baseline CPT endurance time (*i.e.*, seconds immersed in the cold water) and higher self-reported pain levels after completing the CPT would be associated with more DTD, time to decision, and distress during the Beads Task, and (b) Beads Task outcomes would be positively associated with self-reported IU. We also included a measure of perfectionism and a general measure of psychological distress in order to explore the extent to which these constructs related to Beads Task outcomes.

2. Material and methods

2.1. Participants

One-hundred and ten undergraduate students recruited from Introduction to Psychology classes at the University of North Carolina at Chapel Hill (UNC-CH) participated in this study. Eight participants were removed for the following reasons: (a) they provided information during debriefing suggesting that they knew they would not need to put their hand back in the ice water or that they would simply refuse to do so if asked ($n = 3$), (b) they told the researcher that they were looking forward to repeating the CPT (and thus did not perceive the paradigm to be aversive, $n = 3$), (c) they shared that they did not understand the rules of the Beads Task ($n = 1$), and (d) the experimenters noted that the participant seemed to rush through the procedures ($n = 1$). Accordingly, the final sample size for data analysis was 102.

The sample was primarily female (61.8%, $n = 63$), White (77.5%, $n = 79$; 6.9% Black or African American, 7.8% Asian, 3.9% bi- or multiracial, and 3.9% other), non-Latino (94.1%, $n = 96$), right-handed (88.2%, $n = 90$), and first-year students (66.7%, $n = 68$; 16.7% sophomore, 10.8% junior, 5.9% senior) with a mean age of 18.93 years old (SD = 1.14; range 17–22); which is comparable to the demographics of our Introduction to Psychology participant pool at large. Due to the use of the Beads Task and CPT, the following exclusion criteria were present for the study: (1) being color-blind, (2) history of hypertension, peripheral vascular disease, cold urticaria, cold sensitivity, or Raynauds syndrome, and (3) open cuts or lesions on the hands.

2.2. Measures

2.2.1. Intolerance of Uncertainty Scale, short form (IUS-12; Carleton et al., 2007)

The IUS-12 is a shortened version of the original 27-item IUS (Freeston, Rhéaume, Letarte, & Dugas, 1994) that measures reactions to uncertainty, ambiguity, and the future. The measure consists of two subscales: (a) *Prospective IU* measures desire for predictability, preferences for knowing what the future holds, anxiety about future uncertain events, and active engagement in seeking information to increase certainty (*e.g.*, "I always want to know what the future has in store for me"), and (b) *Inhibitory IU* measures avoidance and paralysis in the face of uncertainty (*e.g.*, "When I am uncertain I can't function very well"). Participants rate each item from 1 (*Not at all characteristic of me*) to 5 (*Entirely characteristic of me*). The IUS-12 has good psychometric properties in both clinical and non-clinical samples (Carleton, Mulvogue et al., 2012; Carleton et al., 2007; Helsen, Van, Vlaeyen, & Goubert, 2013; Jacoby, Fabricant, Leonard, Riemann, & Abramowitz, 2013; Khawaja & Yu, 2010; McEvoy & Mahoney, 2011). Internal consistency of the IUS-12 subscales in the present sample was good to excellent ($\alpha = 0.85$–0.90).

2.2.2. Frost Multi-Dimensional Perfectionism Scale (FMPS-22; Cox, Enns, & Clara, 2002)

The FMPS-22 is a revised version of the original 35-item FMPS (Frost, Marten, Lahart, & Rosenblate, 1990) assessing multiple dimensions of perfectionism including: concerns over making mistakes (*e.g.*, "If I fail partly, it is as bad as being a complete failure"), doubts about actions (*e.g.*, "I tend to get behind in my work because I repeat things over and over"), high personal standards (*e.g.*, "I set higher goals for myself than most people"), high parental expectations and criticism (*e.g.*, "As a child, I was punished for doing things

less than perfectly"), and organization (*e.g.*, "I am an organized person"). Participants rate each item on a 5-point Likert scale ranging from 1 (*Strongly disagree*) to 5 (*Strongly agree*). The FMPS-22 has good psychometric properties in clinical and non-clinical samples, demonstrating construct validity and strong associations with the original FMPS (Cox et al., 2002). Internal consistency of the FMPS-22 in the present sample was good ($\alpha = 0.87$).

2.2.3. Depression Anxiety and Stress Scale (DASS-21; Antony, Bieling, Cox, Enns, & Swinson, 1998; Lovibond & Lovibond, 1995)

The DASS-21 is a 21-item self-report measure of general psychological distress containing three seven-item subscales: Depression (DASS-D; *i.e.*, dysphoric mood), Anxiety (DASS-A; *i.e.*, physical arousal, panic attacks, and fear); and Stress (DASS-S; *i.e.*, tension, irritability, agitation, and overreaction to stressful events). Participants rate items on a four-point Likert scale ranging from 0 (*Did not apply to me at all*) to 3 (*Applied to me very much, or most of the time*) and then total scores are multiplied by 2 in order to compare to full scale DASS-42 scores. The DASS-21 has an excellent factor structure, and the subscales have good to excellent internal consistency (Antony et al., 1998). It also has good convergent and known groups validity. Internal consistency of the DASS subscales in the present sample was good ($\alpha = 0.74$–0.88).

2.2.4. Beads Task (Huq et al., 1988; Phillips & Edwards, 1966)

The Beads Task used in the current study consisted of three computerized versions of the task, each containing 2 jars with 50:50 probabilistic ratios. The maximum possible number of beads that could be requested before making a decision was 50. The sequences of beads in the three conditions were determined using a random number generator and are listed below.

Version 1: 50 Purple (P):50 Green (G)

GPPGPPGPGGGPGGPGGGPGGGPGGPGPPPPGGPPGPGGPPGG-PPPGPPG

Version 2: 50 Red (R):50 Blue (B)

RBRRBBRBBRBRBRBBRRBRRBRBBRBRRBRRBBRBRBRR-BRBRRBBBRR

Version 3: 50 Pink (P):50 Yellow (Y)

PYPYPPYYYPYYPYYPYPPYPPYPYPPYPYYPYYPYPYYPYPY-PPYPYPY

Because of the possibility of memory biases and deficits (*e.g.*, Deckersbach, Otto, Savage, Baer, & Jenike, 2000), and decreased memory confidence in some anxiety disorders (*e.g.*, Tolin et al., 2001), all participants were able to see the beads from previous trials displayed at the bottom of their computer screen in order to eliminate any possible influence of memory on the Beads Task.

The experimenter recorded: (a) the number of beads the participant selected before making a decision (*i.e.*, DTD), (b) time taken to reach the decision, and (c) the participant's decision itself (*i.e.*, which jar they thought the beads were coming from). Before learning whether or not they answered correctly, participants also completed a series of three questions (at the end of each version of the task) using a visual analog scale (VAS) ranging from 0 (*Not at all*) to 100 (*Very much*). The questions were: (a) "How certain are you about your decision?", (b) "How distressed do you feel in this moment?", and (c) "How important is it for you to get the answer right and avoid having to put your hand in the ice water?" (which was used to check that participants were engaged in the task).

2.3. Procedure

The study was described to all participants as a one-hour experiment investigating "decision-making." Participants were informed that they would be asked to answer questions on the computer about thoughts, feelings, and behaviors, and that they would complete a "cold water challenge" and a computer-based decision-making task with the help of the experimenter.

All participants were tested individually in the laboratory. The experimenter first obtained informed consent. Using the computer program Qualtrics, participants then completed a demographic survey and the study measures described above. Next, participants completed the CPT, which is one of the most common experimental methods of pain induction (*e.g.*, Franklin et al., 2010; Klatzkin, Mechlin, Bunevicius, & Girdler, 2007; Russ et al., 1992). Participants were asked to submerge their dominant hand (up to the wrist) in a cooler of 5 °C ice water ($M = 5.24°$, $SD = 0.99$). A water circulator attached inside the cooler maintained an even distribution of the water temperature (and prevented the water near the participant's hand from warming up). Participants were instructed to remove their hand from the water when the pain became "too intense for you to take" and to rate their discomfort/pain level on a scale from 0 (*No pain or discomfort*) to 10 (*Worst pain/discomfort you can imagine*) at that time. Experimenters recorded the time latency from CPT onset until the participant removed his or her hand (referred to as "endurance time"), a commonly-used measure of pain tolerance (*e.g.*, Klatzkin et al., 2007; Mechlin, Morrow, Maixner, & Girdler, 2007). Participants were allowed to keep their hand in the water for a maximum of two minutes (after which point the hand becomes numb from the ice water).

Finally, after completing a practice version of the Beads Task (in order to learn the rules), participants completed three different experimental versions of the task (in a counterbalanced order) in the presence of an experimenter (as this has been found to increase reliability of the task; Fear & Healy, 1997). Participants were not informed of the ratio of beads inside the jar, and were misled to believe that there was one jar filled with beads that are mostly one color and a second jar filled with beads that are mostly the other color (*e.g.*, a mostly purple jar *vs.* a mostly green jar). The experimenter also emphasized the importance of answering correctly. Participants were told that if they answered incorrectly, they would have to re-submerge their hand in the ice water for 20 s, plus 2 additional seconds for every bead they chose while making their decision (the amount of time was tracked on the computer screen). On the other hand, if they guessed correctly, participants were told they would not have to re-submerge their hand in the ice water at all. Participants were explicitly instructed to consider the tradeoff between the number of beads they chose to see and their accuracy as they were deciding. In reality, since there was no right or wrong answer (*e.g.*, the jar was actually filled with 50% purple beads and 50% green beads), after completing each Beads Task version and responding to the follow-up questions, all participants were informed that they answered correctly on all three experimental versions of the task, and thus no participants repeated the CPT.

At the end of the visit, participants were debriefed and informed of the mild deception involved in the study. In exchange for their participation, participants received one hour of credit toward the research requirement of Introduction to Psychology.

2.4. Data analysis plan

We used the following statistical approach to test our hypotheses. We first computed descriptive statistics for our self-report measures of cognitions (IUS-12 subscales and FMPS-22) and symptoms (DASS subscales), as well as CPT and Beads Task outcomes. Next, we computed Pearson's correlations between CPT and Beads Task outcome variables as a manipulation check to determine the extent to which experiences with the CPT were associated with subsequent Beads Task performance. Finally, in order to test our primary hypotheses, we calculated Pearson's correlations between the primary Beads Task outcome variables (*i.e.*, DTD, time to deci-

Table 1
Means and standard deviations on study measures ($n = 102$).

	Mean (SD)	Range	Skewness	Kurtosis
IUS-12				
Prospective IU	18.48 (5.51)	9–33	0.52	−0.21
Inhibitory IU	9.33 (4.19)	5–22	1.15	0.80
FMPS-22	63.88 (13.29)	35–109	0.43	0.71
DASS-21[a]				
Depression	6.22 (7.37)	0–36	0.54	0.27
Anxiety	5.10 (5.77)	0–28	0.21	−0.78
Stress	10.31 (7.78)	0–42	−0.34	0.20
CPT				
Endurance time (s)	52.69 (34.90)	7–120	0.92	−0.47
Pain level (0–10)	7.08 (1.62)	2–10	−1.00	1.17
Beads Task				
DTD (0–50)	20.77 (13.70)	3–50	0.90	−0.29
Time to decision (s)[a]	43.49 (36.28)	9–250	0.34	−0.07
Distress (0–100)	33.65 (20.83)	0–94	0.64	0.34
Importance (0–100)	47.42 (24.11)	0–100	0.12	−0.52
Certainty (0–100)	46.46 (17.17)	3–98	0.01	0.10

Note: IUS-12—Intolerance of Uncertainty Scale-12; FMPS-22—Frost Multi-Dimensional Perfectionism Scale-22; DASS-21—Depression Anxiety and Stress Scale-21; CPT—Cold Pressor Task; DTD—draws to decision

[a] The mean and range for DASS scores and Beads Task time to decision are actual values; skewness and kurtosis for these variables are for the square root- and log-transformed values respectively. All subsequent analyses involving these measures used transformed values.

sion, distress) and the self-report cognition and symptom measures to examine how trait levels of IU, perfectionism, and general psychological distress were related to *in vivo* Beads Task performance.

3. Results

3.1. Means on study measures

3.1.1. Self-report measures

Means, standard deviations, range, skewness, and kurtosis values for the self-report measures of symptoms and cognitions appear in Table 1. The sample's mean and range on these measures were comparable to those from previous studies using undergraduate samples (Berman, Stark, Ramsey, Cooperman, & Abramowitz, 2014; Carleton et al., 2007). The distributions of the DASS subscale scores were somewhat positively skewed (skewness: DASS-Depression = 2.13, DASS-Anxiety: 1.59, DASS-Stress: 1.14) and platykurtic (kurtosis: DASS-Depression = 4.90, DASS-Anxiety: 2.94, DASS-Stress: 1.97). As a result, we square root transformed the DASS subscales, which resulted in a more symmetric distribution. None of these other measures displayed problematic levels of skewness or kurtosis (Tabachnick & Fidell, 2013).

3.1.2. Cold Pressor Task outcomes

Table 1 also contains descriptive information about participant performance on the CPT. On average, participants kept their hand in the ice water for almost a minute (with a wide range of individual performances). Participants also found the ice water to be fairly painful and uncomfortable.

3.1.3. Beads Task outcomes

Decisions on the Beads Task were evenly distributed for Version 1 (49% purple *vs.* 51% green) and Version 2 (52.9% red *vs.* 47.1% blue), but less so for Version 3 (77.5% yellow *vs.* 22.5% pink). Since the sequence of beads for all 3 versions was generated using a random number generator in order to represent 50:50 probabilistic ratios, and because primary outcomes (*i.e.*, DTD, time to decision, distress) were comparable across the three task versions, we averaged performance on the three versions for subsequent analyses. See Table 1 for average performance outcomes on the Beads Task. Participants indicated feeling relatively uncertain of their decision (*i.e.*, close to 50/50). They stated that it was moderately important to answer correctly, and that they were mildly to moderately distressed by the task. The distribution of Beads Task decision time was positively skewed (skewness = 2.85) and platykurtic (kurtosis = 11.66). As a result, we log transformed decision time, which resulted in a more symmetric distribution.

Table 2
Correlations between CPT and Beads Task performance ($n = 102$).

	CPT endurance time	CPT pain level
Beads Task		
DTD	0.09	0.06
Time to decision	−0.09	0.06
Distress	−0.51**	0.35**
Importance	−0.42**	0.26*
Certainty	0.10	0.04

Note: CPT—Cold Pressor Task; DTD—draws to decision.
* $p < 0.05$.
** $p < 0.005$ (Bonferroni corrected).

3.2. Associations between CPT and Beads Task performance

3.2.1. Preliminary analyses

CPT water temperature ranged from 2 to 8 °C. Pearson's correlations indicated that water temperature was positively associated with CPT endurance time, $r(102) = 0.20$, $p = 0.04$, but not with pain level $r(102) = -0.01$, $p = 0.96$.[1]

3.2.2. Pearson's correlations.

We then conducted Pearson's correlations between CPT performance (endurance time and pain level) and Beads Task performance (see Table 2). As can be seen, less time with one's hand in the ice water and more distress reported during the CPT were each associated with greater distress and greater perceived importance of answering correctly on the Beads Task. This suggests that experiences with the CPT were indeed associated with subsequent Beads Task performance. A Bonferroni corrected alpha of 0.005 was used to correct for multiple tests (0.05/10). The association between CPT pain level and Beads Task importance did not survive Bonferroni correction; all other associations remained significant.

3.3. Associations between Beads Task performance and self-report measures

3.3.1. IU and other cognitive variables

We computed Pearson's correlations between the primary Beads Task variables (*i.e.*, DTD, time to decision, distress) and the self-report cognition measures (IUS-12 subscales and FMPS-22; see Table 3). Self-reported distress levels during the Beads Task were weakly positively associated with prospective and inhibitory IU scores as well as perfectionism. No other correlations were significant. A Bonferroni corrected alpha of 0.006 was used to correct for multiple tests (0.05/9). Self-reported distress levels during the Beads Task only remained weakly positively associated with inhibitory IU scores at the Bonferroni corrected alpha level.

[1] Given this significant association between CPT performance and water temperature, we conducted additional partial correlations corresponding to the analyses that follow controlling for CPT water temperature. The same pattern of results was observed; thus, the more parsimonious simple correlations are reported in this manuscript.

Table 3
Correlations between Beads Task performance and self-report measures ($n = 102$).

	DTD	Time to decision	Distress
Cognitions			
Prospective IU	−0.06	−0.09	0.20*
Inhibitory IU	−0.03	0.09	0.29**
FMPS-22	0.13	0.13	0.24*
Symptoms			
DASS-D	−0.23*	−0.03	0.06
DASS-A	−0.08	0.01	0.08
DASS-S	−0.04	0.10	0.17

Note: IU—intolerance of uncertainty; FMPS-22—Frost Multi-Dimensional Perfectionism Scale-22; DASS—Depression Anxiety and Stress Scale-21; DTD—draws to decision.

* $p < 0.05$.

** $p < 0.006$ (Bonferroni corrected).

3.3.2. Symptoms

We computed Pearson's correlations between the primary Beads Task variables and the subscales of the DASS. DASS-Depression was weakly negatively associated with DTD. No other correlations were significant. A Bonferroni corrected alpha of 0.006 was used to correct for multiple tests (0.05/9). The association between DASS-Depression and DTD was no longer significant after Bonferroni correction.

4. Discussion

The current study aimed to evaluate an updated version of the Beads Task as a behavioral measure of IU. We developed the current version of the task to be more ecologically valid relative to previous versions (*e.g.*, Jacoby et al., 2014), and indeed, the use of 50/50 probabilistic ratios in our study resulted in participants reporting feeling relatively uncertain after having decided. We also paired the CPT with the Beads Task to heighten task importance and related distress; and indeed, perceived importance of answering correctly (47.42 *vs.* 32.83 out of 100) and ratings of task distress (33.65 *vs.* 5.99 out of 100) were both elevated in the current study relative to undergraduate participants who completed the Beads Task without the CPT in Jacoby et al. (2014). Furthermore, our manipulation check revealed that lower CPT endurance time and higher CPT pain levels were associated with greater distress and perceived importance during the Beads Task. In concert, these findings suggest that adding the CPT as an aversive future outcome that participants wish to avoid amplified distress during the Beads Task decision-making process.

More central to the purpose of this study, *in vivo* distress experienced during the Beads Task was associated with self-report inhibitory IU, but not with prospective IU, perfectionism, or general psychological distress after making statistical adjustments for multiple comparisons (*i.e.*, Bonferroni corrections). Inhibitory IU refers to avoidance and paralysis in the face of uncertainty (*e.g.*, "When I am uncertain I can't function very well" and "The smallest doubt stops me from acting") and is considered to be the more behaviorally focused dimension of IU. Thus, the fact that Beads Task distress is uniquely associated with inhibitory IU, but not prospective IU, suggests that this task may be capturing anxiety due to paralysis while attempting to make an uncertain decision. The finding that distress on the Beads Task was associated with IU, but not perfectionism, is important given that uncertainty and perfectionism are overlapping constructs (*e.g.*, OCCWG, 2005), and clarifies the task's unique associations with IU. Finally, the fact that Beads Task-related distress was not associated with a more general measure of psychological distress similarly suggests that we specifically captured IU-related discomfort. Alternatively, it may also be that given that we had a somewhat restricted and skewed range out of possible scores on the DASS given our non-clinical sample, an association between Beads Task distress and DASS scores was unable to emerge. Indeed, previous research utilizing a sample of individuals with anxiety disorders (Jacoby et al., 2014) has demonstrated significant associations between uncertainty-related distress during the Beads Task and DASS scores.

Our finding that perceived distress in response to an uncertain situation, rather than actual behavioral responses (*i.e.*, DTD and time), was associated with self-report IU is consistent with previous work (Jacoby et al., 2014) and may have clinical implications for the psychoeducational component of cognitive-behavioral therapy for anxiety disorders. Specifically, individuals with these conditions often perceive themselves as "unable" to manage uncertainty; however, it appears that self-reported IU is not associated with impaired behavioral performance; rather these individuals appear to be more *distressed* by ambiguity. Considering that a complete absence of uncertainty is impossible, enhancing an individual's capacity to cope with uncertainty-related distress seems essential for treatment success (Carleton, 2012). Thus, the Beads Task may be useful as a paradigm for assessing the effects of cognitive and behavioral interventions on IU.

Additionally, future research might take advantage of the Beads Task as a paradigm to identify predictors of IU-related distress. For example, individuals with OCD have inflated perceptions of responsibility for harm (Salkovskis et al., 2000), and the Beads Task could be used to study the effects of responsibility on IU-related distress by manipulating whether the threat associated with an incorrect response on the Beads Task (*e.g.*, repeating the CPT) is tied to harm befalling oneself or someone else. We are currently studying this and other such variables in our laboratory to further clarify factors that contribute to IU. Such work might contribute to the conceptualization and treatment of this transdiagnostic phenomenon.

The Beads Task could also be used to help elucidate the mechanisms by which IU contributes to uncertainty-related distress. For instance, it may be that some participants waver between choices on the Beads Task, request more beads to gain a sense of certainty over their decision, and struggle with decision paralysis; whereas others use a more avoidant strategy and make quicker decisions to escape uncertainty-related distress. Indeed, previous work has indicated that IU was associated with the tendency to sacrifice potential reward during a gambling task in order to avoid prolonged uncertainty-related distress (Luhmann et al., 2011). Similarly, individuals high in IU, relative to those with low IU, were less likely to change their decision when presented with an additional response option when reaching a decision about a high-risk vignette scenario in another study (Jensen, Kind, Morrison, & Heimberg, 2014). Altering the Beads Task procedure in similar ways (*e.g.*, introducing an option to avoid either (a) a prolonged period of uncertainty before learning the correct answer or (b) re-entering the decision-making process when additional information is introduced) might address these questions.

The present study has a number of limitations that should be considered. First, our sample consisted of unscreened undergraduates and no structured diagnosed interviews were administered. However, previous research suggests that IU has a dimensional latent structure, which provides opportunities for studying IU-related distress in community samples (Carleton, Weeks et al., 2012). Although the sample's mean and range on the subscales of the IUS-12 was less than that obtained from an intensive outpatient/residential setting (IUS-prospective: $M = 22.55$, $SD = 7.58$; IUS-inhibitory: $M = 16.52$, $SD = 5.79$; Jacoby et al., 2013), scores were comparable to those from previous studies using undergraduate samples (IUS-prospective: $M = 16.68$, $SD = 6.00$; IUS-inhibitory: $M = 9.17$, $SD = 4.15$; Carleton et al., 2007). Nonetheless, future research is needed to examine these constructs in larger clinical samples. Third, it is worth noting that coincidentally the popular

"Ice Bucket Challenge" (which involved dumping a bucket of ice water on one's head to promote awareness of amyotrophic lateral sclerosis, ALS) was highly publicized at the time this study was being conducted. Accordingly, referring to the CPT as a "Cold Water Challenge" during participant recruitment may have attracted sensation-seeking individuals to our study. Finally, despite using a 50:50 random number generator to determine the order of beads in each task version, participant decisions on which jar they thought the beads were coming from disproportionately favored the yellow jar in Version 3. Thus, future research may wish to prioritize the other versions in which participant decisions were evenly distributed.

5. Conclusions

In summary, the current study examined relationships between self-report IU and performance on an updated version of the Beads Task. By linking decisions to an aversive future outcome (*i.e.*, the CPT), the enhanced version was designed to increase ecological validity of this task as an analog for capturing uncertainty in the context of anxiety disorders. *In vivo* distress experienced during the Beads Task was associated with self-report inhibitory IU, which measures avoidance and paralysis in the face of uncertainty, but not with prospective IU, perfectionism, or general psychological distress (after making statistical adjustments for multiple comparisons), suggesting that this task may be uniquely capturing anxiety due to paralysis while attempting to make a decision with no correct answer. These findings are consistent with previous work that one's emotional response to the Beads Task as opposed to one's observed behavioral responses (*i.e.*, draws to decision and time to decision) are most strongly associated with IU and demonstrate construct validity.

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