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Interpretation bias for uncertain threat: A replication and extension

Mary E. Oglesby [a], Amanda M. Raines [a], Nicole A. Short [a], Daniel W. Capron [a, b], Norman B. Schmidt [a, *]

[a] *Florida State University, 600 W College Ave, Tallahassee, FL 32306, USA*
[b] *University of Southern Mississippi, 118 College Dr, Hattiesburg, MS 39406, USA*

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ABSTRACT

Background: Intolerance of uncertainty (IU) has been proposed as an important transdiagnostic variable within various anxiety-related disorders. Research has suggested that individuals high in IU may interpret ambiguous information in a more threatening manner, suggesting a negative interpretation bias for uncertain information. However, interpretation biases within IU have not been adequately tested in the literature.
Methods: The current study evaluated negative interpretation biases for uncertain information by directly measuring an individual's interpretations of ambiguous information across two samples. Participants consisted of 76 (Study 1; 72.4% female) and 31 (Study 2; 81% female) undergraduate students.
Results: Results indicated that individuals high in IU interpret ambiguous scenarios as more threatening compared to negative and/or positive scenarios ($\beta = .45$, $p = .02$). In addition, individuals high in IU showed a negative interpretation bias for ambiguous information, but not benign information (Study 1: $\beta = -.40$, $p < .001$; Study 2: $\beta = -.57$, $p = .002$).
Limitations: Future research should attempt to replicate these findings within clinical populations. In addition, future work would benefit from the inclusion of behavioral assessments of IU.
Conclusions: These findings are the first to detect the presence of a negative interpretation bias for uncertain information among individuals high in IU utilizing a task designed to directly measure an individual's interpretation of information. Given the efficacy and low economic burden associated with interpretation bias modification protocols, and the transdiagnostic nature of IU, targeting IU within these protocols could have a tremendous public health impact.

1. Introduction

According to cognitive models of anxiety, information processing plays a central role in the development and maintenance of anxiety disorders (Beck & Clark, 1997). More specifically, anxious individuals tend to selectively process threat cues from their environment and overestimate the likelihood of their occurrence (Clark & Steer, 1996), which may lead to the creation of schemas that further influence future information processing (Beck & Clark, 1997). There is dispute over which types of information processing may be most critical to anxiety, but interpretative biases are often indicated as an important cognitive vulnerability factor for anxiety (MacLeod & Mathews, 2012; Ouimet, Gawronski, & Dozois, 2009). Interpretation bias is defined as the tendency to interpret novel information from the environment as negative (Beard & Amir, 2008). Prior research has reliably found support for a negative interpretation bias of threat-relevant innocuous information among anxious individuals (Amir, Beard, & Bower, 2005; Eysenck, Mogg, May, Richards, & Mathews, 1991; Ouimet et al., 2009). Furthermore, experimental studies have suggested threat-relevant interpretation biases as being partially involved in the development of anxiety psychopathology (Mathews & Mackintosh, 2000; Mathews, Ridgeway, Cook, & Yiend, 2007; Salemink, van den Hout, & Kindt, 2007).

Given previous research implicating interpretation biases in the development of anxiety disorders, it is important to better understand the role of interpretation biases in not only anxiety disorders, but also individuals who are at risk of developing an anxiety disorder. Specifically, researchers have begun to explore the association of interpretation biases with anxiety-related vulnerability

* Corresponding author. Department of Psychology, Florida State University, 1107 W. Call St., Tallahassee, FL 32306, USA.
E-mail address: schmidt@psy.fsu.edu (N.B. Schmidt).

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factors. This is crucial given the importance and need for the development of preventative interventions aimed at reducing anxiety-related risk factors (Zvolensky, Schmidt, Bernstein, & Keough, 2006). To date, the interpretation bias literature has mainly focused on negative interpretation biases within anxiety sensitivity (AS), a well-known risk factor for anxiety psychopathology (Schmidt, Zvolensky, & Maner, 2006). For example, using a scenarios task where individuals high and low in anxiety sensitivity (AS) were asked to rank three alternative explanations (one negative, one positive, and one neutral) for why a vague panic-related event may have occurred (e.g., “You notice that your heart is beating quickly and pounding”), Teachman (2005) found individuals elevated in AS to be more likely to interpret these vague situations in a catastrophic manner (e.g., “Because there is something wrong with your heart”) as compared to individuals low in AS. A series of recent studies have extended these findings by successfully modifying a negative interpretation bias for AS utilizing Cognitive Bias Modification (CBM) paradigms (Capron & Schmidt, 2014; MacDonald, Koerner, & Antony, 2013; Steinman & Teachman, 2010). For example, utilizing their CBM for interpretation bias (CBM-I) paradigm, Capron and Schmidt (2014) found a single-session intervention to be successful in reducing overall AS at post-treatment and these reductions were maintained through one-month post-intervention.

Intolerance of uncertainty (IU) is an additional vulnerability factor that may contribute to negative interpretation biases within anxiety. IU is often conceptualized as “a dispositional characteristic resulting from negative beliefs about uncertainty and its implications” (Carleton, Fetzner, Hackl, & McEvoy, 2013; Dugas & Robichaud, 2007). Individuals elevated in IU consider the possibility of a negative event occurring as threatening and intolerable, despite the actual probability of it happening (Carleton, Norton, & Asmundson, 2007). Intolerance of ambiguity, a construct related to IU, is often conceptualized as ambiguity in the ‘here and now,’ whereas IU is more focused on threatening interpretations of future uncertainty (Carleton, 2012; Grenier, Barrette, & Ladouceur, 2005). Although related, research has suggested that IU, in comparison to intolerance of ambiguity, is more closely associated with various psychopathology and is therefore a more relevant construct of focus (Carleton, 2012). Historically, IU was thought to have a specific relationship with generalized anxiety disorder (GAD; Dugas, Schwartz, & Francis, 2004), but recent research has begun to highlight the relationship between IU and a variety of anxiety-related disorders. Specifically, the extant literature has found IU to be associated with symptoms of social anxiety disorder (SAD), obsessive-compulsive disorder (OCD), panic disorder, and post-traumatic stress disorder (PTSD) (Boelen & Reijntjes, 2009; Carleton et al., 2013; Fetzner, Horswill, Boelen, & Carleton, 2013; Holaway, Heimberg, & Coles, 2006; Koerner & Dugas, 2008). These findings have lead researchers to propose IU as an important transdiagnostic individual difference variable within anxiety-related disorders (Mahoney & McEvoy, 2012; McEvoy & Mahoney, 2012).

Given the transdiagnostic nature of IU (Carleton, 2012), researchers have begun to investigate the role of IU in the development and maintenance of anxiety-related disorders. Some have theorized that these distorted beliefs about the negative nature of uncertainty lead to biased information processing abilities, incorrect appraisals of elevated threat, and reduced coping strategies in the face of uncertainty (Freeston, Rhéaume, Letarte, Dugas, & Ladouceur, 1994). Consistent with this, (Hedayati, Dugas, Buhr, & Francis, 2003, November) found that individuals high in IU interpret uncertain information in a more threatening manner when compared to negative and positive information. This finding, combined with theoretical understandings of IU, suggests that IU may influence anxiety via biased information processing.

Given the significant relations between IU and various anxiety-related disorders (Carleton, 2012; Ladouceur, Talbot, & Dugas, 1997; Mahoney & McEvoy, 2012) and prior work suggesting individuals elevated in IU interpret uncertainty more negatively, investigating negative interpretation biases associated with IU is an important next step in the interpretation bias literature. Indeed, establishing such biases is a necessary step before attempting to modify this bias. However, only two studies to date have examined whether or not a negative interpretation bias is evident in individuals high in IU (Dugas et al., 2005; Koerner & Dugas, 2008). Both studies found individuals high in IU (compared to low IU) reported greater concern over uncertain situations in a vignettes task within a non-clinical undergraduate sample. In this task, elevated concern over uncertain scenarios was considered to reflect a negative interpretation of the situation. While these results are promising, rating the level of concern is not a direct assessment of the presence of a negative interpretation bias. Instead, this method may be merely capturing increased emotional arousal, but not an automatic, negative interpretation of uncertain information per se. Therefore, a more objective evaluation of a negative interpretation bias for uncertain information is needed. Specifically, a task designed to directly measure an individual's automatic interpretations of information would provide vital information to aid in the creation CBM-I protocols.

The current study had two primary aims. First, we sought to replicate previous research demonstrating the presence of a negative interpretation bias of uncertain information among individuals high in IU utilizing the vignettes task from Dugas et al. (2005). Consistent with prior research (Dugas et al., 2005), we expected to find a significant association between IU and elevated concern over uncertain scenarios (Study 1). Second, we sought to extend these findings by investigating whether or not individuals high in IU possess a negative interpretation bias for uncertain information utilizing a task designed to directly measure an individual's interpretation of information. Specifically, this task measures whether an individual interpreted an uncertain situation in a negative or neutral manner, not solely their level of concern about the event. Based on prior research (Beard & Amir, 2008; Dugas et al., 2005), we hypothesized that individuals high in IU (compared to those low in IU) would display a negative interpretation bias for uncertain information (Study 1). Finally, given the paucity of research examining negative interpretation biases for uncertain information, we sought to replicate this finding within an independent sample utilizing disparate scenarios (Study 2). Given the novel nature of our task, we were interested to see if this effect would generalize to new stimuli within an independent sample. Lastly, negative affect was included as a covariate in Study 1 to be consistent with prior research utilizing the scenarios task (Dugas et al., 2005; Koerner & Dugas, 2008). However, negative affect was not included as a covariate in Study 2 and 3 given that covariates have not been used when investigating interpretation biases in the extant literature (Amir et al., 2005; Capron & Schmidt, 2014; MacDonald et al., 2013).

2. Study 1: method

2.1. Participants

Participants included 76 undergraduate students recruited from a large southern university. Participants were selected based on their responses to the Intolerance of Uncertainty Scale (IUS; Freeston et al., 1994). Specifically, half of the sample was selected for scoring 1.5 standard deviations above the non-clinical mean on the IUS, whereas the other half was unselected (i.e., not required to meet the IUS cut-off). This method was employed to ensure that we would have a continuous range of IU symptoms. Participants were primarily female (72.4% female) with ages ranging from 18 to 35 ($M = 19.13$, $SD = 2.39$). 75% of the sample was Caucasian, 10.5% African American, 5.3% Asian, 1.3% American Indian, 6.5% Other (e.g., bi-racial), and 1.4% declined to respond.

2.2. Procedure

Participants were contacted via email and invited to participate in an uncertainty and stress assessment study in exchange for course credits. Upon arrival to the lab, informed consent was obtained. Next, participants completed a battery of self-report questionnaires including those used in the current analyses. Following the questionnaires, as part of a larger study participants were randomized to one of three conditions: certain threat, uncertain threat, and control condition. Within the certain threat condition, participants were told that later on in the study they would give a 3-min speech. Individuals in the uncertain threat condition were told that later on in the study they would flip a coin to determine whether or not they would give a 3-min speech. Finally, participants in the control condition were told that some participants have to give a speech at the end of the study but they are not one of them.

Regardless of condition, all participants then went on to complete an interpretation bias task, scenarios task, and several other study-specific tasks. After completing all tasks participants were debriefed, thanked for their time, and awarded any course credits they earned. Total participation took approximately 1.5 h and all procedures were approved by the university's institutional review board. All measures reported on here, except the interpretation bias task and scenarios task, were taken prior to the experimental manipulation. Therefore, condition was statistically controlled for in relevant analyses examining these indices.

2.3. Measures

2.3.1. Self-report

Demographics. A comprehensive demographics questionnaire was used to assess numerous variables including age, race, ethnicity, living arrangement, and sexual orientation.

Intolerance of Uncertainty. Intolerance of uncertainty was measured using the Intolerance of Uncertainty Scale, Short Form (IUS-12; Carleton et al., 2007). The IUS-12 is a 12-item self-report measure assessing an individual's ability to tolerate the uncertainty of vague or ambiguous situations, the individual's responses to uncertainty and beliefs regarding the implications of uncertainty to which individuals are able to tolerate uncertainty (Carleton et al., 2007). Items are rated on a 5-point Likert scale ranging from 0 (*Not at all characteristic of me*) to 5 (*Entirely characteristic of me*). The IUS-12 has demonstrated high internal consistency ($\alpha = .91$) in previous research (Carleton et al., 2007). In the current sample, the IUS-12 demonstrated good internal consistency ($\alpha = .93$).

Negative Affect. Negative affect was measured using the Positive and Negative Affect Schedule (PANAS). The PANAS is a 20-item self-report questionnaire assessing two global dimensions of affect: negative and positive (Watson, Clark, & Tellegen, 1988). Individuals were asked to read various words that describe different feelings and emotions and indicate the degree to which they felt that way on average. The PANAS scales have demonstrated high internal consistency and stability over a 2 month time-frame (Watson et al., 1988). Only the negative affect subscale was used in the present investigation. Reliability analysis indicated that the negative affect scale demonstrated good internal consistency ($\alpha = .88$).

2.3.2. Study tasks

Scenarios task. A scenarios task was used to assess participant appraisals of ambiguous, negative, and positive situations (Koerner & Dugas, 2008). Specifically, individuals were asked to read 55 brief, every day scenarios and imagine that the events being described were happening to them. After reading each scenario, participants were then asked to rate their level of concern on a scale from 1 (*not at all concerned*) to 5 (*extremely concerned*). The scenarios depicted various content areas including relationships with friends, romantic partners, and parents, educational performance, finances, personal health, health of loved ones, occupational competence, threat of physical harm or danger, the future, and self-concept (e.g., "My performance in the play was commented on by everyone").

Interpretation Bias (IB) Task. A negative interpretation bias for uncertain information was measured using the Word Sentence Association Paradigm (WSAP; Beard & Amir, 2008). The WSAP was modified by the authors to include phrase and sentences pairs denoting uncertainty, whereas the original WSAP comprised phrase and sentence pairs depicting social situations (Beard & Amir, 2008). Specifically, ambiguous phrases indicating uncertainty were created. In addition, one negative and one neutral interpretation of these phrases were created. Participants completed 80 trials comprised of four phases each. During the first phase, a fixation cross appeared on the computer screen for 500 ms to direct participants toward the screen and alert them that the trial was beginning. Next, an ambiguous phrase (e.g., "Doctor called") appeared on the screen for 1000 ms. Following this, a sentence representing either a negative interpretation (e.g., "I have a terrible disease") or a benign interpretation (e.g., "Appointment reminder") appeared on the screen and remained until participants pressed the space bar to indicate they had finished reading the statement. On half the trials the combination of the phrase and sentence creates a negative interpretation defined as an "uncertain-negative prime"; on the other half of the trials the combination creates a benign interpretation defined as an "uncertain-neutral prime". Finally, participants were instructed to press "1" if they thought the phrase and sentence were related or "2" if they thought the phrase and sentence were un-related. An interpretation bias for uncertain information was calculated by averaging participants responses to whether or not they thought the uncertain-negative primes were related (i.e., "1") or unrelated (i.e., "2"). Specifically, individuals whose average was closer to one when responding to the uncertain-negative primes were said to have a negative interpretation bias for ambiguous information. An interpretation bias for neutral information was calculated with this same procedure and interpreted in the same way, but utilizing the uncertain-neutral primes.

3. Study 1: results

3.1. Preliminary analyses

Preliminary analyses indicated that there were no threats or violations of normality, multicollinearity, or homoscedasticity (Berry, 1993; Tabachnick & Fidell, 2001). In addition, four one-way between-groups ANOVA were conducted to check equivalence of random assignment to condition based on key characteristics. Results indicated that there were no differences among individuals in the certain threat, uncertain threat, or control conditions on age ($F(2, 73) = 1.03$, $p = .36$), gender ($F(2, 73) = .42$, $p = .66$), IUS-12 total scores ($F(2, 73) = .26$, $p = .77$), or PANAS-NA scores ($F(2, 73) = .17$, $p = .84$).

First, means, standard deviations, and zero-order correlations were examined (see Table 1). The sample mean for IUS-12 scores

Table 1
Zero-order correlations, means, and standard deviations for Study 1.

	1	2	3	4	5	6	7	8	*M*	*SD*	*S*	*K*
1. Condition	–	–	–	–	–	–	–	–	2.01	.87	−.02	−1.61
2. PANAS – NA	.00	–	–	–	–	–	–	–	19.58	7.16	.78	.53
3. IUS-12 Total	.03	.50***	–	–	–	–	–	–	29.08	10.63	.44	−.38
4. Ambiguous	.06	.40***	.56***	–	–	–	–	–	88.27	22.92	.32	−.50
5. Negative	.01	.37***	.46***	.81***	–	–	–	–	43.91	6.91	−.73	.07
6. Positive	.10	.21	.31**	.64***	.40***	–	–	–	23.57	9.92	.98	.08
7. Neutral	.17	.29*	.08	.02	−.08	−.01	–	–	1.14	.10	.98	.66
8. Uncertain	−.04	−.21	−.45***	−.40***	−.38***	−.22	.14	–	1.47	.22	.00	−.44

Note. Condition was coded as 1 (certain threat), 2 (uncertain threat), or 3 (control). PANAS – NA, Positive and Negative Affect Schedule – Negative Affect subscale; IUS-12 Total, Intolerance of Uncertainty Scale, Short Form – Total Score; Ambiguous, level of concern over ambiguous situations; Negative, level of concern over negative situations; Positive, level of concern over positive situations; Neutral, responses to uncertain-neutral primes; Uncertain, responses to uncertain-negative primes; *M* = Mean; *SD* = Standard Deviation; *S* = Skewness; *K* = Kurtosis. Responses were coded as 1 (related) or 2 (unrelated).
*$p < .05$, **$p < .01$, ***$p < .001$.

was similar to that found in previous student samples (Carleton, Sharpe, & Asmundon, 2007; Khawaja & Yu, 2010). As expected, IU was correlated with level of concern over ambiguous and negative events (as measured by the scenarios task). Somewhat unexpectedly, IU was also associated with level of concern over positive events. Also as expected, IU was negatively correlated with responses to uncertain-negative primes, but not responses to uncertain-neutral primes (as measured by the IB task). Condition was not associated with level of concern over ratings of ambiguous, negative, or positive situations (all *ps* > .41). In addition, condition was not correlated with responses to uncertain-negative or uncertain-neutral primes (all *ps* > .13). However, given that participants were informed of the condition manipulation before completing the interpretation bias and scenarios tasks, condition was included as a covariate in all analyses to account for potential effects of condition on our dependent variables.

3.2. *Primary analyses*

3.2.1. *Scenarios task*

To test our hypothesis that elevated IU would be associated with increased level of concern regarding ambiguous and negative situations (as measured by the scenarios task), three hierarchical multiple regressions were computed (see Table 3). In each two-tailed regression equation, the dummy coded condition variables as well as negative affect scores (as measured by the PANAS – NA) were entered into Step 1 as covariates. Next, IU (as measured by the IUS-12) was entered into Step 2. Participants' ratings of concern regarding different types of scenarios served as the dependent variables, with ratings of positive, negative, and ambiguous situations in three separate regressions.

In terms of ambiguous scenarios, Step 1 accounted for 18.0% of the variance ($F(3, 71) = 5.19$, $p = .003$), with negative affect ($\beta = .41$, $t = 3.79$, $p < .001$, $sr^2 = .17$) significantly predicting increased levels of concern regarding the scenarios. Next, Step 2 accounted for an additional 14.0% of the variance, with elevated IUS-12 scores predicting increased levels of concern about ambiguous scenarios ($\beta = .43$, $t = 3.78$, $p < .001$, $sr^2 = .14$). Regarding negative scenarios, Step 1 accounted for a significant 17.9% of the variance in level of concern ($F(3, 71) = 5.17$, $p = .003$), with only elevated negative affect ($\beta = .39$, $t = 3.59$, $p = .001$, $sr^2 = .15$) significantly predicting increased level of concern. Next, Step 2 accounted for an additional 8.2% of the variance, with elevated IUS-12 scores predicting increased levels of concern about negative scenarios ($\beta = .33$, $t = 2.78$, $p = .007$, $sr^2 = .08$). Finally, in terms of positive scenarios, Step 1 did not significantly predict level of concern ($F(3, 71) = 1.83$, $p = .150$). Similarly, IUS-12 scores in Step 2 did not significantly predict level of concern over positive scenarios ($\beta = .15$, $t = 1.16$, $p = .25$, $sr^2 = .02$).

Next, to test our second hypothesis that IU would be *most* related to concern regarding ambiguous situations (compared to negative or positive situations), we conducted an additional hierarchical multiple regression. Here, Step 1 included the dummy coded condition variables as well as negative affect as covariates. In Step 2, the levels of concern over ambiguous, negative, and positive scenarios were entered. IUS-12 total scores served as the dependent variable. Step 1 accounted for a significant 25.0% of the variance in IUS-12 scores ($F(3, 71) = 7.89$, $p < .001$), with elevated levels of negative affect significantly predicting increased IU ($\beta = .49$, $t = 4.79$, $p < .001$, $sr^2 = .24$), whereas the condition variables were not significantly related (Condition 1: $\beta = .05$, $p = .70$; Condition 2: $\beta = .07$, $p = .60$). Step 2 accounted for a significant additional 13.1% of the variance in IUS-12 scores (F change = 4.78, $p = .004$). Neither level of concern over negative ($\beta = -.03$, $t = -.18$, $p = .86$, $sr^2 < .01$) or positive ($\beta = -.07$, $t = -.60$, $p = .55$, $sr^2 < .01$) situations significantly predicted IU. Only level of concern over ambiguous situations significantly predicted elevated IU ($\beta = .45$, $t = 2.40$, $p = .02$, $sr^2 = .05$).

3.2.2. *Interpretation bias task*

To test our hypothesis that IU would predict responses to uncertain-negative primes (and not uncertain-neutral primes), two hierarchical multiple regressions were conducted (see Table 4). In the both models, the dummy coded condition variables were entered into Step 1 as covariates. IUS-12 scores were entered into Step 2. Here, responses to uncertain-negative primes served as the dependent variable. Step 1 was not significant ($F(2, 73) = .18$, $p = .837$). Step 2 accounted for an additional 15.7% of the variance in responses to uncertain-negative primes, with elevated IUS-12 scores significantly predicting responses indicating the uncertain-negative pairings were related ($\beta = -.40$, $t = -3.67$, $p < .001$, $sr^2 = .16$).

Table 2
Zero-order correlations, means, and standard deviations for Study 2.

	1	2	3	4	*M*	*SD*	*S*	*K*
1. Condition	–	–	–	–	1.94	.73	.10	−1.01
2. IUS-12 Total	.21	–	–	–	27.23	10.28	.39	−.73
3. Neutral	.00	−.14	–	–	1.09	.10	2.16	5.32
4. Uncertain	.14	−.53**	.36*	–	1.52	.23	.04	−.81

Note. Condition was coded as 1 (certain threat), 2 (uncertain threat), or 3 (control). IUS-12 Total, Intolerance of Uncertainty Scale, Short Form – Total Score. Neutral, responses to uncertain-neutral primes; Uncertain, responses to uncertain-negative primes *M* = Mean; *SD* = Standard Deviation; *S* = Skewness; *K* = Kurtosis. Responses were coded as 1 (related) or 2 (unrelated).
*$p < .05$, **$p < .01$.

Table 3
Hierarchical regression analyses of IU predicting Study 1 scenario type.

Step	Independent variables	Dependent variables: type of scenario		
		Ambiguous scenarios Betas (sr^2)	Negative scenarios Betas (sr^2)	Positive scenarios Betas (sr^2)
1	Condition 1	−.17 (.02)	−.22 (.03)	−.01 (.00)
	Condition 2	−.10 (.00)	−.22 (.03)	.18 (.02)
	PANAS-NA	.41*** (.17)	.39** (.15)	.21 (.04)
	R^2	.18**	.18**	.08
	ΔR^2	–	–	–
2	IUS-12 Total	.43*** (.14)	.33** (.08)	.15 (.02)
	R^2	.32	.26	.10
	ΔR^2	.14***	.08**	.02

Note. Condition 1 = Dummy code variable for condition 1 vs. condition 2. Condition 2 = Dummy code variable for condition 2 vs. condition 3. PANAS-NA = Positive and Negative Affective Scale − Negative Affect Subscale. IUS-12 Total = Intolerance of Uncertainty Scale, Short Form − Total Score.
**$p < .01$; ***$p < .001$; sr^2 = square of semi-partial correlation.

Table 4
Hierarchical regression analyses of IU predicting uncertain-negative and uncertain-neutral prime responses.

Step	Independent variables	Dependent Variables: Study 1 and 2 uncertain-negative and uncertain-neutral prime response			
		Study 1 Uncert-Neg Betas (sr^2)	Study 1 Uncert-Neut Betas (sr^2)	Study 2 Uncert-Neg Betas (sr^2)	Study 2 Uncert-Neut Betas (sr^2)
1	Condition 1	−.04 (.00)	−.14 (.00)	−.21 (.04)	.07 (.00)
	Condition 2	−.09 (.00)	.06 (.00)	−.05 (.00)	.08 (.01)
	R^2	.01	.03	.04	.01
	ΔR^2	–	–	–	–
2	IUS-12 Total	−.40*** (.16)	−.05 (.00)	−.57** (.30)	−.16 (.02)
	R^2	.16	.04	.34	.03
	ΔR^2	.16***	.00	.30**	.02

Note. Condition 1 = Dummy code variable for condition 1 vs. condition 2. Condition 2 = Dummy code variable for condition 2 vs. condition 3. IUS Total = Intolerance of Uncertainty Scale, Short Form − Total Score. Study 1 Uncert-Neg = Study 1 Uncertain-Negative Prime Response; Study 1 Uncert-Neut = Study 1 Uncertain-Neutral Prime Response; Study 2 Uncert-Neg = Study 2 Uncertain-Negative Prime Response; Study 2 Uncert-Neut = Study 2 Uncertain-Neutral Prime Response. Study 1 and Study 2 responses were coded as 1 (related) or 2 (unrelated).
***$p < .001$, **$p < .01$; sr^2 = square of semi-partial correlation.

Next, to demonstrate that IU predicted responses to uncertain-negative, but not uncertain-neutral, primes, we conducted a second hierarchical multiple regression. Again, Step 1 included the covariate of condition and Step 2 included IUS-12 scores. Here, responses to uncertain-neutral primes served as the dependent variable. Step 1 was not significant ($F(2, 73) = 1.25$, $p = .293$). Step 2 also was not significant, with IUS-12 scores not significantly predicting responses to uncertain-neutral primes ($\beta = -.06$, $t = -.52$, $p = .60$, $sr^2 < .01$).

4. Study 2: method

4.1. Participants

Participants included 31 undergraduate students recruited from a large southern university. See previous description of participant selection criteria and rationale. Participants were primarily female (81% female) with ages ranging from 18 to 38 (M = 19.09, SD = 3.50). 85% of the sample was Caucasian, 9% African American, 3% Asian, and 3% Other (e.g., bi-racial).

4.2. Procedure

As in study 1, participants were contacted via email and invited to participate in an uncertainty and stress assessment study in exchange for course credits. There was no overlap in participants between the two studies. Participants were consented and then completed a battery of self-report questionnaires. Following the questionnaires, participants were randomized to one of three conditions (please see previous description of conditions). Participants then completed an interpretation bias task and several other study-specific tasks. After completing all tasks participants were debriefed, thanked for their time, and awarded any course credits they earned.

4.3. Measures

4.3.1. Self-report

Demographics. See previous description of measure.

Intolerance of Uncertainty. See previous description of measure. In the current study, the IUS-12 demonstrated excellent internal consistency ($\alpha = .92$).

4.3.2. Interpretation bias task

Interpretation Bias (IB) Task. To measure a negative interpretation bias for uncertain information within a new sample, 80 new ambiguous phrase and sentence pairs were created. Eighty new ambiguous phrase and sentence pairs were created to investigate whether the presence of a negative interpretation bias for uncertain information would generalize to additional uncertain information independent of the original stimuli. This allowed us to better ensure that the effect found in study 1 was not simply due to the phrase/sentence pairs selected. In addition, we were interested in replicating our findings from study 1 in a new, independent sample. See previous description of task.

5. Study 2: results

5.1. Preliminary analyses

As with study 1, preliminary analyses indicated that there were no threats or violations of normality, multicollinearity, or homoscedasticity. In addition, three one-way between-groups ANOVAs indicated that there were no differences among individuals in the certain threat, uncertain threat, or control conditions on age, gender, or IUS-12 total scores. Preliminary analyses indicated high skewness and kurtosis values for the uncertain-neutral primes, suggesting that the majority of individuals rated these pairings as being related.

First, means, standard deviations, and zero-order correlations were examined (see Table 2). The sample mean for IUS-12 scores was comparable to that found in previous nonclinical samples (Carleton, Sharpe, & Asmundon, 2007; Khawaja & Yu, 2010). As expected, IU was negatively correlated with responses to uncertain-negative primes, but not responses to uncertain-neutral primes (as measured by the IB task). Once again, condition was not correlated with responses to uncertain-negative or uncertain-neutral primes (all *ps* > .47) but was included as a covariate in all analyses to account for potential effects of condition on our dependent variables.

5.2. Primary analyses

5.2.1. Interpretation bias task

To test our hypothesis that IU would predict responses to uncertain-negative primes (and not uncertain-neutral primes), two two-tailed hierarchical multiple regressions were conducted (see Table 4). In the both models, the dummy coded condition variables were entered into Step 1 as covariates. IUS-12 scores were entered into Step 2. Here, responses to uncertain-negative primes served as the dependent variable. Step 1 was not significant ($F(2, 28) = .56$, $p = .577$). Step 2 accounted for an additional 30.3% of the variance in responses to uncertain-negative primes, with elevated IUS-12 scores significantly predicting responses indicating the uncertain-negative pairings were related ($\beta = -.57$, $t = -3.53$, $p = .002$, $sr^2 = .30$).

Next, to demonstrate that IU predicted responses to uncertain-negative, but not uncertain-neutral primes, we conducted a second hierarchical multiple regression. Again, Step 1 included the covariate of condition and Step 2 included IUS-12 scores. Here, responses to uncertain-neutral primes served as the dependent variable. Step 1 was not significant ($F(2, 28) = .10$, $p = .902$). Step 2 also was not significant, with IUS-12 scores not significantly predicting responses to uncertain-neutral primes ($\beta = -.16$, $t = -.81$, $p = .42$, $sr^2 < .01$).

6. Discussion

As hypothesized, IU was significantly associated with level of concern over ambiguous scenarios. This finding remained significant even after covarying for overall levels of negative affect. Although our results revealed an unexpected association between IU and level of concern over negative scenarios, only level of concern over ambiguous scenarios was significantly associated with IU when all scenario types were examined together. Our findings provide an important replication of prior research demonstrating that individuals high in IU display elevated concern over ambiguous scenarios (Dugas et al., 2005; Koerner & Dugas, 2008).

The current investigation extended previous research by examining whether individuals high in IU would display a negative interpretation bias for uncertain information utilizing a task designed to directly measure an individual's interpretation of information, not their level of concern over a scenario. Consistent with expectation, IU was significantly associated with an increased propensity to rate uncertain-negative primes as related, signifying a negative interpretation bias for uncertain/ambiguous information. Furthermore, IU was not significantly associated with a negative interpretation bias for neutral information, suggesting that IU is not associated with the tendency to interpret uncertain information in a more or less neutral way. Given the dearth of research examining the presence of a negative interpretation bias among individuals high in IU, the current study replicated results from Study 1 within an independent sample utilizing distinct stimuli. Consistent with a priori hypotheses and findings from Study 1, results from Study 2 revealed a significant relationship between IU and a negative interpretation bias for uncertain/ambiguous information, but not neutral information.

These studies were the first to investigate whether a negative interpretation bias for ambiguous information is present among individuals high in IU. Although others have found elevated concern over ambiguity among those high in IU, no study to date has investigated this relationship utilizing a task designed to directly measure an individual's interpretations. For this reason, we believe the task used in current investigation is superior to previous methods. In addition, this task is preferred given previous research suggesting that active tasks (versus passive tasks—e.g., word stem completion tasks), such as the task in the current study, result in more robust findings (Hoppitt, Mathews, Yiend, & Mackintosh, 2010a, 2010b; MacDonald et al., 2013).

Taken together, results from the current investigation fit within the broader cognitive model of anxiety. Specifically, cognitive models of anxiety suggest that anxious individuals have a tendency to selectively attend to and interpret cues from their environment in a more threatening manner (Beck & Clark, 1997). According to models of IU, individuals high in IU interpret uncertainty itself as threatening (Carleton et al., 2012; Carleton et al., 2007; Epstein, 1972). Results from the current study are consistent with these models, as participants high in IU were more likely to interpret ambiguous information in a negative and threatening manner. As such, it is likely that these individuals experience increased anxiety surrounding uncertain cues in the environment, which may lead to an increased risk for anxiety psychopathology (Carleton et al., 2012; Dugas et al., 2005). These findings also fit within current transdiagnostic models of IU (Carleton, 2012; Hong & Cheung, 2015; Hong & Lee, 2015) and suggest that a negative interpretation bias for uncertain information, as seen among individuals high in IU, may be vulnerability factor for the later development of various conditions.

Given the transdiagnostic nature of IU (Carleton, 2012; Carleton et al., 2012), the findings from the current investigation are promising when considering treatment implications for anxiety-related disorders. Previous research attempting to reduce interpretation biases among anxious individuals has yielded promising results (Capron & Schmidt, 2014). For example, Capron and Schmidt (2014) found a single-session intervention successful in reducing levels of AS from pre-to post-treatment utilizing a CBM-I paradigm. Our findings suggest that an important next step in the literature would be to modify the existing protocol from the current study into an IU-focused CBM-I paradigm aimed at reducing IU. Given the barriers often associated with treatment utilization (e.g., cost; accessibility) (Schmidt & Keough, 2010), creating and disseminating CBM-I protocols is important considering the ease and accessibility associated with these protocols (e.g., computer-based; limited sessions). In addition, given the transdiagnostic nature of IU and efficacy associated with these paradigms (Beard & Amir, 2008; Capron & Schmidt, 2014; Clerkin, Beard, Fisher, & Schofield, 2014; MacDonald et al., 2013; Mahoney & McEvoy, 2012), incorporating IU-focused CBM-I protocols into cognitive behavior treatments for anxiety may be beneficial.

It is important to note limitations of the current studies. Although our participant selection process resulted in a sample slightly elevated in IU, the current study utilized an undergraduate sample. Future work should attempt to investigate these findings utilizing a clinical sample to examine whether these biases exist among individuals with anxiety psychopathology. In addition, given the cross-sectional nature of our findings, future research should attempt to replicate our findings within a longitudinal framework. Specifically, research examining whether a negative interpretation bias for ambiguous information leads to an increased risk for anxiety psychopathology would be informative. The current study did not test whether a negative interpretation bias for uncertain information was distinct from previous research finding a negative interpretation bias for innocuous information among anxious individuals. Future research would benefit by examining this distinction. Furthermore, the extant literature would profit from a more thorough investigation of whether a negative interpretation bias for uncertain information is a more transdiagnostic explanation for previous work suggesting a negative interpretation bias for banal information. Finally, the current investigation did not utilize a behavioral index of IU. Future work should examine the relationship between behavioral indices of IU and the presence of a negative interpretation bias for uncertain information considering the importance of multi-modal assessment.

Despite these limitations, the current investigation provides valuable information regarding the role of negative interpretation biases within individuals elevated in IU. To our knowledge, this investigation is the first to find the presence of a negative interpretation bias for ambiguous information among those elevated in IU utilizing a task directly measuring an individual's interpretations. Given the transdiagnostic nature of IU and the efficacy and accessibility associated with CBM-I protocols, these findings add considerably to the growing body of literature on interpretation biases and IU. Furthermore, targeting IU within these protocols may have a tremendous public health impact.

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Contributors

Author one wrote the majority of the introduction and discussion sections, as well as assisted with the methods and results sections. Author two assisted with writing the methods section as well as assisting with the introduction and discussion sections. Author three wrote the results section and conducted literature searches. Author four assisted with study creation as well as proof reading and writing assistance. Author five provided critical feedback on all drafts of the manuscript. All authors contributed significantly to the manuscript and approved the final version being submitted.

Declaration of interests

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