An eye-tracking study of attentional biases for uncertainty and generalized anxiety symptoms

by

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Abstract

Intolerance of uncertainty (IU), a dispositional characteristic reflecting negative beliefs about the potential threat of uncertainty (Koerner & Dugas, 2007), is related to information-processing biases (e.g., interpretation biases) that may maintain and exacerbate anxiety symptomatology. However, an attentional bias for uncertainty (ABU) has been relatively understudied. Using eye-tracking technology, the current study aimed to confirm whether IU is associated with ABU and determine whether ABU partially explains the IU-generalized anxiety relationship. It was hypothesized that IU would be associated with facilitated engagement with uncertainty and that ABU would account for significant variance in the IU-generalized anxiety relationship. Results did not support either hypothesis; however, generalized anxiety symptoms were positively associated with impaired disengagement with uncertainty in the total sample ($N = 144$). Exploratory analyses revealed that females high in IU and generalized anxiety symptoms exhibited avoidant engagement with as well as impaired disengagement from uncertainty, while males exhibited no significant attentional biases. Clinical implications and directions for future research are discussed.

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ABU	Attentional bias for uncertainty
FE-1	First operationalization of facilitated engagement with uncertainty (the proportion of first fixations on uncertainty-related words minus the proportion of first fixations on neutral words)
FE-2	Second operationalization of facilitated engagement with uncertainty (the latency until making a first fixation on neutral words minus the latency until making a first fixation on uncertainty-related words)
ID-1	First operationalization of impaired disengagement with uncertainty (the proportion of subsequent [non-initial] fixations on uncertainty-related words minus the proportion of subsequent fixations on neutral words)
ID-2	Second operationalization of impaired disengagement with uncertainty (the total trial time spent attending to uncertainty-related words minus total trial time spent attending to neutral words)
IU	Intolerance of uncertainty
VST	Visual search task

An Eye-Tracking Study of Attentional Biases for Uncertainty and Generalized Anxiety Symptoms

Intolerance of uncertainty (IU), an individual difference factor characterized by negative beliefs about the potential threat that uncertainty implies (Koerner & Dugas, 2006), has been shown to be related to a variety of information-processing biases (e.g. memory and expectancy biases for uncertainty-related information [Dugas et al., 2005; Grupe & Nitschke, 2011]). However, a particular kind of information-processing bias (i.e., attentional bias for uncertainty [ABU]) has remained relatively unexplored within the existing literature. Only one known study has explored the possibility of ABU (Fergus, Bardeen, & Wu, 2013), but it suffered from a notable methodological limitation. Furthermore, no known study has investigated how ABU might explain the relationship between IU and generalized anxiety symptoms. By using eye-tracking technology, which has been shown to be more reliable than traditional stimulus-response paradigms such as the one used by Fergus et al. (Armstrong, & Olatunji, 2012), the current study aimed to replicate the findings of that investigation and to overcome its principle methodological limitation. Further, the current study sought to elucidate the nature of uncertainty-related attentional biases (i.e., whether facilitated engagement or impaired disengagement) and to determine if such a bias indirectly accounts for the relationship between IU and generalized anxiety symptoms.

IU-Generalized Anxiety Relationship

Koerner and Dugas (2006) have defined intolerance of uncertainty (IU) as "a dispositional characteristic that reflects a set of negative beliefs about uncertainty and its implications" (p. 620). At its core, IU may reflect a fundamental fear of the unknown (Carleton, 2012). As such, individuals high in IU tend to find uncertainty and its implications threatening and may have difficulty pursuing goal-directed behavior in the face of uncertainty (Dugas & Robichaud, 2007; Freeston, Rhéaume, Letarte, Dugas, & Ladouceur, 1994; Koerner & Dugas, 2008). Since its first conceptualization, IU has been most extensively studied in the context of generalized anxiety disorder (GAD; Dugas, Gagnon, Ladouceur, & Freeston, 1998; Dugas, Freeston, & Ladouceur, 1997; Koerner & Dugas, 2008). As IU was initially framed as a maintenance and vulnerability factor for GAD, a large body of literature has focused on the association between IU and generalized anxiety symptoms.

For example, Dugas, Gosselin, and Ladouceur (2001) demonstrated that IU is highly associated with excessive and uncontrollable worry, the principle feature of GAD. In a sample of 347 university students, Dugas et al. found that IU shared significantly stronger correlations with GAD-consistent worry than with symptoms of other anxiety disorders (i.e., obsessive-compulsive disorder and panic disorder). Further, the authors demonstrated that participants' level of worry continued to predict a large proportion of the variance in IU, $\Delta r^2 = .34$, after controlling for demographic variables, obsessive-compulsive symptoms, and panic symptoms. Other investigations have corroborated these findings, further evidencing the unique relationship between IU and generalized anxiety symptoms (Buhr & Dugas, 2002, 2006; Dugas et al. 1997; Ladouceur, Gosselin, & Dugas, 2000).

Dugas, Marchand, and Ladouceur (2005) investigated the symptomatic and diagnostic specificity of four components of a cognitive-behavioral model of GAD (i.e., poor problem orientation, positive beliefs about worry, cognitive avoidance, and IU). Using a clinical sample of 17 patients with a diagnosis of GAD and 28 patients with a diagnosis of panic disorder with agoraphobia, the authors found that only IU demonstrated diagnostic specificity to GAD. That is, when measures of all four components were compared between patients with GAD and patients with panic disorder, IU was the only component that significantly differed across the two diagnostic groups. Specifically, IU was higher in patients with GAD than in patients with panic disorder, further corroborating previous evidence of the IU-generalized anxiety relationship.

Targeting IU in treatment has been shown to be effective in reducing generalized anxiety symptoms. In a controlled clinical trial, Ladouceur et al. (2000) evaluated the efficacy of a cognitive-behavioral treatment for generalized anxiety in 26 patients with a primary diagnosis of GAD. Participation was not contingent on having a singular diagnosis of GAD; rather, comorbid diagnoses included a variety of emotional and compulsive disorders (i.e., specific phobia, social phobia, panic disorder with and without agoraphobia, obsessive-compulsive disorder, trichotillomania, and major depression). The treatment's rational was described as helping patients recognize, accept, and develop coping strategies for uncertainty in everyday life, rather than eliminating uncertainty entirely. After 16 one-hour sessions, significant symptom improvements were demonstrated in reductions in worry and anxiety symptoms, as well as in depressive symptoms. After completing treatment, 20 of the 26 patients no longer met criteria for GAD, and gains were maintained at 6- and 12-month follow-up. Treatment outcomes such as these demonstrate that targeting IU in psychotherapy is successful in reducing GAD symptoms and provide more evidence suggesting that IU plays an important role in GAD.

Additional treatment research has demonstrated that, not only can a cognitive-behavioral treatment targeting IU lead to reductions in generalized anxiety symptoms, but also, symptom reductions (i.e., worry) are preceded by reductions in IU itself. Dugas and Ladouceur (2000) evaluated the efficacy of a treatment package in four patients with a primary diagnosis of GAD. In a time-series analysis of change in IU and GAD patients' worry, the authors found that reductions in IU preceded reductions in worry in three of four patients seeking treatment, and this IU-worry relationship reached near statistical significance in the fourth patient. Conversely, reductions in worry did not precede reductions in IU for any of the patients. Similarly, Bomyea et al. (2015) demonstrated that, in a treatment-seeking sample of 28 adults who met criteria for a primary diagnosis of GAD, reductions in IU mediated reductions in worry. Taken together, these investigations provide support for a temporal relationship, in which changes in IU precede changes in generalized anxiety symptoms.

Uncertainty-Related Information-Processing

Given IU's role in generalized anxiety, researchers have attempted to understand the cognitive mechanisms that might underlie IU. According to theories of information-processing, anxiety results in part from biases within different cognitive processes, such as interpretation, memory, and attention allocation (e.g., Beck & Clark, 1997; Eysenck, 2000; Williams, Watts, MacLeod, & Mathews, 1997). Relative to nonanxious individuals, those who suffer from anxiety are thought (a) to be more likely to interpret neutral or uncertain stimuli or situations as threatening (an interpretation bias), (b) to more readily remember threatening cues and events from memory (a memory bias), and (c) to attend to threat-related stimuli over neutral information in the environment (an attentional bias). In a comprehensive review of the literature on IU, Carleton (2012) suggested that IU might stem from such information-processing biases, in which stimuli that denote uncertainty are automatically categorized and processed as threatening. Research has provided evidence for these proposed uncertainty-related information-processing biases. For example, Dugas et al. (2005) found evidence of an uncertainty-related memory bias. In a sample of 101 undergraduate students, individuals high in IU recalled a significantly greater proportion of uncertainty-related words (e.g., "chance") compared to neutral words (e.g., "career") than did individuals low in IU.

Beyond a memory bias for uncertainty-related information, visual cues denoting uncertainty are associated with exaggerated expectancies of aversive outcomes. Grupe and Nitschke (2011) asked 78 students to rate their expectation that aversive visual stimuli (i.e., negatively valenced and arousing pictures from the International Affective Picture System) would follow three different visual cues. An "X" preceded an aversive picture in all trials, while an "O" preceded a neutral, non-aversive picture in all trials. Therefore, "X" and "O" served as certainty cues. Conversely, a "?" preceded an aversive picture in only half of trials and thus served as an uncertainty cue. For all participants, the uncertainty cue was associated with an exaggerated expectancy bias for aversive stimuli; that is, expectations that an aversive stimulus would follow the uncertainty cue were greater than 50%, even though the probability that an aversive picture would follow was exactly 50%. Further, the aversive pictures that followed the uncertainty cue, compared to aversive pictures following the certainty cues, were accompanied by increased negative mood. Such findings suggest that, not only can information denoting uncertainty serve as a threat cue, which is likely associated with exaggerated expectations of aversive outcomes (i.e., a negative expectancy bias), but uncertain outcomes may result in heightened negative emotional responses relative to outcomes that are certain in nature.

Taken together, these findings support information-processing theories of anxiety and Carleton's (2012) suggestion of uncertainty-related information-processing biases. However, while the existing literature has provided some examples of such cognitive biases, other forms of information-processing biases (e.g., ABU) have remained relatively unexplored. Only one known study has considered ABU (Fergus et al., 2013). This gap in the existing literature is notable, given the continuing need to understand the specific means by which IU contributes to generalized anxiety symptoms. Furthermore, it is surprising that researchers have yet to seriously consider the possibility of ABU, given the ability of current models to account for such an attentional bias.

Theoretical Model of Anxiety Symptomatology

One such model, the self-regulatory executive function model, offers an account of how cognitive and metacognitive factors can prolong an individual's sense of threat and maintain emotional disorder by focusing attention on threat cues and increasing the sensitivity of cognitive processing systems to such cues (Wells & Simons, 2009; Wells & Matthews, 1996). Of particular importance to the current study, this model offers an account of how beliefs can activate a particular maladaptive style of cognitive processing called the cognitive attentional syndrome. The cognitive attentional syndrome is characterized in part by an attentional bias to threat. Within the self-regulatory executive function model, threatening information from the environment or from within the body initially undergoes automatic, "low level" processing. The cognitive attentional syndrome is activated, and it then biases attentional resources toward the threatening stimulus and increases the sensitivity of the processing system to threatening information. However, while such sensitization of the processing system to threatening stimuli is meant to avoid potential threats, it also paradoxically maintains heightened negative emotion in response to threatening information and prolongs the emotional distress elicited by the perceived threat (Wells & Simons, 2009).

In the same way, information from the environment that denotes uncertainty might serve as a threat cue. Not only is higher IU associated with greater probability estimates of threat (Bredemeier & Berenbaum, 2008), but also, individuals high in IU find uncertainty itself and its implications threatening (Carleton, 2012). Negative beliefs about the implications of uncertainty can activate the cognitive attentional syndrome. Within the self-regulatory executive function model, information that denotes uncertainty might undergo initial processing and interpretation as potentially threatening. Attentional resources might then become biased toward stimuli that denote uncertainty, and the sensitivity of the processing system to uncertainty-related information would increase. In the same way that attentional biases for threat exacerbate and maintain psychological distress, ABU would heighten and maintain anxious responding in situations characterized by uncertainty. Given evidence of uncertainty-related information-processing biases and the ability of the self-regulatory executive function model to account for ABU, it is surprising that ABU has not received greater consideration in the existing literature as a potential mechanism through which IU contributes to anxiety-related outcomes.

Components of Attentional Biases

The current discussion of attentional biases for both threat- and uncertainty-related information warrants a review of the specific nature of attentional biases broadly. Cisler and Koster (2010) discuss an ongoing line of inquiry within attentional bias research regarding the specific attentional processes that might underlie these biases (i.e., facilitated engagement and impaired disengagement). Facilitated engagement refers to the ease or relative speed with which attention is drawn to a relevant stimulus (e.g., a cue denoting threat or uncertainty) and is thought to arise from a relatively automatic attention-orienting process controlled by a neural threat detection mechanism. Impaired disengagement, however, refers to the degree to which a threat- or uncertainty-related stimulus holds attention, thereby impairing one's ability to disengage from it or switch to other stimuli within the environment. Cisler and Koster (2010) conceptualize impaired disengagement as a component explained by deficits in attentional control.

Research has provided evidence of facilitated engagement and impaired disengagement, both separately and in conjunction, within anxiety and stress-related disorders, while some research has failed to find evidence of threat-related attentional biases altogether. As such, the degree to which facilitated engagement and impaired disengagement account for anxiety and related pathology is unclear (e.g., Armstrong & Olatunji, 2012; Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007). Identifying the specific attentional component(s) that might underlie ABU may have important theoretical and clinical implications. For example, if the current investigation finds that facilitated engagement, rather than impaired disengagement, is the attentional component by which ABU operates, it would provide evidence that uncertainty-related information serves as a threat cue that activates an automatic, 'bottom-up' threat detection mechanism. Moreover, it would suggest that targeting a bottom-up and relatively automatic attentional bias for uncertainty might prove to be a beneficial addition to attention bias modification programs for generalized anxiety symptoms. Conversely, if impaired disengagement, rather than facilitated engagement, is found to be the attentional component that underlies ABU, it would suggest that ABU reflects a deficit in more effortful attentional control strategies. The clinical implications of such a finding may suggest that treatments for generalized anxiety symptoms could target the effortful control of attention allocation, thereby training individuals to disengage from potentially threatening stimuli and cues for uncertainty.

Preliminary Evidence of ABU and its Limitations

As previously noted, only one known study has investigated whether ABU is associated with higher IU. Fergus et al. (2013) used a stimulus-response visual search task to investigate the association between IU and ABU. One hundred and four undergraduate students were presented with an array of four strings of letters (one of which differed from the others in some way) on a computer screen. Participants were instructed to identify which letter string was unlike the others and then to indicate whether this "oddball" letter string was an English word. The English words were categorized as uncertainty-related (e.g., "vague") or neutral (e.g., "table"). Fergus et al. investigated both facilitated engagement with uncertainty (operationalized as faster responding to uncertainty-related words relative to neutral words within a matrix of non-word distractors) and impaired disengagement with uncertainty (operationalized as slower responding to non-words within a matrix of uncertainty-related word distractors relative to non-words within a matrix of neutral word distractors). The authors found evidence of facilitated engagement but not impaired disengagement. That is, participants with relatively higher levels of IU demonstrated faster responding to uncertainty-related words compared to neutral words. Furthermore, after controlling for anxiety, depression, and general distress, inhibitory IU (i.e., a subcomponent of IU characterized by behavioral inhibition in the presence of uncertainty) continued to significantly predict greater facilitated engagement with uncertainty-related words.

Though Fergus et al. (2013) provided a critical first step in understanding ABU, their study's limitations are worth considering. The most notable limitation is the use of a stimulus-response paradigm to investigate ABU. Though a number of investigations using stimulus-response paradigms have found associations between attentional biases for threat and psychological distress (e.g., anxiety and depression), there is a considerable amount of evidence to the contrary (see van Bockstaele e& Verschuere, 2014). These inconsistencies may be the result of using task response times to calculate attentional bias as a static signal (i.e., bias at a constant rate over time). According to Zvielli, Bernstein, and Koster (2014), standard methods for calculating attentional bias fail to account for the temporal dynamics of attentional biases. Moreover, use of response times in this manner may account for the notoriously poor reliability of these scores. For example, Schmuckle (2005) investigated the reliability of three different versions of one of the most commonly used stimulus-response paradigms, the dot-probe task, in three studies. Threatening words served as target stimuli in two studies, and threatening pictures were used in the third study. Results indicated that none of the versions of this widely used stimulus-response task demonstrated acceptable internal consistency or test-retest reliability, calling into question the validity of using such procedures to assess attentional biases within the emotional disorders. Additionally, given the poor psychometric properties of these tasks, it should come as no surprise that inconsistencies in replication are common, and further, when study findings are significant, effect sizes tend to be small to medium (see Bar-Haim et al., 2007). More ecologically valid and telling measures of attentional biases must model the data in such a way as to capture the dynamic processes of visual attention.

While the use of a stimulus-response paradigm is a significant limitation of Fergus et al.'s (2013) study of ABU, methods of remedying this issue do exist. One such method is the use eye-tracking technology. Unlike traditional stimulus-response paradigms, eye-tracking technology provides a continuous recording of participants' attention over the course of the task, thus providing the ability to increase the task's reliability by accurately modeling the temporal dynamics of ABU (Armstrong & Olatunji, 2012). Therefore, eye-tracking technology provides a more reliable measure of attention allocation than the paradigm utilized by Fergus et al. Thus, the proposed study utilized eye-tracking technology to investigate ABU and elucidate the attentional components that underlie it. Furthermore, beyond replication of Fergus et al.'s initial investigation, the current study sought to determine whether ABU can help to explain a significant proportion of the variance in the IU-generalized anxiety symptom relationship.

Hypotheses

Hypothesis 1. Higher IU would be associated with greater attentional bias for uncertainty-related information. Given the results of Fergus et al. (2013), it was hypothesized that ABU would present as facilitated engagement with such uncertainty-related stimuli rather than as impaired disengagement.

Hypothesis 2. An indirect effect of ABU would be found in the relationship between IU and generalized anxiety symptoms, such that ABU would account for significant variance in the IU-generalized anxiety relationship.

Method

Participants

One hundred and seventy-four undergraduate students were recruited through the Department of Psychology's research participation webpage, on which students may sign up to participate in research for course credit. Eligible participants were required to be between the ages of 18 and 64 years. Students with an uncorrected visual impairment were excluded from participation, thereby avoiding confounds associated with the visual search task. To avoid potential confounds related to study stimuli (i.e., English words), participants for whom English was a second language (n = 10) were excluded from later analyses. Within this sample of 164 students, 20 participants were excluded from subsequent analyses due to (a) 100% missing eye-tracking or questionnaire data (n = 9), (b) being noted by research assistants for marked deviations from standard study protocol (e.g., displaying apparent and objective inattentiveness, computer errors that interrupted task completion; n = 15), or (c) having less than 75% valid eye-tracking data (n = 16), a threshold consistent with that used in other eye-tracking procedures (e.g., Bardeen & Daniel, 2017; Graham, Hoover, Ceballow, & Komogortsev, 2011; Macatee, Albanese, Schmidt, & Cougle, 2017).

The final sample was comprised of 144 participants. Participants' average age was 19.58 years (*SD* = 2.47; *range* = 18 – 39). The sample was predominantly female (n = 118; 81.9%), and cisgender (n = 142; 98.6%), with one participant identifying as transgender and one participant self-identifying as "agender." In terms of race, 87.5% of the sample identified as White, 9.0% as Black, 1.4% as Asian, 0.7% as American Indian, and 1.4% described their race in their own terms (e.g., "biracial," "Asian and White"). Moreover, 96.5% of the sample identified as Non-Hispanic. The average percentage of valid eye-tracking data in the final sample was 92.96% (*SD* = 5.71%).

Participants were asked to report whether they were prescribed or had taken any stimulant medications that might artificially influence the results of the visual search task (e.g., Adderall, Ritalin). Participants also reported whether they had consumed other stimulant substances (i.e., caffeine and/or nicotine) on the day of testing. Seven participants (4.9%) reported having a prescription for stimulant medication, and four participants (2.8%) reported having taken their stimulant medication on the day of testing. Further, 57 participants (39.6%) reported having consumed other stimulant substances (i.e., caffeine and/or nicotine) on the day of testing. All demographic variables and participants' use of stimulants were examined as potential covariates.

Measures

Intolerance of Uncertainty Scale, Short Form. The Intolerance of Uncertainty Scale, Short Form (IUS-12; Carleton et al., 2007) is a 12-item self-report instrument that measures cognitive and emotional reactions to uncertainty (e.g. "Unforeseen events upset me greatly") as well as behavioral responses to uncertainty (e.g. "I must get away from all uncertain situations"). Items are scored on a 5-point Likert scale ranging from 1 (*not at all characteristic of me*) to 5 (*entirely characteristic of me*). Total scores range from 12 to 60, with higher scores indicating higher intolerance of uncertainty. The IUS-12 has demonstrated strong correlations with the original 27-item IUS, *r*s ranging from .94 (Khawaja & Yu, 2010) to .96 (Carleton et al., 2007), and has also demonstrated good to excellent internal consistency, αs ranging from .83 to .93 (Hale et al., 2016), and adequate test-retest reliability in a non-clinical sample over a two-week period, $r = .77$ (Khawaja & Yu, 2010). Furthermore, the IUS-12 has demonstrated convergent validity with measures related to anxiety, worry, and generalized anxiety symptoms (i.e., the Beck Anxiety Inventory [Beck, Epstein, Brown, & Steer, 1988], Penn State Worry Questionnaire [PSWQ; Meyer, Miller, Metzger, & Borkovec, 1990], and Generalized Anxiety Disorder Questionnaire [Newman et al., 2002]; *r*s = .57, .54, and .61 respectively) in a large, racially diverse undergraduate sample (Carleton et al., 2007). Similarly, the IUS-12 has been shown to predict trait anxiety in clinical and non-clinical samples (Khawaja & Yu, 2010). Internal consistency of the IUS-12 total score was excellent within the final sample, $\alpha = .93$.

Generalized Anxiety Disorder Scale – 7. The Generalized Anxiety Disorder Scale (GAD-7; Spitzer, Kroenke, Williams, & Löwe, 2006) is a 7-item self-report screening measure of GAD symptoms that aims to identify likely cases of GAD and measure symptom severity. Each item within the GAD-7 describes a symptom of GAD (e.g., "Not being able to stop or control worrying," "Trouble relaxing"). The GAD-7 instructs participants to estimate how often, during the last two weeks, they have been bothered by each symptom. Response estimates are scored as 0 (*not at all*), 1 (*several days*), 2 (*more than half the days*), and 3 (*nearly every day*). Total scores range from 0 to 21, with higher scores indicating a greater frequency of symptom expression. The GAD-7 has demonstrated adequate to excellent internal consistency, αs ranging from .79 (Dear et al., 2011) to .92, and good test-retest reliability, $r = .83$ (Spitzer et al., 2006). Furthermore, the GAD-7 has evidenced strong convergent validity with other measures of anxiety, *r*s ranging from .72 (the Beck Anxiety Inventory; Beck et al., 1988) to .74 (the anxiety subscale of the Hopkins Symptoms Checklist; Derogatis, Lipman, Rickels, Uhlenhuth, & Covi, 1974; Spitzer et al., 2006), and a strong correlation with worry, r = .64 (PSWQ; Kertz, Bigda-Peyton, & Björgvinsson, 2013). Moreover, providing further evidence of its construct validity, the GAD-7 has demonstrated moderate, negative correlations with a measure of life satisfaction (Questionnaire on Life Satisfaction; Henrich & Herschbach, 2000), r = -.34 (Löwe et al., 2008) and with a measure of well-being (Schwartz Outcome Scale; Blais, Kehl-Fie, & Blias, 2008), r = -.53 (Kertz et al., 2013). The GAD-7 demonstrated excellent internal consistency within the final sample, α = .92.

Visual Search Task

The visual search task (VST) used in the current study was based on the methods of Pineles et al. (Pineles, Shipherd, Mostoufi, Abromovitz, & Yovel, 2009; Pineles, Shipherd, Welch, & Yovel, 2007) and consisted of two components representing (1) facilitated engagement and (2) impaired disengagement with uncertainty-related stimuli. Stimuli included three types of English words (uncertainty-related, neutral household-related, and uncategorized neutral words) as well as non-words (unpronounceable strings of letters with no semantic meaning).

The facilitated engagement component included two categories of experimental trials, in which either (1) an uncertainty-related word (e.g. "vague") or (2) a neutral household-related word (e.g., "table") served as the target stimulus within an array of three identical non-word distractors (e.g., "iqngq"). To ensure that participants would not lose interest in the task due to an expectation that all targets would be English words (and thus, to encourage participant engagement), a third trial category was included, in which a non-word target was placed in an array of non-word stimuli. However, data collected during this third trial category were not included in analyses.

Two indices of facilitated engagement were computed. Specifically, the first index of facilitated engagement with uncertainty (FE-1) was calculated as the difference between the proportion of first fixations (i.e., gaze durations lasting at least 100ms; Quigley, Nelson, Carriere, Smilek, & Purdon, 2012) on uncertainty-related words and the proportion of first fixations on neutral household words. Higher scores indicated that participants more often fixated on uncertainty stimuli first among other stimuli. The second index of facilitated engagement (FE-2) was calculated as the difference between the latency until first fixation on neutral household-related stimuli and the latency until first fixation on uncertainty stimuli. Higher scores indicated that participants made their first fixation on uncertainty stimuli more quickly than they made their first fixation on neutral household-related stimuli. The use of these two indicators aimed to address the questions of (a) whether uncertainty-related stimuli are fixated on first among those with higher IU compared to those lower in IU and (b) whether uncertainty stimuli are attended to more quickly than neutral stimuli among those with higher IU.

The impaired disengagement component also included two categories of experimental trials, in which a non-word served as the target within an array of either (1) three identical uncertainty-related words or (2) three identical neutral household words. Similar to the facilitated engagement component, a third trial category was included in the impaired disengagement component to encourage participant engagement. Specifically, an uncategorized neutral word (e.g., “rattle”) served as the target within an array of three identical distracters (i.e., neutral household words) for these trials. Data from these trials were not included in analyses.

Two indices of impaired disengagement were computed. The first index of impaired disengagement (ID-1) was the difference between the proportion of subsequent fixations (i.e., non-initial fixations lasting at least 100ms) on uncertainty-related distractors and the proportion of subsequent fixations on neutral household-related distractors. Higher scores indicated that participants made more secondary fixations on uncertainty distractors than on neutral distractors. The second index of impaired disengagement (ID-2) was the difference between the proportion of total trial time spent on uncertainty distractors and the proportion of total trial time spent on neutral household-related distractors. Higher scores indicated that participants spent more trial time gazing at uncertainty stimuli than neutral stimuli. These two operationalizations of impaired disengagement aimed to address the questions of (a) whether the frequency of fixations on uncertainty stimuli is greater than the frequency of fixations on neutral stimuli among those higher in IU and (b) whether those high in IU fixate on uncertainty stimuli longer than neutral stimuli.

For both VST components, participants were instructed to locate the stimulus that differed from the others within the same array; that is, participants were to find the "oddball" target within an array of distractors. Participants were also to decide if the oddball target was an English word by pressing the "/" key for English words the "z" key for non-words. Unlike in traditional stimulus-response paradigms, participant response (i.e., correct or incorrect) was not used as a variable in eye-tracking analyses; rather, asking participants to make a decision about the target word was meant to encourage participant engagement with the task. In order to make the most efficient use of time within the VST, task trials ended and progressed to the next trial after participants responded either "/" or "z."

The VST began with 10 practice trials, each followed by visual feedback ("Correct" or "Incorrect"). Each trial began with a fixation cross ("+"), presented in the center of the screen for 700ms, after which an array of four stimuli appeared. All four stimuli were spaced equally apart and were arranged in a 2x2 matrix centered on the computer screen. Stimuli remained on the screen until participants responded ("/" or "z"), after which a blank screen was presented prior to beginning the next trial. The duration of inter-trial delays varied randomly between 750ms and 1250ms. The VST comprised four blocks (two blocks per component), and each block included 30 trials (10 from each category of stimuli). Trial presentation was randomized within blocks, and a 15-second delay separated one block from another, during which participants were instructed to "remain seated and use this time to take a break." For more details about the methodology of the original VST, refer to Pineles et al. (2009). An illustration of the three trial categories within both components of the VST and of the sequence of events within trials is presented in the Appendix (Figure 1; modified from Pineles et al., 2009).

As previously stated, the VST used three types of English words: uncertainty-related words, neutral household-related words, and uncategorized neutral words. The list of uncertainty-related and household-related words, developed by Dugas et al. (2005) and used by Fergus et al. (2013) is displayed in Table 1. All uncertainty-related words were selected according to their neutral valence, their being relatively easy to understand, and the extent to which they conveyed uncertainty, previously assessed by Dugas et al. Household-related words were used to ensure that any observed effects did not result from an effect of categorized words. Uncertainty-related and household-related words were previously matched on frequency of usage and length (Fergus et al., 2013).

Procedure

Trained research assistants discussed study procedures and addressed participants' questions and concerns, after which all participants provided verbal informed consent. Participants then provided demographic data (e.g., biological sex, gender identity, age) and completed the VST in accordance with the methods described above. Eye movements were recorded using a Tobii X2-60 Eye-Tracker and Tobii Studios eye-tracking software. To calibrate the eye-tracker, participants were required to follow a dot with their eyes as the dot moved to nine locations on a computer screen. After completing the VST, participants completed self-report measures. Participants were then debriefed on the purpose of the study and provided with a list of mental health service providers in the area. The average time to complete the study was 1.56 hours (*SD* = 0.34).

Analytic Strategy

Preliminary Analyses. All variables of interest (IUS-12, GAD-7, and the four ABU indices) were examined for deviations from normality (skewness and kurtosis between -2 and 2; Gravetter & Wallnau, 2014) and univariate outliers (values ≥ 3 *SD*s +/- mean). Multivariate outliers were explored by calculating the Mahalanobis distance of each case based on our multivariate analyses (critical $\chi^2[6] \geq 22.46$, $p < .001$). Demographic variables (e.g., sex, age) were examined as potential covariates. Due to the relative racial and ethnic homogeneity within the sample, race and ethnicity were collapsed into a dichotomous race/ethnicity variable (i.e., White non-Hispanic [n = 122, 84.7%], Non-White/Hispanic [n = 22, 15.3%]). As all but two participants in the final sample identified as cis-gender, gender identity was not included in covariate analyses. Bivariate correlations were computed to investigate whether variables of interest were significantly associated with seven demographic variables (i.e., sex, age, dichotomized race/ethnicity, stimulant prescription, prescription use, and other stimulant use; Kosinski, 2006) and one study-related variables (i.e., starting condition of the VST; Kosinski, 2006; Pineles et al., 2009).

Primary Analyses. In order to test Hypothesis 1 (that higher IU would be associated with greater attentional bias for uncertainty-related information, specifically facilitated engagement with uncertainty-related stimuli), partial correlations were computed between the IUS-12 and all four ABU indices. Relevant demographic and study-related variables were entered as covariates into correlational analyses. In order to test Hypothesis 2 (that ABU would contribute a significant indirect effect to the IU-generalized anxiety symptom relationship) an indirect-effects analysis was conducted per the methodology of Preacher and Hayes (2004) using the PROCESS macro (Hayes, 2012) in SPSS (Version 22). Specifically, path *a* represented the regression of each ABU index onto the IUS-12 individually; path *b* represented the regression of the GAD-7 onto each ABU index and the IUS-12, individually; path *c* represented the regression of the GAD-7 onto the IUS-12. A more parsimonious analytical model would omit path *c* and assume that the relationship between IU and generalized anxiety symptoms can be fully accounted for by ABU. However, the lack of previous research into ABU and its potential contribution to the IU-generalized anxiety relationship precludes an assumption of full ABU mediation. Therefore, a more conservative hypothesis of partial mediation was made (i.e., that ABU would partially account for the variability in path *c*). As in the analyses of Hypothesis 1, relevant demographic and study-related variables were entered as covariates.

Sample size and power analysis. In order to achieve an 80% probability of identifying effects within the proposed study when alpha is set to .05, a minimum sample of 126 participants is required to detect the small-to-medium correlation between IU and ABU found in Fergus et al.'s (2013) study. Regarding indirect effect analyses, the coefficient of path *a* was estimated as small-to-medium in size(per Fergus et al.'s findings). As no known investigation has examined the relationship between ABU and generalized anxiety symptoms, convention suggests that the coefficient of path *b* be estimated as medium in size. In a thorough discussion of the six most commonly used and most highly recommended methods for testing indirect effects, Fritz and

MacKinnon (2007) calculated the sample sizes required to achieve a power of .80 across all six indirect effect analyses for different combinations of coefficient sizes. In order to obtain a power of .80 and to detect a small-to-medium effect within path *a* and a medium effect within path *b,* Fritz and MacKinnon recommend collecting data from at least 115 participants. Furthermore, in their exploration of the six most commonly used indirect effect analyses, Fritz and MacKinnon found the bias-corrected bootstrapped sampling distribution to be the most powerful method, capable of detecting effects of varying sizes with smaller samples than that of other indirect effect detection analyses. Therefore, in order to maximize the likelihood of detecting an indirect effect of ABU within the IU-generalized anxiety symptom relationship, the proposed investigation utilized a bias-corrected bootstrapped sampling distribution (drawing 5000 samples) of the indirect effects of ABU indices and collected data from the final sample of 144 participants, a sample size greater than that recommended for all analyses described previously.

Results

Preliminary Analyses

No violations in normality were observed in any of the six variables of interest (skewness *range* = -0.32, 1.05; kurtosis *range* = -0.24, 0.78). One univariate outlier was found in ID-1 (z score = 3.27), and one near-outlier was found in ID-2 (z score = 2.99). Inspection of both cases revealed no reason to suspect that these two participants did not belong to the population from which the larger sample was drawn. Nonetheless, primary analyses (described below) were performed with and without these two cases to ensure that they did not unduly influence results. No multivariate outliers were found (maximum Mahalanobis distance = 21.39). Exploration of bivariate correlations between variables of interest and demographic and study-related variables revealed that participant sex was significantly correlated with ID-2, $r = .20$, $p = .01$. That is, males spent more time than females attending to uncertainty-related distractors (compared to household-related distractors) during disengagement trials. Thus, participant sex was controlled for in subsequent analyses.

Primary Analyses

Hypotheses 1. Means, standard deviations, and partial correlations between variables of interest are displayed in Table 2. The first hypothesis, that higher IU would be associated with greater facilitated engagement with uncertainty-related information, was not supported; no significant relationship emerged between the IUS-12 and any index of ABU. Partial correlations (controlling for participant sex) revealed a significant relationship between the IUS-12 and GAD-7 (r = .61), between the two indices of facilitated engagement (r = .40), and the two indices of impaired disengagement (r = .36), ps < .001. A significant correlation was found between the GAD-7 and ID-2, r = .16, p = .05. Removal of the two univariate outliers (described above) increased the magnitude of this correlation to r = .18 and rendered it significant at p = .04. The direction of this relationship suggests that participants high in generalized anxiety symptoms had greater difficulty disengaging attention from uncertainty-related distractors to identify the "oddball" letter string (i.e., impaired disengagement). No other meaningful changes were observed after excluding univariate outliers.

Hypothesis 2. The second hypothesis, that ABU would account for a significant proportion of variance in the IU-generalized anxiety relationship (i.e., an indirect effect), was not supported. Specifically, results examining FE-1 as a mediator were as follows: the effects of IUS-12 on FE-1 (path *a; b* = -0.001, p = .16), and FE-1 on the GAD-7 (path *b; b* = -0.90, p = .79) were not significant. The total effect of IUS-12 on GAD-7 (path *c*; *b* = 0.30, p < .001) was significant and remained after accounting for the indirect effect of FE-1. The indirect effect of

FE-1 was not significant (*b* = 0.001, 95% CI = -0.006, 0.014). Results examining FE-2 as a mediator were as follows: the effects of IUS-12 on FE-2 (path *a; b* = -1.50, *p* = .11), and FE-2 on the GAD-7 (path *b; b* = 0.001, *p* = .84) were not significant. The total effect of IUS-12 on GAD-7 (path *c*; *b* = 0.31, $p < .001$) was significant and remained after accounting for the indirect effect of FE-2. The indirect effect of FE-2 was not significant (*b* = -0.001, 95% CI = -0.017, 0.008). Results examining ID-1 as a mediator were as follows: the effects of IUS-12 on ID-1 (path *a; b* = -0.0001, *p* = .80), and ID-1 on the GAD-7 (path *b; b* = 0.43, *p* = .94) were not significant. The total effect of IUS-12 on GAD-7 (path *c*; *b* = 0.30, $p < .001$) was significant and remained after accounting for the indirect effect of ID-1. The indirect effect of ID-1 was not significant (*b* = -0.0001, 95% CI = -0.007, 0.007). Results examining ID-2 as a mediator were as follows: the effects of IUS-12 on ID-2 (path *a; b* = 0.001, *p* = .31), and ID-2 on the GAD-7 (path *b; b* = 7.39, *p* = .12) were not significant. The total effect of IUS-12 on GAD-7 (path *c*; *b* = 0.30, $p < .001$) was significant and remained after accounting for the indirect effect of ID-2. The indirect effect of ID-2 was not significant (*b* = 0.005, 95% CI = -0.003, 0.022).

Indirect effects of ABU indices in the IU-generalized anxiety relationship were reexamined without the two univariate outliers noted previously. No meaningful changes were found after the exclusion of outliers. All path *a* coefficients (i.e., the effect of IUS-12 on ABU indices) were non-significant. All path *b* coefficients (i.e., the effect of ABU indices on GAD-7) were non-significant. All path *c* coefficients (i.e., the effect of IUS-12 on GAD-7) were significant at *p* <. 001 and remained after accounting for the indirect effect of each ABU index. Finally, the indirect effect of each ABU index was non-significant when excluding outliers, and no meaningful changes in the magnitude of their effects were observed.

Exploratory Analyses

Recent evidence suggests that males and females may differ in the way in which they process threat information. For example, Tran, Lamplmayr, Pintzinger, and Pfabigan (2013) found that females who self-reported relatively higher levels of anxiety demonstrated an attentional bias toward *angry* faces when stimuli were presented for an extremely short duration (i.e., 50 milliseconds). In contrast, this early threat bias was not observed for males who reported higher levels of anxiety. Tan, Ma, Gao, Wu, and Fang (2011) found that high trait anxiety females, compared to high trait anxiety males, exhibited biased attention toward subliminally presented fearful faces (i.e., fearful faces rendered invisible via binocular occlusion). This bias was not observed during supraliminal presentation of stimuli. Further, high trait anxiety males, compared to high trait anxiety females, demonstrated a marginally significant (p = .059) bias for attending to fearful faces during supraliminal, but not subliminal, presentation. Similarly, in an event-related potential study, Sass et al. (2010) found that undergraduate females with high self-reported anxious arousal exhibited early visual processing (100ms) of threat-related words compared to high anxious arousal males. Taken together, these findings suggest that the time-course of attentional biases for threat may differ between sexes. Specifically, females may exhibit an earlier, more covert, attentional biases for threat information, while males may exhibit biased attention for threat at later, more overt stages of information processing. Therefore, exploratory analyses were conducted, in which correlations between variables of interest were examined with output split by sex (Table 3).

Results among females (n = 118) revealed significant negative correlations between FE-1 and IUS-12, r = -.20, p = .03, and between FE-1 and GAD-7, r = -.21, p = .02. Such associations suggest that females high in IU and generalized anxiety symptoms, compared to females low in

IU and generalized anxiety symptoms, made fewer initial fixations on uncertainty "oddballs" and more initial fixations on household "oddballs" when such words were embedded in a matrix of distractors. A marginally significant correlation emerged between FE-2 and IUS-12, $r = -.16$, $p = .08$, suggesting that females high in IU, compared to females low in IU, were slower to fixate on the uncertainty "oddball" and faster to fixate on the household "oddball" when such words were embedded among distractors. Taken together, findings specific to indices reflecting engagement within the female subsample suggested that females demonstrated *impaired* engagement with uncertainty-related words in comparison to neutral household-related words. That is, females demonstrated an attentional bias away from such stimuli in engagement trials. Regarding indices of disengagement, results revealed a significant positive correlation between ID-2 and GAD-7, $r = .21$, $p = .03$, suggesting that females with more severe GAD symptoms, compared to females with less severe GAD symptoms, spent a greater proportion of trial time attending to uncertainty distractors (i.e., greater difficulty disengaging attention from uncertainty to identify the "oddball" letter string) after such stimuli had captured attention.

Results among males ($n = 26$) revealed no statistically significant associations between ABU indices and IU or generalized anxiety symptoms. However, the magnitude and direction of the correlation between the IUS-12 and our first facilitated engagement variable in this small subsample are of note. Specifically, FE-1 and the IUS-12 shared a correlation of $r = .27$, $p = .19$. In contrast to the relationship between FE-1 and the IUS-12 among females, this positive correlation among males suggests that males with higher IU made more initial fixations on uncertainty "oddballs" than initial fixations on household "oddballs" when such stimuli were embedded in a matrix of distractors. Further, a marginally significant correlation emerged between FE-1 and the GAD-7, $r = .33$, $p = .10$, suggesting that males with more severe GAD symptoms, compared to males with less severe GAD symptoms, made more initial fixations on uncertainty “oddballs” than initial fixations on household “oddballs” when such stimuli were embedded in a matrix of distractors. Put differently, males appeared to demonstrate *facilitated* engagement with uncertainty-related stimuli in line with study hypotheses, but the small number of male participants was likely insufficient to render these correlations significant.

Discussion

IU has been shown to be an important individual difference factor across anxiety disorders and may be particularly important in the development and maintenance of GAD. Past research has found IU to relate to various information-processing biases (e.g., memory biases, expectancy biases), in which stimuli denoting uncertainty are preferentially processed. ABU, an attentional bias for uncertainty-related information, has been proposed as one such information-processing bias (Carleton, 2012), but it has yet to be thoroughly investigated within the existing literature. While one known study has considered ABU (Fergus et al., 2013), that investigation suffered from a notable methodological limitation common to many studies of attentional biases (i.e., poor reliability of stimulus-response paradigms). Furthermore, no known study has explored how ABU might account for the relationship between IU and generalized anxiety symptoms. Thus, the current study sought to give further consideration to ABU. Using eye-tracking technology (previously shown to be more reliable that stimulus-response paradigms; Armstrong, & Olatunji, 2012), the current study aimed (1) to corroborate the findings of Fergus et al. and overcome its principle methodological limitation, and (2) to determine whether ABU indirectly accounts for the relationship between IU and generalized anxiety symptoms. It was predicted that higher IU would be associated with greater facilitated engagement with (rather than impaired disengagement from) uncertainty stimuli and that such an attentional bias would account for a significant proportion of the relationship between IU and generalized anxiety symptoms.

Neither of these hypotheses were supported. Within the final sample of 144 undergraduate students, no significant relationship was found between IU and any of four indices of ABU (neither facilitated engagement nor impaired disengagement). Although not predicted specifically, a significant correlation was found between participants' generalized anxiety symptoms and impaired disengagement from uncertainty stimuli, suggesting that those with more severe generalized anxiety symptoms spend more time attending to uncertainty-related distractors relative to neutral distractors. No significant indirect effect of IU on generalized anxiety symptoms through ABU was found. These null results are surprising. As reviewed by Goodwin, Yiend, & Hirsch (2017), individuals with a clinical diagnosis of GAD and those with high levels of trait worry demonstrate a stronger attentional bias toward threat compared to healthy controls. Given that individuals high in IU find uncertainty itself threatening (Carleton, 2012), one would expect attentional biases toward stimuli that represent uncertainty to emerge among participants high in IU and generalized anxiety symptoms. Therefore, a more thorough investigation of variables that may plausibly influence the presentation of ABU (e.g., sex) is warranted.

Interpretation of Results

Evidence has accumulated that the time-course of attentional biases to threat may differ between males and females (Sass et al., 2010; Tan et al., 2011; Tran et al., 2013). Specifically, females may exhibit attentional biases for threat at earlier, more automatic stages of information processing, while males may demonstrate attentional biases for threat at later, more effortful stages. Therefore, exploratory analyses were conducted to investigate the possibility that results from the current sample differed as a function of participant sex. Within the female subsample, significant negative correlations that were small to medium in size emerged between the first index of facilitated engagement, IU, and generalized anxiety symptoms. Female participants high in IU and generalized anxiety symptoms, compared to females low in IU and generalized anxiety symptoms, were less likely to make an initial fixation on uncertainty-related targets compared to neutral targets when such words were embedded in a matrix of distractors. It was not expected that engagement with uncertainty would be inversely related to IU and generalized anxiety symptoms; however, consideration of covert attentional processes may shed light on these unexpected findings.

Recent research has endeavored to disentangle covert and overt attention and generally supports the idea that covert and overt attention are related but distinct processes (Amir, Zvielli, & Bernstein, 2016; Heyman, Montemayor, & Grisanzio, 2017; Hunt & Kingstone, 2003). That is, covertly attending to a stimulus in the environment often results in an eye movement (overt attention) being prepared and initiated toward that stimulus, but not always. While often coupled in time, covert and overt attention can be decoupled by a number of factors, such as greater distance between task stimuli (Heyman et al., 2017) and effortful inhibition of overt attention (Amir et al., 2016). Given current findings in the female subsample, one possible explanation may include covert identification of uncertainty-related stimuli and subsequent, overt avoidance of such stimuli. Put differently, females high in IU and generalized anxiety symptoms in the current study may have covertly detected uncertainty-related (and purportedly threatening) words at early stages of information processing (i.e., prior to the initiation of eye movements) and then overtly avoided making initial fixations on such words at later stages of information processing (i.e., after eye movements had been prepared and inhibited). Such an inference seems plausible given the unexpected direction of ABU (i.e., impaired or avoidant engagement with uncertainty) in the current female subsample and given the evidence to date that females exhibit attentional biases for threat information in earlier stages of information processing compared to males.

Findings within the current male subsample also seem in line with this possible explanation. While the male subsample was likely too small and underpowered to detect significant relationships between variables of interest, medium-sized positive correlations were observed between IU, generalized anxiety symptoms, and the first index of facilitated engagement. Specifically, males high in IU and generalized anxiety symptoms, compared to males low in IU and generalized anxiety symptoms, made more initial fixations on uncertainty targets relative to neutral targets embedded in a matrix of distractors, a pattern of results in direct opposition to findings in the female subsample. That is, males exhibited facilitated overt engagement with uncertainty stimuli in line with study hypotheses. Differences in the time-course of attentional biases between females and males again help to make sense of these findings. Given evidence that males display attentional biases to threat at later stages of information processing relative to females, it seems reasonable to infer that the current male subsample lacked the early, covert detection of uncertainty-related words presumed to be at play in the female subsample and overtly attended to such words as predicted.

While firm conclusions cannot be made on this matter without replication and expansion of this study protocol (see below), a number of implications may be drawn from current findings, particularly within the realm of clinical practice. IU has emerged as an important mechanism of change in psychotherapy in recent years (e.g., Keefer et al., 2017; McEvoy & Mahoney, 2012; Oglesby, Allan, & Schmidt, 2017; McEvoy & Erceg-Hurn, 2016; Stevens, Rogers, Campbell, Björgvinsson, & Kertz, 2018; Torbit, & Laposa, 2016), and researchers and clinicians continue to develop effective treatment protocols that explicitly target IU and novel paradigms to modify attentional biases (i.e., attention bias modification; Hakamata et al., 2010; Heeren, Mogoasa, Philippot, & McNally, 2015; Lowther & Newman, 2014; Woud, Verwoerd, & Krans, 2017). One avenue for future research and clinical intervention might include targeting how individuals high in IU and anxiety deploy attentional resources to process cues that denote uncertainty. Attention bias modification paradigms are amenable to the inclusion of a variety of stimuli (e.g., pictures, faces, words; threatening, dysphoric, uncertainty-related) and may be well suited to the task of shaping more adaptive processing of cues that denote uncertainty. Given current findings, it may be that individuals high in and IU and generalized anxiety symptoms would benefit from attention bias modification training. More specifically, females may benefit from training designed to foster approach, rather than avoidance, of uncertainty-related cues, while males may benefit from training designed to foster disengagement from, or less perseverative sustained attention on uncertainty-related cues. Generally, current findings suggest that clinical intervention for individuals high in IU and generalized anxiety symptoms may be augmented and enhanced by behavior training aimed at modifying attentional processes in contexts characterized by uncertainty.

Limitations and Future Directions

Current findings must be viewed in light of various limitations. First among them is the use of a convenience sample of undergraduate students, which cannot be considered representative of the larger population. Specifically, the racial and ethnic composition of the current sample was overwhelmingly White and non-Hispanic, and the female-to-male ratio was approximately 4:1. Thus, we cannot be certain of the generalizability of current findings to the larger population. Future research would do well to recruit community samples with greater representation of other racial and ethnic groups and with a more balanced gender ratio. Doing so would enable replication of our results and would allow for a more powerful analysis of ABU between sexes.

Low levels of symptomatology within the current sample also may have limited our ability to detect meaningful effects. The average GAD-7 score in the current sample was 6.12 (*SD* = 5.32), considerably less than the average GAD-7 score of patients with a clinical diagnosis of GAD (*means* = 11.45 – 14.40; Löwe et al., 2008; Mahoney et al., 2016; Spitzer et al., 2006). Moreover, 75.7% of the current sample reported symptoms below the recommended cutoff for identifying likely cases of GAD (i.e., GAD-7 scores ≥ 10; Spitzer et al., 2006). Some have questioned this benchmark due to concerns of poor sensitivity and have recommend a more lenient cutoff (GAD-7 scores ≥ 8; Kertz et al., 2013). Even with this more relaxed criterion, the majority of participants (67.4%) would not likely meet criteria for a diagnosis of GAD. Therefore, it is important to replicate current study procedures in both the general population and clinical samples with more individuals scoring at the high end of the continuum of anxiety and related symptoms (e.g. worry).

GAD is characterized by uncontrollable worry, and worry is a predominantly verbal process (Borkovec & Inz, 1990). Evidence has accumulated that attentional biases toward threat emerge among participants with GAD and among high trait worriers when using words rather than non-word pictures as experimental stimuli (Oathes, Siegle, & Ray, 2011) and when instructing high trait worriers to worry verbally rather than to worry in mental images and scenarios (Williams, Mathews, & Hirsch, 2014). In the most current systematic review of attentional biases in patients with GAD and high-trait worriers, Goodwin et al. (2017) found that attentional bias findings varied by stimulus type. No study using pictures as experimental stimuli within that review found evidence of an attentional bias to threat among participants with GAD/high-trait worriers compared to healthy controls. Further, only four of seven studies using facial stimuli within that review found group differences in attentional bias between patients with GAD/high-trait worriers and healthy controls. In contrast, 21 out of 24 studies using words as experimental stimuli (across several experimental paradigms) within Goodwin et al.'s review found participants with GAD/high-trait worriers to demonstrate a significant attentional bias to threat compared to healthy controls.

Such findings may help to assuage any concerns about the validity of this study's principle behavioral task. However, given the importance of worry in GAD, the primary outcome measure used in this study (i.e., the GAD-7) may have limited our ability to detect meaningful effects. As previously described, the GAD-7 has been validated and widely used as a screening measure for GAD, but only two of its seven items assess the pervasiveness ("Worrying too much about different things") and uncontrollability ("Not being able to stop or control worrying") of worry seen in GAD. The remaining five items of the GAD-7 reflect the somatic ("Being so restless that it's hard to sit still") and affective ("Becoming easily annoyed or irritable") components of generalized anxiety. It is possible that these components of GAD, although certainly important within the clinical picture, are not as robustly related to attentional biases as persistent and uncontrollable worry. Using a measure specific to worry, such as the PSWQ (Meyer et al., 1990), might have yielded a stronger pattern of results. In fact, recent evidence suggests that attentional biases to threat predict daily worry in the context of real-world stressors. Macatee et al. (2017) employed a prospective study design, in which participants' attentional biases to positive, threatening, and dysphoric stimuli were assessed via eye tracking, and participants then reported on daily levels of worry and the occurrence of daily stressors over the following two weeks. Results indicated that sustained attention to threatening and dysphoric stimuli during the in-lab attentional bias assessment predicted greater levels of daily worry on days characterized by more stressors. It may be that difficulty disengaging attention from threatening information (and presumably from uncertainty-related information as well) is associated with difficulty disengaging from worry.

Such results suggest that attentional biases in GAD, perhaps including ABU, may share a unique relationship with GAD's central feature – pervasive worry. However, Macatee et al.'s (2017) findings suggest more. Attentional biases within that study were assessed within two contexts, first at baseline and again after an anxious mood/stress induction. Only sustained attention on threatening stimuli following the stress induction predicted daily worry within the context of real-world stressors. That is, Macatee et al. found mood-congruent attentional biases to be more important in the prediction of worry than attentional biases measured as a static, trait-like disposition. Mood-congruent and/or context-dependent attentional biases have been replicated by others (Nelson, Purdon, Quigley, Carriere, & Smilek, 2015; Quigley et al., 2012). In a free-viewing eye-tracking study, Quigley et al. (2012) found evidence for attentional bias toward threat, but not positive stimuli, following an anxious mood induction, but not at baseline. Moreover, higher state anxiety was related to greater attention to threat stimuli, while no association was found between attention to threat and trait anxiety. Nelson et al. (2015) replicated these results and found that, while all participants preferentially attended to threat stimuli relative to neutral stimuli, trait anxiety shared no relationship with attentional biases to threat. Rather, state anxiety alone following an anxiety induction task was associated with greater sustained attention on threat stimuli. Given the growing interest in state-dependent attentional biases, future research into ABU would do well to consider state levels of anxiety and stress. One would hypothesize that replication of the current study protocol with an experimental manipulation of participants' affective state would yield more robust relationships between ABU, IU, and generalized anxiety symptoms in the experimental (anxiety/stress-induced) group compared to a control group.

Given that self-report measures of individual differences (e.g., distress tolerance) do not always exhibit significant correlations with behavioral tasks purported to assess the same constructs (e.g., Ameral, Palm Reed, Cameron, & Armstrong, 2014), it would be premature to dismiss the small but significant correlations found between our self-report measures of IU and generalized anxiety and eye-tracking indices of ABU. Nonetheless, an additional limitation of the current study and an avenue for continued investigation is the inclusion of a behavioral measure of IU. For example, the Beads Task (Jacoby, Abramowitz, Buck, & Fabricant, 2014; Sternheim, Startup, & Schmidt, 2011) is purported to provide a quantitative index of individual behavior within contexts of varying levels of uncertainty. Inclusion of such a task may reveal more robust (or perhaps more surprising and unexpected) associations between ABU and IU. Relatedly, as was seen in this study, the IUS-12 and GAD-7 are strongly correlated, and some proportion of this relationship is likely due to shared method variance. The use of two self-report measures to assess our independent and dependent variables may have limited our ability to detect meaningful indirect effects through ABU. In addition to an inclusion of a behavioral IU task, inclusion of some other assessment of generalized anxiety symptoms (e.g., diagnostic interview and clinical severity ratings, having participants generate a list of worrisome topics) may be beneficial in extending current findings.

Lastly, given evidence of gender differences in attentional biases to date, future research into ABU may benefit from a more thorough investigation of the timing of such biases between males and females. For example, modifications to other behavioral tasks assessing attentional biases (e.g. the traditional dot-probe task) have included presentations of task stimuli at different durations (e.g., 50ms, 250ms, 750ms, 1000ms). Such a task would allow for a direct exploration of the time-course of attentional deployment between females and males, and one might hypothesize that females, in comparison to males, would demonstrate attentional biases at shorter stimulus durations.

Conclusions

This is only the second known study to consider ABU, a theoretically plausible information-processing bias with potential clinical import. Further, this is the first known study to explore ABU via eye-tracking technology and to extend this work within the context of generalized anxiety symptoms. Current findings suggest that ABU, specifically impaired/avoidant engagement with uncertainty-related stimuli, and impaired disengaging from uncertainty-related stimuli, are related to more severe generalized anxiety symptoms. Further, there may be important differences in the presentation of ABU between females and males, such that females, relative to males, may exhibit early, covert detection of uncertainty and later, overt avoidance of uncertainty stimuli. In contrast, males may exhibit overt engagement with cues that denote uncertainty.

Given the relative novelty of ABU as a construct of interest, the state of the literature is ripe with opportunities for continued research. Several remaining gaps within our understanding of ABU and the IU-generalized anxiety relationship have been highlighted in the course of this discussion. It is hoped that current findings will spur further investigation of this construct and will prove useful in the generation of new research questions and means of inquiry.

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Appendix

Table 1
VST Stimuli

Uncertainty-related words	Household-related words
Chance	Window
Maybe	Table
Perhaps	Picture
Random	Kettle
Unclear	Utensil
Uncertain	Appliance
Unforeseen	Dishwasher
Unknown	Cabinet
Unsure	Mantel
Vague	Clock

Note. Words matched for length and frequency of use

Table 2
Means, Standard Deviations, and Partial Correlations between Variables of Interest

	IUS-12	GAD-7	FE-1	FE-2	ID-1	ID-2	*Mean*	*SD*
IUS-12	---						30.42	10.68
GAD-7	.61***	---					6.12	5.32
FE-1	-.13	-.09	---				0.03	0.10
FE-2	-.14	-.07	.40***	---			31.12	117.99
ID-1	-.01	.00	-.01	.05	---		-0.01	0.06
ID-2	.10	.16*	.01	.10	.36***	---	-0.01	0.08

Note. IUS-12 – Intolerance of Uncertainty Scale-12 total score; GAD-7 – Generalized Anxiety Disorder Scale-7 total score; FE-1 – first index of facilitated engagement; FE-2 – second index of facilitated engagement; ID-1 – first index of impaired disengagement; ID-2 – second index of impaired disengagement; participant sex entered as a covariate; SD – standard deviation
*** $p < .001$; ** $p < .01$; * $p < .05$

Table 3
Correlations between Variables of Interest by Sex

		IUS-12	GAD-7	FE-1	FE-2	ID-1	ID-2
Females	IUS-12	-					
n = 118	GAD-7	.63***	-				
	FE-1	-.20*	-.21*	-			
	FE-2	-.16^	-.09	.41***	-		
	ID-1	-.04	-.03	.01	.06	-	
	ID-2	.11	.21*	.01	.03	.37***	-
Males	IUS-12	-					
n = 26	GAD-7	.55**	-				
	FE-1	.27	.33^	-			
	FE-2	-.04	-.02	.37^	-		
	ID-1	.10	.08	-.17	.02	-	
	ID-2	-.03	-.01	-.04	.35^	.33^	-

Note. IUS-12 – Intolerance of Uncertainty Scale-12 total score; GAD-7 – Generalized Anxiety Disorder Scale-7 total score; FE-1 – first index of facilitated engagement; FE-2 – second index of facilitated engagement; ID-1 – first index of impaired disengagement; ID-2 – second index of impaired disengagement; *** $p < .001$; ** $p < .01$; * $p < .05$; ^ $p \leq .10$

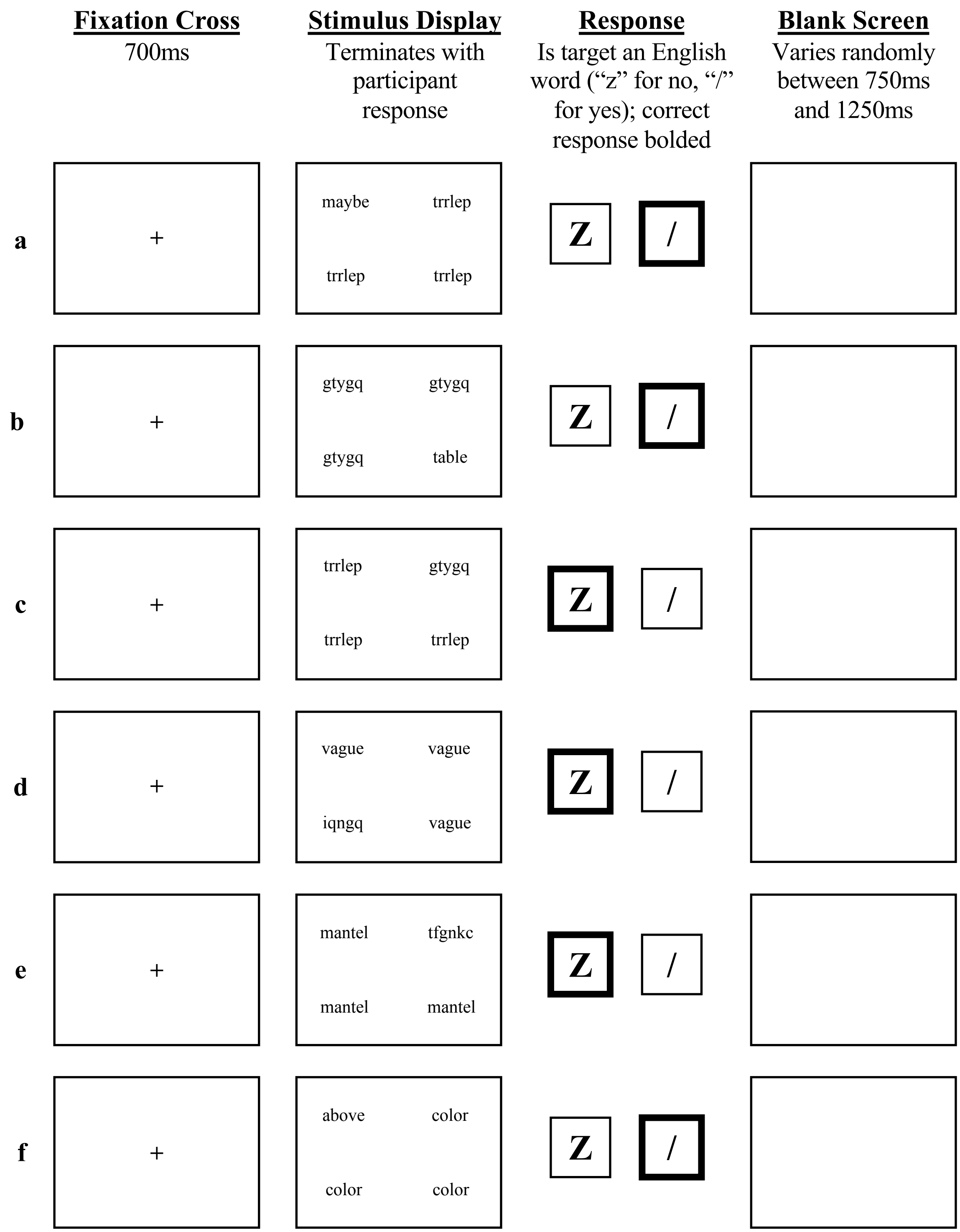

Figure 1. Trials (a) and (b) represent facilitated engagement, while trials (d) and (e) represent impaired disengagement. Trials (c) and (f) are meant to encourage active participation but are not included in analysis.