

*I told you it was safe: associations
between intolerance of uncertainty and
different parameters of uncertainty during
instructed threat of shock*

Article

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Abstract

Background and Objectives. Self-reported Intolerance of Uncertainty (IU) is the tendency to find uncertainty aversive. There is a lack of empirical research on how IU modulates anticipatory responding during threatening contexts with different parameters of uncertainty. **Methods.** Exploratory secondary analyses were conducted on an existing data set ($n = 45$) to examine whether IU is related to a particular parameter of uncertainty during instructed threat of shock (i.e. certain shock, certain safety from shock, outcome uncertainty of shock, temporal uncertainty of shock). **Results.** Analyses revealed that IU was associated with larger auditory startle blink during the anticipatory period for the certain safety from shock condition relative to the certain shock condition. **Limitations.** The sample was relatively small. **Conclusions.** Individuals with higher self-reported IU may be more inclined to generalize threat to safety cues in the context of instructed threat of shock.

Keywords: Intolerance of uncertainty; Threat; Safety; Instructions; Startle

1. Introduction

Individuals who score high in self-reported intolerance of uncertainty (IU) tend to find uncertainty anxiety provoking (Carleton, 2016). IU has recently been defined as ‘a dispositional incapacity to endure the aversive response triggered by the perceived absence of salient, key, or sufficient information, and sustained by the associated perception of uncertainty’ (Carleton, 2016; p. 31). High IU scores have been observed in a number of mental health disorders (Gentes & Ruscio, 2011; Mahoney & McEvoy, 2012). A growing literature has begun to show that individuals with higher self-reported IU display heightened anticipatory responding under conditions with uncertain threat (Tanovic, Gee, & Joormann, 2018). Despite this, there is a lack of research that has directly examined how IU modulates anticipatory responding during threatening contexts with different parameters of uncertainty (i.e. *if* or *when* a threatening stimulus will occur).

The majority of research on IU has, so far, focused on using experimental tasks that manipulate outcome uncertainty of threat (i.e. *if* a threatening stimulus is likely to occur) and temporal uncertainty of threat (i.e. *when* a threatening stimulus is likely to occur in time) (for review, see Tanovic et al., 2018). In these tasks, the parameters of uncertainty are ‘known’ because participants are instructed about the outcome and temporal uncertainty of threatening stimuli. Furthermore, individuals high in IU relative to low IU have been shown to exhibit heightened neural activity during the anticipation of unpredictable threatening outcomes such as negative pictures (Somerville et al., 2013) and electric shocks (Tanovic, Pruessner, & Joormann, 2018). However, a lack of IU effects on physiological indices such as skin conductance during the anticipation of

unpredictable threatening outcomes (i.e. negative pictures) has also been observed (Grupe & Nitschke, 2011; Morriss, 2019). There is a small literature on IU and the temporal uncertainty of threat. In these studies, higher IU, relative to lower IU is associated with greater auditory startle blink to temporally unpredictable electric shock (Nelson, Liu, Sarapas, & Shankman, 2016; Nelson & Shankman, 2011). In sum, the findings are mixed and limited for the role of IU in modulating anticipatory responding to different parameters of uncertainty.

In order to advance our conceptual understanding of IU and ascertain its clinical relevance, further work is needed to parse out the extent and specificity to which IU modulates anticipatory responding during threatening contexts with different parameters of uncertainty (i.e. *if* or *when* a threat will occur) (Shihata, McEvoy, Mullan, & Carleton, 2016). Recently, Bennett, Dickmann & Larson (2018) used an instructed threat of shock task to manipulate different parameters of uncertainty whilst auditory startle blink was recorded: certain shock, outcome uncertainty of shock, temporal uncertainty of shock, and certain safety from shock. Here, we revisited Bennett et al.'s (2018) data and conducted exploratory secondary analyses to examine whether IU is related to a particular parameter of uncertainty (i.e. *if* or *when*) during instructed threat of shock.

2. Materials and methods

For a detailed account of the procedure and design please refer to the original study (Bennett, Dickmann, & Larson, 2018).

2.1 Participants

For this study, 51 participants (students) were recruited from the University of Wisconsin-Milwaukee. After exclusions (4 data collection errors, 2 file corruption), the final sample size was 45 ($M_{\text{age}} = 21.69$, $SD_{\text{age}} = 5.99$; 31 female, 13 male, 1 transgender; Ethnicity: 26 White not of Hispanic origin, 6 Asian/Pacific Islander, 4 Hispanic/Latino, 3 Multiracial/Biracial, 2 African American/Black, 2 Other, 1 Middle Eastern, 1 Not specified). Six participants reported taking psychotropic medications for mental health disorders (2 anxiety, 2 attention deficit hyperactivity, 1 anxiety and post traumatic stress, and 1 unspecified). All participants provided written informed consent. Participants received a \$15 Amazon gift card and course credit in exchange for their participation.

2.2 Procedure

Participants underwent a shock threshold work-up and completed startle habituation. During the main task, participants completed two runs of four blocks. Auditory startle blink was measured during the anticipation (bar) and intertrial (ITI) periods of the task. At the end of each block, participants rated their level of subjective anxiety. After finishing the task participants completed questionnaires assessing self-reported anxiety.

2.3 Task design

On a computer, participants viewed “loading bars” that slowly filled over the course of the anticipation period (10 s). The loading bars were accompanied with instructions that specified whether a shock would occur. The four conditions included: 1) certain shock (C), with a shock always occurring at the end of the loading bar (10s); 2) temporal

uncertainty of shock (TU), with a shock always occurring at a random time between 2s and 10s during the loading bar's filling (i.e., the bar filled randomly, 'jumping from left to right'); 3) occurrence uncertainty of shock (OU), with a 50% chance of a shock occurring at the end of the loading bar (10s); and 4) certain safety from shock (S), with no shocks throughout or at the end of the loading bar anticipation period (10s).

The task included eight blocks, each block contained five trials of a single condition, for a total of 40 trials, 10 per condition. The order of the blocks was counterbalanced. Each trial lasted for a maximum of 35 seconds and contained one startle probe during the loading bar anticipation period and one during the ITI, which varied between 9s and 24.5s. There were a total of 12 startle probes per condition, six during the bar, and six during the ITI, for a total of 48 startle probes overall. There was 25 shocks overall. Shocks were never delivered during the ITI of any condition.

2.4 Questionnaires

The 12-item short version of the Intolerance of Uncertainty Scale (IUS) (Carleton, Norton, & Asmundson, 2007) and State-Trait Anxiety Inventory (STAI (the trait scale)) (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) were collected. The distributions of IUS and STAI were normally distributed (IUS: $M = 28.18$, $SD = 7.83$, range = 13-45, $\alpha = .85$, $n = 45$; STAI: $M = 39.11$, $SD = 8.99$, range = 20-64, $\alpha = .65$, $n = 44$)

2.5 Data collection and reduction of auditory startle blink

Startle response data were measured using a BioNomadix® 2Ch EMG Receiver (Biopac Systems, Goleta, CA) from two 4-mm Ag/AgCl sensors placed below the left eye, over the orbicularis muscle. One sensor was placed 1 cm below the pupil and the other 1 cm towards the outer canthi of the left eye. The ground sensor was placed in the center of the forehead.

Blinks were recorded and processed using Biopac's Acqknowledge software. Eyeblink startle EMG was filtered online using a 5–500 Hz bandpass filter, filtered offline using a 28 Hz high-pass filter (4th order Butterworth), rectified, and filtered offline using a 30 Hz low-pass filter (4th order Butterworth). Peak amplitudes were measured in the 20–200 ms time window following the white noise startle probe. Trials were rejected if there was greater than a $\pm 40\mu\text{V}$ deflection in the 50ms baseline period. Blinks were visually inspected and were removed from analyses if the startle response did not begin and end within the 20–200 ms time window. Auditory startle blinks were t-scored to control for individual differences in reactivity.

2.6 Analyses

To investigate the impact of IU in anticipation of threat and safety from shock, we correlated IUS with t-scored auditory startle blink difference scores from the following conditions: $[C_{\text{bar}} - S_{\text{bar}}]$; $[OU_{\text{bar}} - S_{\text{bar}}]$; $[TU_{\text{bar}} - S_{\text{bar}}]$; $[C_{\text{ITI}} - S_{\text{ITI}}]$; $[OU_{\text{ITI}} - S_{\text{ITI}}]$; $[TU_{\text{ITI}} - S_{\text{ITI}}]$. The S condition was the only condition not to include shock and therefore served as a useful baseline against the C, OU and TU conditions. If there was a significant correlation between IUS and t-scored auditory startle blink, we assessed IUS's specificity over STAI (another self-report measure of anxiety) by conducting hierarchical regression models

with the auditory startle blink entered as the dependent, and STAI entered at step 1 and IU entered at step 2 as independents. The order of the self-report measures in the hierarchical model is based on assessing if there is specific variance related to IUS over STAI, and not related to any assumptions related to the order of the factors (i.e. that STAI is higher order than IUS).

3. Results

The auditory startle blink difference scores met assumptions for normality (skew and kurtosis values were between ± 3). IUS was significantly inversely correlated with the $[C_{bar}-S_{bar}]$ difference score $[r(43) = -.306, p = .041]$; see Figure 1], suggesting that higher IUS scores were associated with greater auditory startle blink to the certain safety from shock condition relative to the certain shock condition. Furthermore, IUS scores were also inversely correlated at trend with the $[OU_{bar}-S_{bar}]$ and $[TU_{bar}-S_{bar}]$ difference scores: $[OU_{bar}-S_{bar}, r(43) = -.292, p = .052]$; $[TU_{bar}-S_{bar}, r(43) = -.276, p = .066]$, indicating that higher IUS scores were associated with greater auditory startle blink to the certain safety from shock condition relative to the outcome uncertainty of shock and the temporal uncertainty of shock conditions¹. IUS scores were not significantly correlated with any of the difference scores from the intertrial interval period, $ps > .5$.

¹ When excluding participants who were taking psychotropic medications ($n = 6$), the correlations between IUS and auditory startle blink difference scores for the bar period remained in the same direction: $[C_{bar}-S_{bar}, r(38) = -.321, p = .046]$; $[OU_{bar}-S_{bar}, r(38) = -.357, p = .026]$; $[TU_{bar}-S_{bar}, r(38) = -.267, p = .100]$

The relationship between IUS and the $[C_{\text{bar}} - S_{\text{bar}}]$ difference score was significantly specific to IUS, over STAI: first step $[R^2 = .002, F(1,42) = .085, p = .772]$; second step $[\Delta R^2 = .108, F(1,41) = 4.997, p = .031]$.

4. Discussion

In the current study, we examined whether IU was related to a particular parameter of uncertainty during instructed threat of shock. Exploratory analyses revealed that IU was associated with larger auditory startle blink during the anticipatory period for the certain safety from shock condition relative to the certain shock condition. In addition, albeit at trend, IU was associated with larger auditory startle blink during the anticipatory period for the certain safety from shock relative to both the outcome uncertainty of shock and temporal uncertainty of shock conditions. However, IU was not associated with auditory startle blink during the intertrial interval period for any of the conditions. Overall, the results suggest that individuals higher in IU may be more inclined to generalize threat to safety cues, at least in the context of instructed threat of shock with different parameters of uncertainty.

Based on the previous limited literature (for review see Tanovic et al., 2018), IU would have been expected to be related to larger auditory startle blink during the anticipatory period for conditions with greater uncertainty of shock (i.e. the outcome and temporal shock conditions). While our results with IU during the instructed threat of shock task may seem counterintuitive, there could be multiple explanations for what we found. Firstly, it is possible that individuals high in IU may be more tolerant of conditions that are 'known' (i.e. instructed) and reinforced with threat (i.e. shock), than those that

are 'known' and not reinforced with threat. Such postulations support IU theory, which suggests that individuals with high IU may prefer the certainty of a negative outcome (Carleton, 2016). Indeed, in studies where participants have received detailed instructions about different parameters of uncertain threat (i.e. *if* or *when* a threatening stimulus will occur), the results for neural and physiological measures of anticipatory responding have been mixed for IU (for discussion see, Morriss, 2019). However, in studies where the participants are uninstructed about the parameters of uncertain threat (i.e. participants have to learn the contingencies through experience) the results have been more consistent for IU, such that higher IU is associated with greater neural and physiological measures of anticipatory responding to uncertain threat (Dunsmoor, Campese, Ceceli, LeDoux, & Phelps, 2015; Morriss, Saldarini, Chapman, Pollard, & van Reekum, 2019; Morriss & van Reekum, 2019). Secondly, research from the associative learning literature suggests that individuals with higher IU are prone to generalizing threat to safe stimuli, particularly during contexts with greater uncertainty such as extinction learning (i.e. where contingencies of threat and safety change, unbeknownst to participants) (Bauer et al., 2020; Morriss, Christakou, & Van Reekum, 2016). From the results of the study we can speculate that individuals high in IU may expect the worst outcome, and therefore generalize threat to safe conditions in contexts with uncertainty, regardless if the context is instructed (e.g. information about uncertain threat is provided) or uninstructed (e.g. information about uncertainty is gathered through experience).

The present study had shortcomings which should be addressed in future research to assess the robustness and generalizability of the results reported. The

sample was relatively small and based on a Western student population. Therefore the study should be replicated in larger and more representative samples. Moreover, future work may benefit from modifying and extending the experimental design in a number of ways: (1) using different aversive stimuli where there is more or less control over its aversiveness, (2) comparing instructed and uninstructed conditions with different levels of uncertainty and threat. Lastly, given that the IU subscales have been linked to different mental health symptoms (McEvoy & Mahoney, 2011), it may be beneficial to also examine the specificity of the IU subscales (inhibitory and prospective) in relation to anticipatory responding under different parameters of uncertainty (see supplementary material). Conducting such work will be crucial for understanding IU conceptually and in relation to psychopathology.

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Figure Caption

Figure 1. Correlations between IUS and t-scored auditory startle blink difference scores from each instructed condition. Higher IUS was associated with greater auditory startle blink to the certain safe condition, compared to the certain shock condition. A similar pattern at trend level was found for IUS with the other conditions. T-scored auditory startle blink measured in micro volts (μV). C = certain shock; OU = outcome uncertainty of shock; TU = temporal uncertainty of shock; S = safety from shock.

