Behaviour Research and Therapy 137 (2021) 103799

Contents lists available at ScienceDirect

Behaviour Research and Therapy

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

Shorter communication

Intolerance of uncertainty and threat reversal: A conceptual replication of Morriss et al. (2019)

Gaëtan Mertens[a,b,*,1], Jayne Morriss[c,1]

[a] Department of Medical and Clinical Psychology, Tilburg University, Tilburg, the Netherlands
[b] Department of Clinical Psychology, Utrecht University, Utrecht, the Netherlands
[c] School of Psychology, University of Reading, Reading, United Kingdom

ARTICLE INFO

Keywords:
Intolerance of uncertainty
Threat conditioning
Threat reversal
Instructions
Psychophysiology

ABSTRACT

The ability to update responding to threat cues is an important adaptive ability. Recently, Morriss et al. (2019) demonstrated that participants scoring high in Intolerance of Uncertainty (IU) were more capable of threat reversal. The current report aimed to conceptually replicate these results of Morriss et al. (2019) in an independent sample using a comparable paradigm ($n = 102$). Following a threat conditioning phase, participants were told that cues associated with threat and safety from electric shock would reverse. Responding was measured with skin conductance and fear potentiated startle. We failed to conceptually replicate the results of Morriss et al. (2019). Instead, we found that, for participants who received precise contingency instructions prior to acquisition, lower IUS (controlling for STAI-T) relative to higher IUS was associated with greater threat reversal, indexed via skin conductance responses. These results suggest that IU and contingency instructions differentially modulate the course of threat reversal.

1. Introduction

Humans and many other animals possess the adaptive ability to learn which cues signal potential upcoming danger. This learning process is typically studied in the laboratory using the threat conditioning paradigm, in which a conditioned (neutral) stimulus (CS+) is repeatedly paired with an aversive unconditioned stimulus (US; e.g., an electric shock). Often, this procedure is supplemented with a second stimulus (CS-) that is not paired with the US to control for non-associative learning (e.g., sensitization, habituation), which is termed differential threat conditioning (Lonsdorf et al., 2017). Typically, this procedure results in participants demonstrating subjective, behavioral and physiological threat-related responses toward the CS + as compared to the CS-.

Once something is learned, it is also important to maintain flexibility and update responses towards changed contingencies in the environment. Inflexible responding towards cues that either no longer predict danger or suddenly do predict danger can be costly and impede survival. Hence, flexible responding towards safety and danger cues is a capacity that has evolved in many organisms.[2] Flexible responding towards changed contingencies is often studied using extinction (i.e., CS+ is no longer followed by the US) and reversal (i.e., reversed contingencies between the CSs and US) procedures. In healthy human participants, responses are typically updated when CS-US contingencies change, particularly when these procedures are complemented with verbal instructions regarding the contingencies (Luck & Lipp, 2016; Mertens, Boddez, Sevenster, Engelhard, & De Houwer, 2018). In contrast, patients suffering from anxiety-related disorders (e.g., Duits et al., 2015) and healthy participants with anxious personality types (e.g., Haaker et al., 2015) appear to be less flexible in changing their threat responses when CS-US contingencies change.

A body of work has begun to highlight how individual differences in Intolerance of Uncertainty (IU), a transdiagnostic dispositional tendency to find uncertainty aversive (Carleton, 2016a, 2016b), plays a critical role in threat extinction (Dunsmoor, Campese, Ceceli, LeDoux, & Phelps, 2015; Lucas, Luck, & Lipp, 2018; Morriss, 2019; Morriss & van Reekum,

---

* Corresponding author. Department of Medical and Clinical Psychology, Warandelaan 2, room T526, Tilburg University, 5037AB Tilburg, the Netherlands.
E-mail address: g.mertens@tilburguniversity.edu (G. Mertens).

[1] Both authors contributed equally to this manuscript.

[2] Flexible responding to threat and safety cues requires being able to discriminate between them. Hence, discrimination and generalization is also a fundamental capacity for adaptive behavior and is often studied within threat conditioning. However, this topic is outside of the scope current manuscript. We refer readers to the many excellent review articles on threat and fear generalization (e.g., Dymond, Dunsmoor, Vervliet, Roche, & Hermans, 2015).

https://doi.org/10.1016/j.brat.2020.103799
Received 27 March 2020; Received in revised form 8 December 2020; Accepted 28 December 2020

2019) and generalization (Bauer et al., 2020; San Martín, Jacobs, & Vervliet, 2020). For example, individuals with higher IU display reduced threat extinction, indexed via multiple physiology and neural measures (for review see Tanovic, Gee & Joorman, 2018). The uncertainty regarding the change of outcome during extinction is thought to drive anxiety-related arousal in individuals with high IU. Recently, Morriss et al. (2019) reported a study showing that participants scoring higher in IU, relative to lower IU, were more likely to update threat responding (as measured by skin conductance responses) when CS-US contingencies were reversed (uninstructed). Taken together these results suggest that when learned associations change, individuals with higher IU may find the absence of information (i.e. omission of US in extinction) more threatening than having some information (i.e. pairing the US with another stimulus). However, given that the study of Morriss et al. (2019) was one of the first studies to demonstrate a relationship between high IU and reversal learning, further replication of this result is warranted. Furthermore, conceptual replication helps to determine the generality of the findings and uncover potential moderators of an effect.

To this end, this report aims to conceptually replicate the result of Morriss et al. (2019) in an independent sample. Particularly, in a recent study by the first author, instructed reversal learning in a threat conditioning paradigm was investigated in a sample of 102 healthy volunteers. The primary goal of that study was to investigate the impact of verbal contingency instructions (i.e., no contingency instructions, general contingency instructions, and precise contingency instructions) on conditioned threat acquisition (Mertens, Boddez, Krypotos, & Engelhard, 2021). However, as this study also included contingency reversal instructions and assessed IU, the data of this study are also well suited to investigate whether the results of Morriss et al. (2019) could be conceptually replicated in an independent sample with a different reversal manipulation (i.e., instructed instead of uninstructed reversal).

2. Methods

2.1. Preregistration and prior use of the data

As indicated, this study and the associated data were collected to test another primary hypothesis and these results are reported elsewhere (see Mertens et al., 2021). For the original study, the hypothesis, sample, procedure, data analysis steps and test criteria were preregistered (10.17605/OSF·IO/7J56P). However, it should be noted that the assessment of IU and trait anxiety, the hypothesis tested in this paper and the associated statistical tests were not preregistered.

2.2. Participants

For this study, 108 healthy students were recruited at Utrecht University. However, the data of six participants was excluded due to problems with the storage of the data ($n = 4$) or the physiological markers ($n = 2$). Therefore, the final sample size was N = 102 (Precise Instruction condition, $n = 35$; General Instruction condition, $n = 33$; No Instruction condition, $n = 34$). This sample size was based on a sample size calculation to address the primary aim of the original study (see Mertens et al., 2021). However, for the current purposes, this sample size provides good statistical power ($1 - \beta > 0.8$) to detect a small-to-medium correlations ($r = 0.28$) with an α-value of 0.05 (see https://www.sample-size.net/correlation-sample-size/).

The sample consisted predominantly of female university students (70 female, 32 male participants; mean age = 23.25, SD = 3.57). Participants in the three conditions of the study did not differ in age, gender distribution, trait anxiety, US intensity levels or rated US unpleasantness (F/X^2-values < 1; see Mertens et al., 2021). The procedure of this study was approved by the ethics committee of the Faculty of Social and Behavioral Science at Utrecht University (FETC16-054). Participants received financial compensation (€8) or course credit in exchange for their participation.

3. Materials

3.1. Hardware and software

This study was run on standard lab computers (HP Z230 Desktop) running Windows 10. The experiment was programmed using Inquisit v4.0 (https://www.millisecond.com/). Skin conductance responses and startle responses were used using a Biosemi bio-amplifier system and standard galvanic skin response (GSR) and electromyography (EMG) electrodes filled with conductive gel (https://www.biosemi.com/). Psychophysiological signals were further processed offline using BrainVision Analyzer 2.0 software (https://www.brainproducts.com/).

3.2. Stimuli

Conditioned stimuli were two grey geometrical shapes (circle and square; 300 by 300 pixels) presented on a 23-inch computer screen (screen resolution: 1920 by 1080 pixels). The US consisted of a 500 ms electrical pulse generated using a Digitimer DS7A current stimulator. The intensity of the US was individually adjusted for each participants (see Procedure section).

3.3. Questionnaires

The trait version of the State-Trait Anxiety Inventory (STAI-T; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) was used to assess the participants' general trait anxiety level. The STAI-T consists of 20 items (e.g.: "I feel secure") and participants were asked to use the rating scale to rate how much the item describes themselves. The scale had a high level of internal consistency, as determined by a Cronbach's alpha of 0.915. The range of STAI-T scores was comparable across instruction condition (Precise Instruction condition: $M = 42.23$, $SD = 8.66$, Range = 23–58; General Instruction condition: $M = 41.55$, $SD = 8.96$, Range = 24–59; No Instruction condition: $M = 40.18$, $SD = 10.48$, Range = 27–71).

The 12-item short version of the Intolerance of Uncertainty Scale (IUS) was used to measure IU. It should be noted that in the study by Morriss et al. (2019) the original 27-item version of the IUS was used (Buhr & Dugas, 2002; Freeston, Rhéaume, Letarte, Dugas, & Ladouceur, 1994). The revised version maintains excellent internal consistency, while also being highly correlated to the original IUS and related measures of anxiety (Carleton, Norton, & Asmundson, 2007). In this sample, the questionnaire had a high level of internal consistency, as determined by a Cronbach's alpha of 0.835. The range of IUS scores was comparable across instruction conditions (Precise Instruction condition: $M = 30.31$, $SD = 8.06$, Range = 18–49; General Instruction condition: $M = 30$, $SD = 7.16$, Range = 17–46; No Instruction condition: $M = 30.15$, $SD = 7.37$, Range = 15–45). No significant differences in IUS scores were observed between groups, p's > 0.8.

IUS and STAI-T were significantly positively correlated $r(100) = 0.432$, $p < .001$.

3.4. Procedure

The procedure of this is extensively described in Mertens et al. (2021). As such, here we will focus on the most important procedural aspects for the current study. Prior to participation, participants were asked to wash their hands and skin sites for electrode attachment were prepared using a scrub gel. Next, measurement and shock-administration electrodes were attached and shock-level intensity was determined through a gradual work-up procedure. In this procedure, participants were asked to select a shock intensity level that they found unpleasant, but tolerably painful. Particularly, an intensity level of approximately 6 as reported by the participants was selected on a scale from 0 (not at all painful) to 10 (maximally tolerably painful).

Following electrode attachment and the shock work-up procedure, a contingency instruction manipulation took place in the experiment. Particularly, one third of the participants were given no particular instructions regarding the contingency between the CSs and the US in the experiment (no contingency instructions condition; "*In the following experiment you will see two different shapes appear on the screen: A square and a circle. You will also sometimes receive an electrical shock.*"). Another group was given general, but not precise, instructions about the contingencies in the study (general contingency instructions condition; "*In the following experiment you will see two different shapes appear on the screen: A square and a circle. One of the shapes will sometimes be followed by an electrical shock and the other shape will never be followed by an electrical shock. Your task is to learn to predict when the shock will be presented*"). Finally, a third group was given precise instructions about the contingencies in the experiment (precise contingency instructions condition; "I*n the following experiment you will see two different shapes appear on the screen: A square and a circle. The square[/circle]will sometimes be followed by an electrical shock and the circle[/square]will never be followed by an electrical shock.*"). Following the instructions manipulation, a startle probe (50 ms; 85 dB) habituation phase (10 presentation, 7 s inter-trial interval) first took place, followed by a threat conditioning phase. During threat conditioning, one of the two CSs (circle or square, counterbalanced) was followed by the US (i.e., the electric shock) in 75% of the trials. Each CS was presented 8 times (i.e., 16 trials in total) for 8 s. In each trial, a startle probe was presented 7 s after CS onset. In case of a reinforced trial, the US was administered immediately at CS offset. The inter-trial interval was either 12, 14 or 16 s. The order of CS presentations was semi-random with the restriction of maximally two identical consecutive trials. At the end of the acquisition phase, participants' contingency awareness of the stimulus contingencies was assessed by asking participants to indicate which of the two CSs (square or circle) was followed by the electrical shock and which of the two CSs was not followed by the electrical shock. For both questions, participants had to indicate how certain they were of their answer.

After the threat acquisition phase, all participants received the same contingency reversal instructions ("*In the next phase of the experiment, the relationship between the shapes and the electric shock will be reversed: The square[/circle] WILL now NOT be followed by the electric shock. The circle [/square] WILL now SOMETIMES be followed by the electric shock.*") followed by 5 more presentations of each CS. Presentations of the CSs were not reinforced, with the exception of one reinforcement of the initial CS- on the 3rd trial (i.e., 20% reinforcement rate).

4. Data reduction and analysis

4.1. Skin conductance responses (SCRs)

SCRs were calculated by subtracting the mean value of a baseline period (2 s before CS onset) from the highest peak during the 1–7 s interval post CS onset (Pineles, Orr, & Orr, 2009). Thereafter, skin conductance values were range corrected using the largest response for each participant and square root transformed to normalize the data (Dawson, Schell, Filion, & Berntson, 2007). A minimum response criterion was set at 0.02 μS. Values lower than this cut-off were set to 0.

4.2. Fear potentiated startle (FPS)

The electromyography signal of the startle response was filtered (28–500 Hz), smoothed (15.9 Hz low-pass filter), and rectified. Startle magnitude was calculated by subtracting the baseline value (time window: 0–20 ms after probe onset) from the highest peak value in the 21–150 ms time window after startle probe onset. These values were then T-transformed using each participants' individual mean and standard deviation (Blumenthal et al., 2005).

4.3. Main analysis

To investigate the impact of IU on threat responses in both the acquisition phase and the reversal phase, SCR and FPS responses were averaged across all trials in each phase. Trials were averaged across each phase for the current study to make it as comparable to Morriss et al. (2019) as possible. In Morriss et al. (2019) the factor Time was included, where trials were split into early and late blocks. However, in the current study the factor Time was not appropriate, given that there were fewer trials in this study compared to Morriss et al. (2019) for each stimulus type during acquisition (8 vs. 12) and reversal (5 vs.16). Based on prior work (Morriss et al., 2019) interactions were expected between IU and CS type (controlling for STAI-T variance), particularly in the reversal phase.

The analysis was conducted using a mixed linear models (MLM) procedure in SPSS 24.0 (SPSS, Inc; Chicago, Illinois). CS type (CS+ and CS-/NewCS+ and NewCS-) and instructions (no contingency instructions, general contingency instructions, precise contingency instructions) were entered as fixed effects at level 1 and individual subjects were entered as a random effect at level 2. IUS and STAI-T were both entered as continuous predictor variables. In the MLMs, a diagonal covariance matrix was used for fixed effects, a variance components covariance structure was used for random effects and a maximum likelihood estimator was used.

5. Results

5.1. Skin conductance responses

During acquisition participants displayed greater SCR to the CS+, compared to CS- [Stimulus: $F(1, 102) = 99.004$, $p < .001$; (see Table 1). This differential pattern in SCR was observed for all instruction conditions, $ps < .005$. Moreover, stronger differentiation in SCR between the CS+ and CS- was found for the precise and general instruction conditions, compared to the no contingency instruction condition [Stimulus x Instruction: $F(1, 102) = 5.442$, $p = .006$]. No other main effects of Instruction or significant interactions with IU (or STAI-T) were observed for SCR during acquisition, max $F = 1.598$.

During reversal participants displayed larger SCR magnitude to the NewCS+, compared to the NewCS- [Stimulus: $F(1, 102) = 24.904$, $p < .001$; see Table 1]. Moreover, SCR results differed depending on IUS and instruction condition [Stimulus x Instruction x IUS: $F(1, 102) = 3.223$, $p = .044$; see Fig. 1]. To further assess the interaction between Stimulus x Instruction x IUS, we conducted partial correlations (i.e. partial correlations between IUS and SCR difference [NewCS + - NewCS-], controlling for STAI-T) and tests of significance between the partial correlation coefficients from each instruction type. In the precise contingency group, lower IUS (controlling for STAI-T), relative to higher IUS, was associated with greater SCR to the NewCS + vs. NewCS- [$r(32) = 0.443$, $p = .009$]. No significant partial correlations between IUS (controlling for STAI-T) and SCR to the NewCS + vs. NewCS- were observed for the general contingency and no instruction groups, p's > 0.4. The partial correlation coefficient for the precise contingency group was at trend different than the general instruction group [$z = -1.67$, $p = .096$] and significantly different than the no instruction group [$z = -2.45$, $p = .014$]. The results from the follow up tests survived correction for multiple comparisons (p's $< .016$ for partial correlations and p's < 0.025 for the significant difference between partial correlation coefficients) based on the Benjamini-Hochberg False Discovery Rate procedure (Benjamini & Hochberg, 1995).

No other main effects of Instruction or significant interactions with IUS (or STAI-T) were observed for SCR during reversal, max $F = 2.706$.

5.2. Fear potentiated startle

During acquisition participants displayed greater FPS to the CS+,

Table 1
Means (standard deviation) by measure, phase, instruction and stimulus.

	Acquisition						Reversal					
	Precise Contingency Instructions		General Contingency Instructions		No Contingency Instructions		Precise Contingency Instructions		General Contingency Instructions		No Contingency Instructions	
	CS+	CS-	CS+	CS-	CS+	CS-	NewCS+	NewCS-	NewCS+	NewCS-	NewCS+	NewCS-
Square root transformed SCR ($\sqrt{}$μs)	0.49	0.27	0.44	0.23	0.4	0.31	0.4	0.21	0.38	0.27	0.36	0.3
	(.22)	(.15)	(.2)	(.14)	(.22)	(.19)	(.26)	(.17)	(.27)	(.21)	(.24)	(.22)
FPS (μV)	52.4	48	51.9	47.4	50.4	49.1	49.8	44.5	51	46.7	49.5	45.7
	(3.4)	(3.8)	(4)	(3.3)	(3.5)	(2.9)	(4.7)	(3.7)	(4.5)	(4.9)	(5.6)	(3.8)

Note: SCR ($\sqrt{}$μS), square root transformed skin conductance measured in microSiemens. FPS (μV), T-scored fear potentiated startle measured in microVolts.

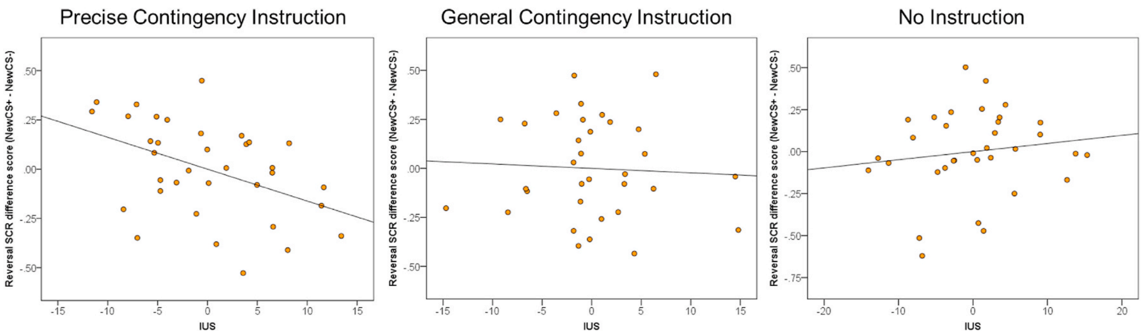

Fig. 1. Partial correlations between IUS (controlling for STAI-T) and SCR difference scores (NewCS + - NewCS-) during threat reversal. Individuals with lower IUS, relative to higher IUS, who received contingency instructions prior to acquisition displayed larger SCR responses to the NewCS + vs. NewCS-. For those who received general or no instruction prior to acquisition, individual differences in IUS were not associated with SCR responses to the NewCS + vs. NewCS-. SCR ($\sqrt{}$μS), square root transformed skin conductance measured in microSiemens.

compared to CS- [Stimulus: $F(1, 202.806) = 61.205$, $p < .001$; (see Table 1). No other main effects of Instruction or significant interactions with IU (or STAI-T) were observed for FPS during acquisition, max $F = 2.196$.

Similarly, during reversal during reversal participants displayed greater FPS to the NewCS+, compared to NewCS- [Stimulus: $F(1, 98.164) = 46.668$, $p < .001$; (see Table 1). No other main effects of Instruction or significant interactions with IUS (or STAI-T) were observed for FPS during acquisition, max $F = 2.606$.

6. Discussion

In the current study, we failed to conceptually replicate the IU and threat reversal results of Morriss et al. (2019). Instead, we found that, specifically in the Precise Instruction condition, lower IU relative to higher IU was associated with greater threat reversal, as measured via SCR. The SCR findings were specific for IU, over shared variability with STAI-T. Whilst our results were different from Morriss et al. (2019), they further our understanding of IU and contingency instruction in the updating of threat and safety associations, which may have clinical relevance for anxiety and stress disorders.

In an uninstructed threat conditioning experiment Morriss et al. (2019) showed that participants scoring higher in IU, relative to lower IU, were more capable of threat reversal, indexed via SCR. This directly contrasts with the results obtained here (i.e., lower IU participants updating SCR responding more efficiently in the precise contingency instruction group). The main difference between Morriss et al.'s (2019) study and the current study is the use of verbal contingency instructions. We can speculate that in the absence of contingency instructions and with a 50% reinforcement schedule (as in the study by Morriss et al., 2019), individuals with higher IU, relative to lower IU are more aroused by uncertainty during threat reversal, and therefore are more motivated to resolve this uncertainty.

Interestingly, in the present study we found that lower IU relative to higher IU, only in the Precise Instructions condition, was related to greater threat reversal, measured via SCR. Individual differences in IU were not found to modulate threat reversal, via SCR, in the general or no instruction groups. However, while not significant, in the current experiment, a similar pattern was observed for SCR in the no instruction group to that of Morriss et al. (2019), whereby higher IU, relative to lower IU, was associated with greater threat reversal.

From these findings, we can speculate that individuals with lower IU, relative to higher IU, may be more likely to believe precise contingency instructions, particularly if they are consistent (i.e. the same instruction from acquisition and reversal). In this study we cannot ascertain if this IU-related effect is specific to receiving contingency information about threat and safety associations during reversal or is generally related to receiving contingency information about threat and safety associations. However, the relationship between IU and contingency instruction is unlikely to be specific to reversal, given prior work showing that IU and contingency instruction in combination alter the course of extinction learning (Morriss & van Reekum, 2019).

The mean and range of IU scores in the sample for each experimental manipulation (instruction type) were comparable to that of Morriss et al. (2019), and to that observed in community samples (Carleton et al., 2012). Notably, both study samples did have individuals with IU scores (>40) comparable to that observed in clinical populations with anxiety and obsessive compulsive disorders (Carleton et al., 2012). However, there were other differences between the studies which may have altered the relationship between IU and threat reversal. For instance there were fewer trials per stimulus type during reversal (5 vs.16), the reinforcement rate (75% vs. 50%) and US's (shock vs. human scream) were different, and startle probes were used. Furthermore, a different way of quantifying SCRs was used in this study (i.e., maximum value in the 1–7 s post-CS interval minus the baseline value, instead of trough-to-peak scoring in the 0.5–3.5 s post-CS interval). Different handling of SCR data can result in variability in results (see Lonsdorf et al., 2019), though previously strong correlation between these quantification methods have been reported (r = 0.62-0.86; Pineles et al., 2009). Finally, the short version of the IUS was used in this study, whereas Morriss et al. (2019) used the long version in their study.[3] Importantly, despite these differences, IU was still associated with changes in SCR during threat reversal. Such findings suggest that IU plays an important role in the updating of threat and safety associations, whether it be through extinction or reversal.

FPS was not found to reflect individual differences in IU in this sample. To our knowledge only two published associative learning studies have observed an effect of IU on startle (Chin, Nelson, Jackson, & Hajcak, 2016; Sjouwerman, Scharfenort, & Lonsdorf, 2020). The majority of associative learning studies have found effects of IU on SCR (Dunsmoor et al., 2015; Lucas et al., 2018; Morriss, 2019; Morriss & van Reekum, 2019). Further work is needed to tease apart associations between IU and different psychophysiological measures.

In conclusion, these initial results provide some insight into how IU and contingency instructions modulate the updating of threat and safety associations, which may be relevant for understanding the conceptualization of IU and related psychopathology (Carleton, 2016a, 2016b).

Acknowledgements

The research reported in this paper was funded by a NWO Vici grant (grant number: 453-15-005) awarded to Iris M. Engelhard and supported by a: (1) NARSAD Young Investigator Grant from the Brain & Behavior Research Foundation (27567) and (2) an ESRC New Investigator Grant (ES/R01145/1) awarded to Jayne Morriss.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.brat.2020.103799.

Declaration of interest statement

The authors declare no conflict of interest regarding the research reported in this article.

Data availability statement

The data of the experiment reported in this article and data analysis scripts can be found on OSF (https://osf.io/pb9w7/).

Author contributions

G.M. designed the experiment and collected the data. G.M. wrote the introduction and methods. J.M. wrote the results and discussion. G.M. and J.M edited the final manuscript.

References

Bauer, E. A., MacNamara, A., Sandre, A., Lonsdorf, T. B., Weinberg, A., Morriss, J., et al. (2020). Intolerance of uncertainty and threat generalization: A replication and extension. *Psychophysiology.* , Article e13546. https://doi.org/10.1111/psyp.13546.

Benjamini, Y., & Hochberg, Y. (1995). Controlling the false discovery rate: A practical and powerful approach to multiple testing. *Journal of the Royal Statistical Society: Series B, 57*, 289–300. https://doi.org/10.1111/j.2517-6161.1995.tb02031.x.

Blumenthal, T. D., Cuthbert, B. N., Filion, D. L., Hackley, S., Lipp, O. V., & Van Boxtel, A. (2005). Committee report: Guidelines for human startle eyeblink electromyographic studies. *Psychophysiology, 42*, 1–15. https://doi.org/10.1111/j.1469-8986.2005.00271.x.

Buhr, K., & Dugas, M. J. (2002). The intolerance of uncertainty scale: Psychometric properties of the English version. *Behaviour Research and Therapy, 40*, 931–945. https://doi.org/10.1016/S0005-7967(01)00092-4.

Carleton, R. N. (2016a). Fear of the unknown: One fear to rule them all? *Journal of Anxiety Disorders, 41*, 5–21. https://doi.org/10.1016/j.janxdis.2016.03.011.

Carleton, R. N. (2016b). Into the unknown: A review and synthesis of contemporary models involving uncertainty. *Journal of Anxiety Disorders, 39*, 30–43. https://doi.org/10.1016/j.janxdis.2016.02.007.

Carleton, R. N., Mulvogue, M. K., Thibodeau, M. A., McCabe, R. E., Antony, M. M., & Asmundson, G. J. (2012). Increasingly certain about uncertainty: Intolerance of uncertainty across anxiety and depression. *Journal of Anxiety Disorders, 26*, 468–479. https://doi.org/10.1016/j.janxdis.2012.01.011.

Carleton, R. N., Norton, M. A. P. J., & Asmundson, G. J. G. (2007). Fearing the unknown: A short version of the intolerance of uncertainty scale. *Journal of Anxiety Disorders, 21*, 105–117. https://doi.org/10.1016/j.janxdis.2006.03.014.

Chin, B., Nelson, B. D., Jackson, F., & Hajcak, G. (2016). Intolerance of uncertainty and startle potentiation in relation to different threat reinforcement rates. *International Journal of Psychophysiology, 99*, 79–84. https://doi.org/10.1016/j.ijpsycho.2015.11.006.

Dawson, M. E., Schell, A. M., Filion, D. L., & Berntson, G. G. (2007). The electrodermal system. In J. T. Cacioppo, L. G. Tassinary, & G. Berntson (Eds.), *Handbook of psychophysiology* (3rd ed., pp. 157–181). Cambridge University Press.

Duits, P., Cath, D. C., Lissek, S., Hox, J. J., Hamm, A. O., Engelhard, I. M., et al. (2015). Updated meta-analysis of classical fear conditioning in the anxiety disorders. *Depression and Anxiety, 32*, 239–253. https://doi.org/10.1002/da.22353.

Dunsmoor, J. E., Campese, V. D., Ceceli, A. O., LeDoux, J. E., & Phelps, E. A. (2015). Novelty-facilitated extinction: Providing a novel outcome in place of an expected threat diminishes recovery of defensive responses. *Biological Psychiatry, 78*, 203–209. https://doi.org/10.1016/j.biopsych.2014.12.008.

Dymond, S., Dunsmoor, J. E., Vervliet, B., Roche, B., & Hermans, D. (2015). Fear generalization in humans: Systematic review and implications for anxiety disorder research. *Behavior Therapy, 46*, 561–582. https://doi.org/10.1016/j.beth.2014.10.001.

Freeston, M. H., Rhéaume, J., Letarte, H., Dugas, M. J., & Ladouceur, R. (1994). Why do people worry? *Personality and Individual Differences, 17*, 791–802. https://doi.org/10.1016/0191-8869(94)90048-5.

Haaker, J., Lonsdorf, T. B., Schümann, D., Menz, M., Brassen, S., Bunzeck, N., et al. (2015). Deficient inhibitory processing in trait anxiety: Evidence from context-dependent fear learning, extinction recall and renewal. *Biological Psychology, 111*, 65–72. https://doi.org/10.1016/j.biopsycho.2015.07.010.

Lonsdorf, T. B., Klingelhöfer-Jens, M., Andreatta, M., Beckers, T., Chalkia, A., Gerlicher, A., & Sjouwerman, R. (2019). Navigating the garden of forking paths for data exclusions in fear conditioning research. *Elife, 8*, Article e52465. https://doi.org/10.7554/eLife.52465.

Lonsdorf, T. B., Menz, M. M., Andreatta, M., Fullana, M. A., Golkar, A., Haaker, J., et al. (2017). Don't fear 'fear conditioning': Methodological considerations for the design and analysis of studies on human fear acquisition, extinction, and return of fear. *Neuroscience & Biobehavioral Reviews, 77*, 247–285. https://doi.org/10.1016/j.neubiorev.2017.02.026.

Lucas, K., Luck, C. C., & Lipp, O. V. (2018). Novelty-facilitated extinction and the reinstatement of conditional human fear. *Behaviour Research and Therapy, 109*, 68–74. https://doi.org/10.1016/j.brat.2018.08.002.

Luck, C. C., & Lipp, O. V. (2016). Instructed extinction in human fear conditioning: History, recent developments, and future directions. *Australian Journal of Psychology, 68*, 209–227. https://doi.org/10.1111/ajpy.12135.

Mertens, G., Boddez, Y., Krypotos, A.-M., & Engelhard, I. M. (2021). Human fear conditioning depends on stimulus contingency instructions. *Biological Psychology, 158*, 107994. https://doi.org/10.1016/j.biopsycho.2020.107994.

Mertens, G., Boddez, Y., Sevenster, D., Engelhard, I. M., & De Houwer, J. (2018). A review on the effects of verbal instructions in human fear conditioning: Empirical findings, theoretical considerations, and future directions. *Biological Psychology, 137*, 49–64. https://doi.org/10.1016/j.biopsycho.2018.07.002.

Morriss, J. (2019). What do I do now? Intolerance of uncertainty is associated with discrete patterns of anticipatory physiological responding to different contexts. *Psychophysiology, 56*, Article e13396. https://doi.org/10.1111/psyp.13396.

Morriss, J., Saldarini, F., Chapman, C., Pollard, M., & van Reekum, C. M. (2019). Out with the old and in with the new: The role of intolerance of uncertainty in reversal of threat and safety. *Journal of Experimental Psychopathology, 10*. https://doi.org/10.1177/2F2043808719834451, 204380871983445.

Morriss, J., & van Reekum, C. (2019). I feel safe when I know: Contingency instruction promotes threat extinction in high intolerance of uncertainty individuals. *Behaviour Research and Therapy, 116*, 111–118. https://doi.org/10.1016/j.brat.2019.03.004.

Pineles, S. L., Orr, M. R., & Orr, S. P. (2009). An alternative scoring method for skin conductance responding in a differential fear conditioning paradigm with a long-duration conditioned stimulus. *Psychophysiology, 46*, 984–995. https://doi.org/10.1111/j.1469-8986.2009.00852.x.

San Martín, C., Jacobs, B., & Vervliet, B. (2020). Further characterization of relief dynamics in the conditioning and generalization of avoidance: Effects of distress

---

[3] In the original Morriss et al. (2019) study the IUS-27 was used. To double check that the IUS-12 scores were comparable between studies, we extracted the IUS-12 scores (the IUS-12 can be derived from the IUS-27) from the Morriss et al. (2019) study and compared them against the IUS-12 scores from the current study. No significant differences in IUS-12 scores were observed between the original Morriss et al. (2019) study ($M = 28.91$, $SD = 10.12$) and any of the groups for the current study (Precise Instruction condition, $M = 30.31$, $SD = 8.06$; General Instruction condition: $M = 30$, SD = 7.16; No Instruction condition: $M = 30.15$, $SD = 7.37$), p's > 0.5. Therefore, the IUS-12 scores were comparable between studies.

tolerance and intolerance of uncertainty. *Behaviour Research and Therapy, 124*, 103526. https://doi.org/10.1016/j.brat.2019.103526.

Sjouwerman, R., Scharfenort, R., & Lonsdorf, T. B. (2020). Individual differences in fear acquisition: Multivariate analyses of different Emotional Negativity scales, physiological responding, subjective measures, and neural activation. *Scientific Reports, 10*, 15283. https://doi.org/10.1038/s41598-020-72007-5.

Spielberger, C. D., Gorsuch, R. L., Lushene, R., Vagg, P. R., & Jacobs, G. A. (1983). *Manual for the state-trait anxiety inventory*. Palo Alto, CA: Consulting Psychologists Press.

Tanovic, E., Gee, D. G., & Joormann, J. (2018). Intolerance of uncertainty: Neural and psychophysiological correlates of the perception of uncertainty as threatening. *Clinical Psychology Review, 60*, 87–99. https://doi.org/10.1016/j.cpr.2018.01.001.