Slowed extinction of repetitive threat-neutralization behavior in anxiety-related disorders: Effects from a novel fear-conditioning paradigm

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Abstract

Repetitive threat-neutralization is a common behavior pattern across anxiety disorders and obsessive-compulsive disorder (OCD) that contributes to functional impairment. However, laboratory studies of this behavioral phenomenon are scant. In the present study, we examined effects of anxiety-related disorders and anxiety sensitivity on repetitive threat-neutralization behavior.

Adults recruited from the community (*n*=40) with and without anxiety-related disorders completed clinician-administered and self-reported anxiety assessments and the Tap-to-Safety Task. Task stimuli included a threat cue (CS+) paired with shock, safety cues (CS-) never paired with shock, and safe stimuli varying in similarity to the CS+. The task included choice trials, in which participants could repeatedly tap a button to reduce risk of shock, while also reducing accumulation of reward points. In an extinction phase, shocks were no longer administered. We conducted linear mixed-effects models to examine differences related to anxiety sensitivity and anxiety disorder diagnosis in repetitive threat-neutralization behavior across stimulus types.

Participants with greater anxiety sensitivity showed more adaptive neutralization behavior to the true threat-cue as well as more unnecessary neutralization to the former threat-cue. Those with anxiety-related disorders showed more neutralization behavior to the former threat-cue. Anxiety sensitivity and anxiety-related disorder status were both associated with less-steep declines in neutralization behavior across trials of extinction, consistent with the hypothesis that neutralization behaviors would persist in safe situations for anxious individuals.

These findings suggest that the TTS task captures anxiety-related individual differences in extinction of repetitive threat-neutralization behavior, and provides an adaptable tool for probing threat-related behaviors.

Keywords: avoidance, threat, fear conditioning, anxiety, decision-making, anxiety sensitivity

1. Introduction

Humans employ a variety of defensive behaviors to survive threats and mitigate anxiety (LeDoux & Daw, 2018). While adaptive in certain contexts, for those with anxiety-related disorders (e.g., anxiety disorders, obsessive-compulsive disorder [OCD]), defensive behaviors are often maladaptive, occurring out of proportion to the actual threat, and/or at the expense of other rewards or goals (Hofmann & Hay, 2018; Roberts et al., 2022). Defensive behaviors can also interfere with extinction learning, (i.e., "protection from extinction"; Diehl et al., 2019; McGuire et al., 2016; Lovibond et al., 2009), contributing to a vicious cycle of persistent avoidance and distress.

Existing animal and human paradigms have shed light on behavior patterns involving avoidance of threat (Ball & Gunaydin, 2022; LeDoux & Daw, 2018) and have informed optimal methods for reducing avoidance in exposure-based therapies (Craske et al., 2022). However, real-world defensive behaviors are varied and complex, and the clinical utility of avoidance research is limited by the extent to which avoidance paradigms adequately model clinically-relevant defensive behaviors. Most avoidance paradigms model *active avoidance* (i.e., moving away from threat) or *passive avoidance* (i.e., withholding action to stay away from threat). By contrast, some behavior patterns commonly observed in anxiety-related disorders are *repetitive,* such as seeking reassurance to prevent interpersonal conflict, checking appliances to avoid a fire, or reviewing a to-do list to reduce the likelihood of forgetting tasks. A better understanding of such *repetitive threat-neutralization* behaviors and their relationship with anxiety-related psychopathology is needed to improve methods for reducing these behaviors.

In the present study, we investigated individual differences in repetitive threat-neutralization among adults with and without anxiety-related disorders (AD). We applied the Tap-to-Safety (TTS) task, a novel behavioral paradigm that employs Pavlovian fear conditioning to induce threat, then introduces the option of engaging in repetitive threat-neutralization behavior that reduces risk while also reducing accrual of reward points. We assessed effects of anxiety sensitivity (AS), a transdiagnostic risk factor for anxiety disorders and OCD (Taylor et al., 2007, Tulacı & İzci, 2023) that has been previously associated with heightened maladaptive avoidance (Hunt et al., 2019).

We hypothesized that greater AS, and anxiety-related disorder status, would be associated with a) elevated neutralization behavior to a true threat-cue, b) overgeneralization of neutralization behavior to safe stimuli resembling the threat-cue, and c) persistent neutralization behavior to a former threat-cue following removal of threat.

2. Method

2.1 Participants

Right-handed adults aged 18–65 *(n*= 46) were recruited from the community and local mental health clinics. The sample was recruited to capture a range of anxiety-related traits, and included participants either with no psychiatric disorder, or with a current diagnosis of anxiety disorder and/or OCD diagnosis. Mood disorders were allowed if a current anxiety disorder and/or OCD diagnosis was also present.

Key exclusion criteria included: current psychosis-spectrum or bipolar disorder; moderate/severe substance use disorder; PTSD; active suicidal ideation; current use of antipsychotics, anxiolytics, mood stabilizers, or antidepressants (stable-dose selective serotonin reuptake inhibitors [SSRIs] ≥6 weeks were permitted); excessive caffeine or stimulant use (>1000 mg/day); MRI contraindications; and medical conditions that could be compromised by or interfere with task participation.

2.2 Procedure

Anxiety-related disorder status was determined via the MINI International Neuropsychiatric Interview 7 (DSM-5), administered in a separate screening protocol. Participants also completed the Anxiety Sensitivity Index – 3 (Taylor et al., 2007). Immediately prior to completion of the Tap-To-Safety (TTS) task, shock electrodes were attached to the right ankle. A shock workup procedure was completed to determine an uncomfortable but tolerable level of electrical stimulation (participant rating 8/10, with 10 being the maximum they would be willing to tolerate). Participants then completed the TTS Task, a novel fear-conditioning paradigm designed to probe repetitive threat-neutralization behavior (Berg et al., 2025). All participants provided written informed consent and all procedures were approved by the WCG Institutional Review Board (protocol #20242665, #20192170, and #20200161).

2.3 Tap-To-Safety Task

The TTS task is described in detail elsewhere (Berg et al., 2025); code for the task programming is available upon request. Briefly, the task elicits competing motivations for threat-neutralization and reward accrual. The task begins with Pavlovian conditioning to a threat-cue paired with shock and safety-cues never paired with shock. Next, participants are instructed that they will be able to repeatedly tap a button to reduce their risk of shock (i.e., repetitive threat-neutralization [RTN]), but that doing so will interfere with accrual of reward points. The next phase includes trials with the neutralization option, with the threat and safety cues as well as safe stimuli with varying resemblance to the threat-cue, to assess generalization of repetitive threat-neutralization behavior. Finally, participants complete an extinction phase with the neutralization option, to assess the extent to which RTN persists in a safe situation.

2.3.1. Task Stimuli

Participants viewed stimuli sequentially on a computer screen, including rings of varying sizes and a V-shaped outlier stimulus (Figure 1A). One ring of extreme size was a threat cue (CS+) associated with shock, the ring at the opposite extreme was a safety cue (oCS-) never paired with shock. Ring size was counterbalanced across participants so that for half of participants the largest ring was the CS+, and for remaining participants the smallest ring was the CS+. The V-shaped stimulus was also a safety cue never paired with shock (vCS-). Six rings of intermediate size were generalization stimuli (GSs) forming a continuum of similarity between CS+ and oCS-; these and were never paired with shock. For all analyses involving GSs, pairs of adjacent GSs were binned, forming three stimulus-classes for analysis: GS1, GS2 and GS3.

2.3.2 Trial Structure and Trial Types

On all trials, the stimulus (CS+, GS, oCS-, or vCS-) was displayed in the center of the screen throughout the trial, and a fixation point was displayed in between trials. Trials included ratings using a slider onscreen that appeared after stimulus onset and prior to the outcome of the trial. Sliders included verbal instructions to rate either a) risk of shock on the current trial or b) momentary anxiety, and displayed five response options with anchors labeled 1 = “None”, 3 = “Some”, 5 = “A Lot”.

The task included passive and choice trials (Figure 1B-C). On passive trials, following initial stimulus onset, participants were asked to make a rating, then received the outcome of the trial (i.e., shock or no shock). On choice trials, following initial stimulus onset and the rating, participants then had the option to engage in repetitive threat-neutralization behavior for 4 seconds. Following the threat-neutralization window, participants then made a second anxiety or risk rating, then received shock or no shock. Repetitive threat-neutralization consisted of repeatedly tapping a button with the left pinky to reduce the probability of shock. During the 4-

second window for neutralization behavior, an avatar was displayed running across the screen collecting reward points. Tapping the button slowed the accrual of points, thereby introducing motivational conflict between engaging in repetitive threat-neutralization versus passively receiving reward. No monetary value or external reward was attached to points; participants were shown their points total throughout the task.

2.3.3. Task Phases

Task phases are summarized in Figure 1D. The task began with a Pavlovian Acquisition phase, involving passive trials with CS+, oCS-, and vCS-, with 75% of the CS+ presentations co-terminating with shock. Next, participants completed a tapping-speed test. Participants were given 10 speed-test trials in which they were asked to tap a button using their left little finger as fast as they can for 4 seconds. The highest number of taps was recorded as that participant's maximum rate, and the relationship between tapping in the task and shock probability was individually calibrated based on this maximum rate. Participants then viewed instructions describing how tapping the button would reduce shock and result in fewer points, followed by practice trials.

Next, to index discrimination of neutralization behavior between threat and safety cues, participants completed the Discrimination phase, involving interspersed passive and choice trials with CS+, oCS-, and vCS-. This was followed by the Generalization phase, involving interspersed passive and choice trials with CS+, oCS-, vCS-, and GSs. Finally, the Extinction phase involved passive and choice trials interspersed with CS+, oCS-, and vCS-, and no shocks were delivered. Of note, CS+ choice trials in the Extinction phase were introduced after presentation of 6 CS+ passive trials, to allow the opportunity for extinction learning without neutralization.

2.3.4 Behavioral Outcome Measures

The primary behavioral outcome was tapping behavior (i.e., RTN), indexed as the amount of tapping during the 4-second RTN window as a percentage of each participant's individually calibrated maximum tapping rate, established in the tapping-speed test. Other behavioral measures included trial ratings concerning risk (of shock) and anxiety ratings.

2.5 Equipment

The task was programmed using PsychoPy software. Participants made risk and anxiety ratings and performed repetitive threat-neutralization using a Current Designs bimanual 4-button response pad; the right-hand pad had four buttons in a curved formation and was used for risk and anxiety ratings, and the left-hand pad included one button for the little finger and was used for the speed test and repetitive threat-neutralization (described below). Electric shocks were delivered to the right ankle by a constant current stimulator (Digitimer DS7A, Digitimer North America, Fort Lauderdale, FL).

2.4 Statistical Analyses

To examine individual differences in RTN behavior, perceived risk, and anxiety, we fit linear mixed-effects models (LMEs) using the *nlme* package in R. AS scores were modeled as continuous predictors, with models estimated separately by task phase. Models of the form *Task measure ~ Stimulus × AS* and *Task measure ~ Stimulus × Group (anxiety-related disorder (AD), healthy comparison)* tested whether individual differences moderated behavioral responses across stimuli type, in each task phase separately. Following significant AS findings, we used the R package *emtrends* to estimate slopes between AS and the task measure for each stimulus type. Additionally, following significant AS findings, we conducted post-hoc LMEs for the social, cognitive, and physical subscales of the ASI-3. Significant group findings were followed up with

post-hoc *t*-test comparisons of responding to each stimulus type between groups. To examine individual differences in extinction rates, we conducted LMEs with data from the Extinction phase, with the form *Task measure ~ Trial × Stimulus × AS* and *Task measure ~ Trial × Stimulus × Group*. Random effects for participant ID were included in all LMEs. Age, sex, and maximum tapping speed were considered as potential covariates; based on model comparison using Aikake's information criterion, these covariates were not included in final models (Figures S1, S2, and S3).

3. Results

3.1 Participant Demographics

A total of 40 participants completed the task; of these, 5 were excluded for not displaying conditioning effects (risk ratings during the Acquisition phase to CS+ < vCS-). A total of n=35 were included in the analyses presented here. Participant demographics and clinical characteristics are reported in Table 1.

3.2 Effects of Anxiety Sensitivity

In the Discrimination phase, significant Stimulus × AS interactions emerged for tapping behavior (p = .025; Table 2, Figure 2A). Post-hoc analyses indicated a positive trend between AS and tapping to the CS+, p = .113, and not for other stimuli (ps>.342), suggesting that the interaction effect was driven by elevated CS+ tapping among those with greater AS. Post-hoc analyses by anxiety sensitivity subscale are shown in Table S1-S3. Effects of AS on risk anxiety ratings during Discrimination were not significant.

In the Generalization phase, significant Stimulus × AS interactions were found for both risk ratings (p = .003; Table 2, Figure 2B) and tapping behavior (p = <.001; Table 2, Figure 2B). Post-hoc analyses indicated a positive trend between AS and tapping to the CS+ (p=.111), as well as between AS and risk ratings to the CS+ (p=.051); slopes for other stimuli were not significant (ps>.133). These findings indicate AS-related elevations in neutralization behavior, commensurate with elevated appraisals of true threat. Effects of AS on anxiety ratings during Generalization were not significant.

In the Extinction phase, when the threat cue was no longer paired with shock, similar Stimulus × AS interactions were found for both risk ratings (p = .002,Table 2, Figure 2C) and tapping behavior (p = .001,Table 2, Figure 2C); post-hoc analyses indicated a positive relationship between AS and tapping to the former CS+, p = .011, but not for other stimuli (ps>.595). Similarly, a positive relationship was identified between AS and risk ratings to the former CS+, p = .001, and not for other stimuli (ps>.180). This pattern reflects persistent maladaptive neutralization and elevated perceived risk toward the former threat cue among individuals with higher AS. Effects of AS on anxiety ratings during Extinction were not significant.

3.3 Effects of Anxiety-Related Diagnosis

Group × Stimulus interactions were significant for both risk ratings and tapping behavior during the Extinction phase only (Table 3, Figure 3). Post hoc comparisons revealed those with AD demonstrated more neutralization to the CS+, (t(21.27)=2.11,p=.047), but not to other stimuli (ps> .769), and higher risk ratings to the CS+, (t(29.71)=2.45,p=.020), but not to other stimuli (ps> .347). Together, these findings indicate that individuals with AD maintained greater maladaptive, repetitive threat-neutralization and perceived greater risk to the former threat cue compared to safety cues, relative to healthy controls. Effects of group on anxiety ratings were not found (ps>.35).

3.4 Effects of Anxiety Sensitivity and Anxiety-Related Diagnosis across Trials of Extinction

During Extinction, there was a significant Trial x AS interaction for both risk ratings and tapping behavior (Table 4, Figure 4). Similarly, there was a significant Trial x Group interaction for both risk ratings and tapping behavior during Extinction (Table 4, Figure 5). These findings indicate that individuals with higher AS and those with AD maintained higher risk ratings and tapping behavior to the former threat cue across the trials of the Extinction phase, when tapping is maladaptive. Post-hoc analyses indicated that anxiety sensitivity findings were consistent across social, physical, and cognitive subscales. (Table S4)

4. Discussion

In this study, we examined anxiety-related individual differences in repetitive threat-neutralization (RTN) behavior using the Tap-To-Safety Task. Our findings provide initial evidence that the task captures meaningful anxiety-related variation in maladaptive threat-neutralization patterns. Identifying individual differences in the propensity to engage in RTN behaviors has the potential to inform models of anxiety and OCD and the development of more targeted interventions.

Results supported our hypotheses that anxiety sensitivity and anxiety-related disorders would be associated with more RTN to true threats and poorer extinction of RTN, at the expense of reward accrual. Trial-level analyses within the Extinction phase confirmed that both higher anxiety sensitivity and anxiety disorder status were linked to persistent RTN, commensurate with elevated perceived risk, despite repeated exposure to the former threat-cue without shock. In contrast, our hypotheses regarding anxiety-related overgeneralization of RTN were not supported.

4.1 Theoretical and clinical implications

These findings converge with and extend prior research demonstrating heightened avoidance and deficits in extinction learning among anxious individuals (Diehl et al., 2019; McGuire et al., 2016). Furthermore, anxiety sensitivity has been linked to internalizing disorders, higher response to fear, and heightened attention to threat (Naragon-Gainey, 2010; Bilodeau-Houle et al., 2020; Viana et al., 2021; Li et al., 2023), as well as behavioral avoidance (Hunt et al., 2019). The present findings further delineate the role of anxiety sensitivity in threat-related behavior. One potential clinical implication is that, in exposure-based therapies, elevated anxiety sensitivity might confer a need for a longer course of treatment to ensure extinction and avoidance reduction.

4.2 Limitations and future directions

Several limitations to the current study should be noted. The transdiagnostic sample included individuals with anxiety-related disorders, but may not capture behavior patterns that are specific to individual diagnostic categories. Future work in larger clinical samples can extend the clinical utility of these findings by linking task indices with specific clinical symptoms.

In addition, while the present results provide a proof-of-concept for a novel paradigm assessing anxiety-related differences in repetitive threat-neutralization behavior, some methodological limitations of the task should be considered. The task was designed with a relatively small number of extinction trials, to enable examination of both generalization and extinction in a manageable timeframe for participant attention. The first half of the Extinction phase combines passive CS+ trials with both passive and choice CS- trials. While these early presentations of CS+ without a neutralization option and without shock provided an opportunity for extinction learning, the inclusion of CS- choice trials during this phase made it more attentionally demanding, which may have interfered with extinction learning. In light of the present findings, future adaptations of the paradigm with a longer and/or simpler Extinction

phase will further clarify anxiety-related differences in extinction. In addition, in the present version of the task, the amount of reward available was constant across trials, as was the relationship between effort and shock avoidance, limiting our ability to interpret the observed behavior patterns. Future adaptations of the task can manipulate these parameters to disentangle the roles of threat, reward, and effort in avoidance motivation, and to further delineate anxiety-related differences.

The present task used geometric shapes and mild electric shocks to enable *de novo* conditioning, to avoid confounding effects of prior associations participants may have had with already-feared stimuli. However, the use of symptom-specific CSs or USs (e.g., symptom provocation images or verbal prompts) in future adaptations of the task may increase the external validity of the task. Future task adaptations can also modify the type of behavior elicited: for instance, a version of the task in which mental effort serves to neutralize threat may be a better analogue for more covert symptom presentations, such as worry or mental compulsions.

5. Conclusion

Together, these findings suggest that the TTS task successfully elicits maladaptive repetitive threat-neutralization behavior, and captures meaningful individual differences tied to both trait anxiety sensitivity and anxiety-related psychopathology. When confronted with previously-threatening stimuli, anxious individuals showed persistent neutralization behavior at the cost of reward accrual. The TTS task provides a promising experimental platform for studying repetitive threat-neutralization and its role in anxiety and related disorders. Future research with larger clinical populations, and with adaptations of the task, can shed light on individual differences in neutralization behavior, and optimal methods for its reduction.

CRediT authorship contribution statement

Riley Rozniarek: Writing – Original Draft, Visualization, Investigation, Formal Analysis, Data curation. Annette Rostel: Writing – Review & Editing, Formal Analysis. Aardron Robinson: Software, Methodology. Ryan Smith: Writing – Review & Editing, Conceptualization. Martin P. Paulus: Writing – Review & Editing. Robin L. Aupperle: Writing – Review & Editing, Conceptualization. Hannah Berg: Writing – Review & Editing, Visualization, Supervision, Resources, Project administration, Methodology, Data curation, Conceptualization, Funding acquisition.

Declaration of competing interest

Dr. Martin Paulus has received royalties for an article about methamphetamine published in UpToDate. The other authors declare that there were no conflicts of interest with respect to the authorship or the publication of this article.

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References

1. Ball, T. M., & Gunaydin, L. A. (2022). Measuring maladaptive avoidance: From animal models to clinical anxiety. *Neuropsychopharmacology*, *47*(5), 978–986. https://doi.org/10.1038/s41386-021-01263-4

2. Berg, H., Rozniarek, R., Robinson, A., Smith, R., & Aupperle, R. (2025). *The tap-to-safety task: A probe for repetitive threat-neutralization behavior*. Preprint at https://doi.org/10.31234/osf.io/zsx23_v2

3. Bilodeau-Houle, A., Bouchard, V., Morand-Beaulieu, S., Herringa, R. J., Milad, M. R., & Marin, M.-F. (2020). Anxiety sensitivity moderates the association between father-child relationship security and fear transmission. *Frontiers in Psychology*, *11*, 579514. https://doi.org/10.3389/fpsyg.2020.579514

4. Craske, M. G., Treanor, M., Zbozinek, T. D., & Vervliet, B. (2022). Optimizing exposure therapy with an inhibitory retrieval approach and the OptEx Nexus. Behaviour Research and Therapy, 152, 104069. https://doi.org/10.1016/j.brat.2022.104069

5. Diehl, M. M., Bravo-Rivera, C., & Quirk, G. J. (2019). The study of active avoidance: A platform for discussion. *Neuroscience & Biobehavioral Reviews*, *107*, 229–237. https://doi.org/10.1016/j.neubiorev.2019.09.010

6. Gupta, R. S., Kujawa, A., Fresco, D. M., Kang, H., & Vago, D. R. (2022). Mindfulness-based cognitive therapy: A preliminary examination of the (Event-related) potential for modifying threat-related attentional bias in anxiety. *Mindfulness*, *13*(7), 1719–1732. https://doi.org/10.1007/s12671-022-01910-x

7. Gupta, R. S., Kujawa, A., & Vago, D. R. (2019). The neural chronometry of threat-related attentional bias: Event-related potential (ERP) evidence for early and late stages of selective attentional processing. *International Journal of Psychophysiology : Official Journal of the International Organization of Psychophysiology*, *146*, 20–42. https://doi.org/10.1016/j.ijpsycho.2019.08.006

8. Hofmann, S. G., & Hay, A. C. (2018). Rethinking avoidance: Toward a balanced approach to avoidance in treating anxiety disorders. *Journal of Anxiety Disorders*, *55*, 14–21. https://doi.org/10.1016/j.janxdis.2018.03.004

9. Hunt, C., Cooper, S. E., Hartnell, M. P., & Lissek, S. (2019). Anxiety sensitivity and intolerance of uncertainty facilitate associations between generalized Pavlovian fear and maladaptive avoidance decisions. Journal of Abnormal Psychology, 128(4), 315–326. https://doi.org/10.1037/abn0000422

10. LeDoux, J., & Daw, N. D. (2018). Surviving threats: Neural circuit and computational implications of a new taxonomy of defensive behaviour. Nature Reviews Neuroscience, 19(5), 269–282. https://doi.org/10.1038/nrn.2018.22

11. Li, Y., Tian, W., Liu, P., & Geng, F. (2023). A cross-sectional analysis of the relationships between anxiety sensitivity and youth irritability: The mediated roles of insomnia and selective attention for threat. *BMC Psychiatry*, *23*(1), 782. https://doi.org/10.1186/s12888-023-05280-z

12. Lovibond, P. F., Mitchell, C. J., Minard, E., Brady, A., & Menzies, R. G. (2009). Safety behaviours preserve threat beliefs: Protection from extinction of human fear conditioning by an avoidance response. Behaviour Research and Therapy, 47(8), 716–720. https://doi.org/10.1016/j.brat.2009.04.013

13. McGuire, J. F., Orr, S. P., Essoe, J. K.-Y., McCracken, J. T., Storch, E. A., & Piacentini, J. (2016). Extinction learning in childhood anxiety disorders, obsessive compulsive disorder and post-traumatic stress disorder: Implications for treatment. *Expert Review of Neurotherapeutics*, *16*(10), 1155–1174. https://doi.org/10.1080/14737175.2016.1199276
14. Naragon-Gainey, K. (2010). Meta-analysis of the relations of anxiety sensitivity to the depressive and anxiety disorders. *Psychological Bulletin*, *136*(1), 128–150. https://doi.org/10.1037/a0018055
15. Roberts, C., Apergis-Schoute, A. M., Bruhl, A., Nowak, M., Baldwin, D. S., Sahakian, B. J., & Robbins, T. W. (2022). Threat reversal learning and avoidance habits in generalised anxiety disorder. *Translational Psychiatry*, *12*(1), 216. https://doi.org/10.1038/s41398-022-01981-3
16. Taylor, S., Zvolensky, M. J., Cox, B. J., Deacon, B., Heimberg, R. G., Ledley, D. R., Abramowitz, J. S., Holaway, R. M., Sandin, B., Stewart, S. H., Coles, M., Eng, W., Daly, E. S., Arrindell, W. A., Bouvard, M., & Cardenas, S. J. (2007). Robust dimensions of anxiety sensitivity: Development and initial validation of the Anxiety Sensitivity Index-3. *Psychological Assessment*, *19*(2), 176–188. https://doi.org/10.1037/1040-3590.19.2.176
17. Tulacı, R. G., & İzci Kasal, M. (2023). The relationship between family accommodation and anxiety sensitivity in obsessive-compulsive disorder. *Cureus*. https://doi.org/10.7759/cureus.43793
18. Viana, A. G., Trent, E. S., Raines, E. M., Woodward, E. C., Storch, E. A., & Zvolensky, M. J. (2021). Childhood anxiety sensitivity, fear downregulation, and anxious behaviors: Vagal suppression as a moderator of risk. *Emotion*, *21*(2), 430–441. https://doi.org/10.1037/emo0000713

Table 1. Demographics

		Anxiety Diagnosis (n=14)	Healthy Comparison (n=21)	
		M (SD)	***M (SD)***	***p***
Age		35.3 (8.8)	34 (14.4)	.731
		N (%)	***N (%)***	
Sex	Male	2 (14.3%)	9 (42.9%)	.137†
	Female	12 (85.7%)	12 (57.1%)	
Race	American Indian or Alaska Native	1 (7.1%)	0 (0%)	.683†
	Asian	3 (21.4%)	5 (23.8%)	
	Black or African American	0 (0%)	1 (4.8%)	
	Native Hawaiian or Pacific Islander	0 (0%)	0 (0%)	
	White	5 (35.7%)	11 (52.4%)	
	Other	1 (7.1%)	1 (3.8%)	
	Multiracial	4 (28.6)	3 (14.3%)	
		M (SD)	***M (SD)***	
Anxiety Sensitivity		30.6 (15)	8.5 (9.2)	<.001
Current Diagnosis		***N (%)***		-
	Social anxiety disorder	2 (14.3%)	-	
	Panic disorder	6 (42.9%)	-	
	Obsessive-compulsive disorder	3 (21.4%)	-	
	Generalized anxiety disorder	7 (50.0%)	-	

Note: Diagnoses determined via the MINI International Neuropsychiatric Interview 7 (DSM-V); participants with more than one diagnosis were included. †Fisher's exact test

Table 2. Effects of Anxiety Sensitivity on Risk, Anxiety, and Tapping

		Effects of stimulus-type x ASI-3 Total Score interactions			
		DF	*F*	*p*	η_p^2
Discrimination Phase					
	Risk Rating				
	Stimulus x AS	2, 66	2.10	.130	.06
	Anxiety Rating				
	Stimulus x AS	2, 66	0.44	.640	.01
	Tapping				
	Stimulus x AS	2, 66	3.88	.025 *	.11
Generalization Phase					
	Risk Rating				
	Stimulus x AS	5, 165	3.83	.003 **	.10
	Anxiety Rating				
	Stimulus x AS	5, 165	2.03	.080	.06
	Tapping				
	Stimulus x AS	5, 165	6.65	<.001 ***	.17
Extinction Phase					
	Risk Rating				
	Stimulus x AS	2, 66	7.04	.002 **	.18
	Anxiety Rating				
	Stimulus x AS	2, 66	1.11	.340	.03
	Tapping				
	Stimulus x AS	2, 66	7.42	.001 **	.18

Note. Models took the form *Task measure ~ Stimulus* Trait,* with random effects for participant. AS: anxiety sensitivity.

Table 3. Effects of Anxiety-Related Disorder Status on Risk, Anxiety, and Tapping

		Effects of stimulus-type x group interactions			
		DF	*F*	*p*	η_p^2
Discrimination Phase					
	Risk Rating				
	Stimulus x Group	2, 66	0.531	.590	.02
	Anxiety Rating				
	Stimulus x Group	2, 66	0.55	.582	.02
	Tapping				
	Stimulus x Group	2, 66	1.29	.283	.04
Generalization Phase					
	Risk Rating				
	Stimulus x Group	5, 165	0.61	.690	.02
	Anxiety Rating				
	Stimulus x Group	5, 165	0.471	.797	.01
	Tapping				
	Stimulus x Group	5, 165	1.83	.109	.05
Extinction Phase					
	Risk Rating				
	Stimulus x Group	2, 66	4.57	.014 *	.12
	Anxiety Rating				
	Stimulus x Group	2, 66	0.25	.779	<.01
	Tapping				
	Stimulus x Group	2, 66	4.65	.013 *	.12

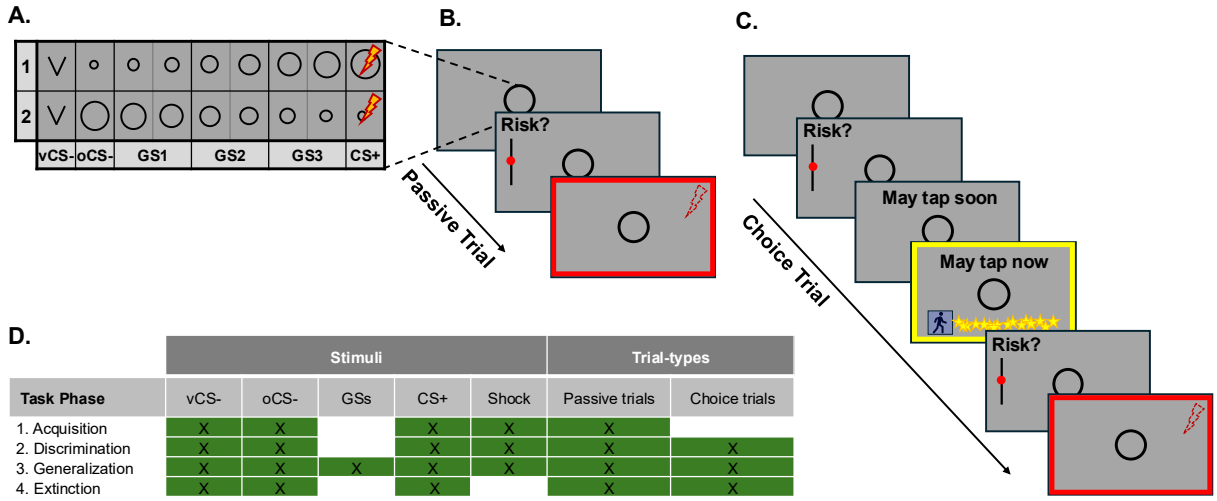
Note. Models took the form *Task measure ~ Stimulus* Trait,* with random effects for participant.

Table 4. Interactions between Trial, Stimulus, and Trait Predictors on Task Measures during the Extinction Phase

		Effects of trial x trait and trial x stim x trait interactions			
		DF	*F*	*p*	η_p^2
Extinction Phase					
ASI-3 Total Score	Risk Rating				
	Trial x AS	1, 585	4.04	.045 *	<.01
	Trial x Stim x AS	2, 585	0.10	.901	<.01
	Anxiety Rating				
	Trial x AS	1, 585	0.27	.604	<.01
	Trial x Stim x AS	2, 585	0.27	.766	<.01
	Tapping				
	Trial x AS	1, 585	39.69	<.001 ***	.06
	Trial x Stim x AS	2, 585	0.16	.852	<.01
Group	Risk Rating				
	Trial x Group	1, 585	5.63	.018 *	<.01
	Trial x Stim x Group	2, 585	0.12	.890	<.01
	Anxiety Rating				
	Trial x Group	1, 585	<0.01	.987	<.01
	Trial x Stim x Group	2, 585	0.29	.747	<.01
	Tapping				
	Trial x Group	1, 585	26.48	<.001 ***	.04
	Trial x Stim x Group	2, 585	0.09	.915	<.01

Note. Models took the form *Task measure ~ Trial * Stimulus * Trait,* with random effects for participant. Models were tested only in the Extinction phase. AS: anxiety sensitivity.

Figure 1. The Tap-To-Safety Task.

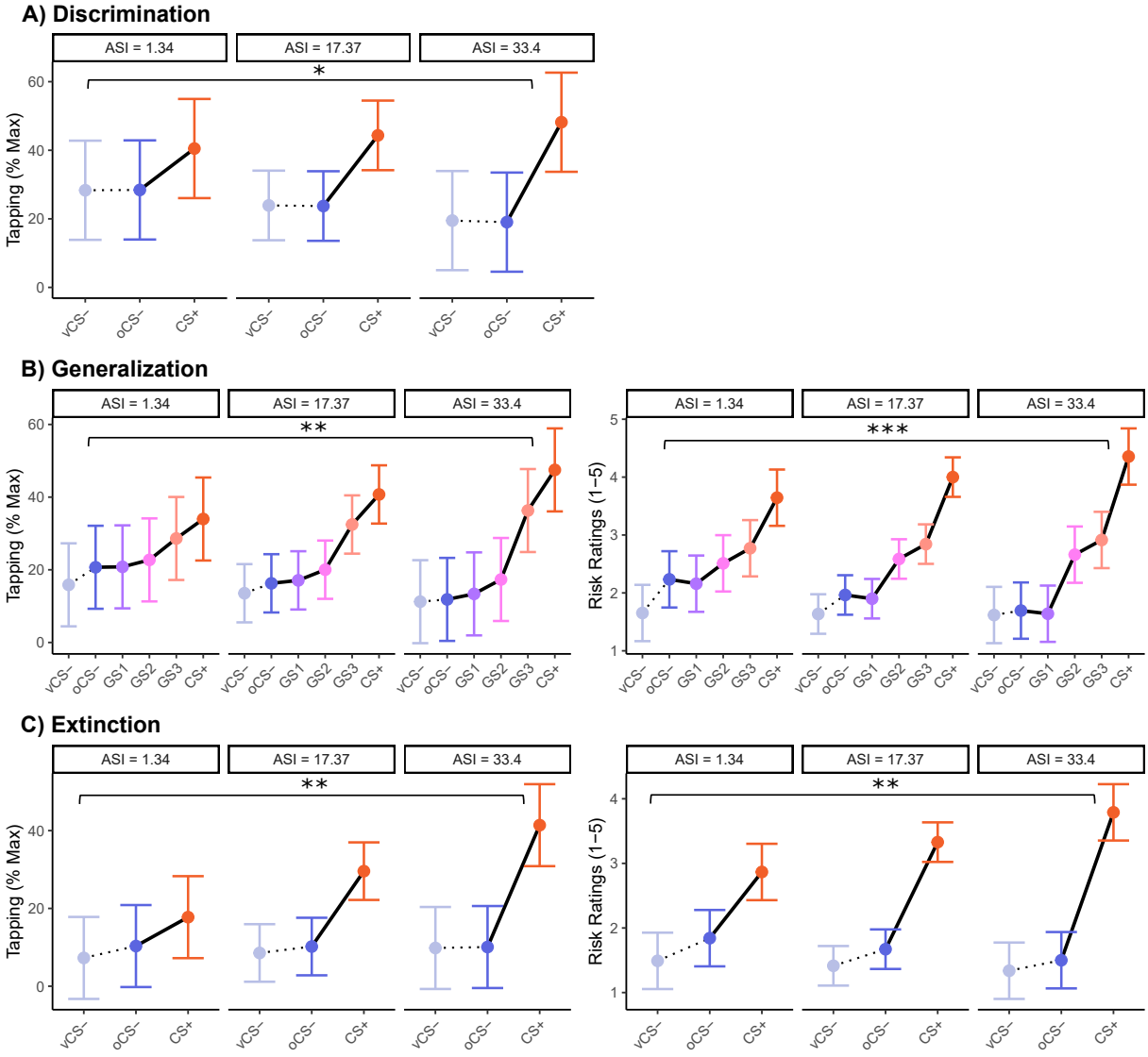


D.

	Stimuli					Trial-types	
Task Phase	vCS-	oCS-	GSs	CS+	Shock	Passive trials	Choice trials
1. Acquisition	X	X		X	X	X	
2. Discrimination	X	X		X	X	X	X
3. Generalization	X	X	X	X	X	X	X
4. Extinction	X	X		X		X	X

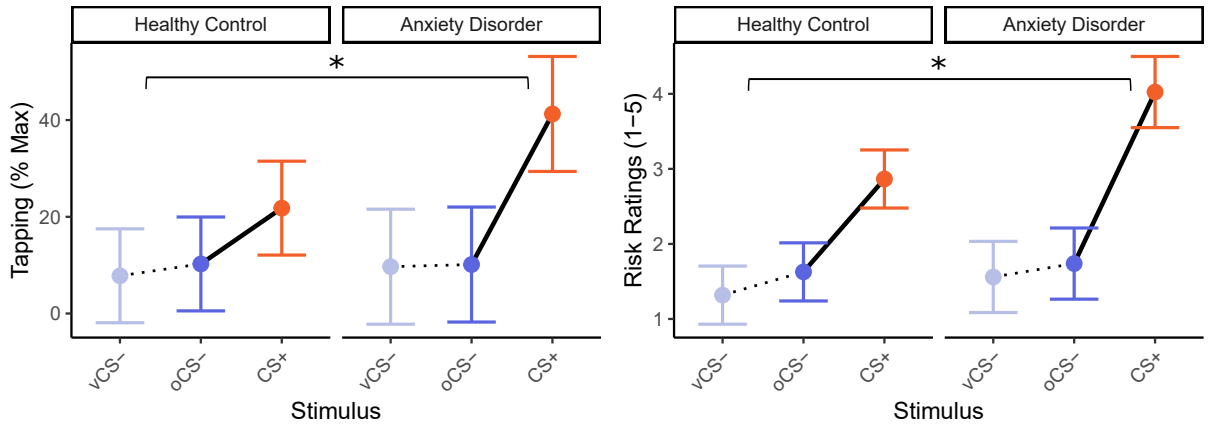
The task included stimuli presented one at a time. **A.** A ring of one extreme size served as the threat cue (conditioned stimulus; CS+) paired with mild electric shock; the other extreme served as the safety cue (oCS-) never paired with shock, a V-shaped stimulus served as an outlier that was also never paired with shock (vCS-). Rings of varying intermediary sizes served as generalization stimuli (GSs) and were also never paired with shock. **B.** Passive trials were included to establish and maintain threat contingencies. On passive trials, participants viewed a stimulus, made a rating of either perceived risk of shock or current anxiety, and received the outcome (shock or no shock). **C.** To assess repetitive threat-neutralization under various threat contexts, choice trials were included in which participants could engage in repetitive threat-neutralization behavior by repeatedly tapping a button to reduce their risk of shock, while also reducing accrual of points. **D.** The task was structured in four phases: an Acquisition phase involving passive trials only of vCS-, oCS- and CS+, a Discrimination phase in which choice trials were introduced, a Generalization phase in which GSs were introduced, and an Extinction phase in which no stimuli were paired with shock.

Figure 2. Anxiety sensitivity associated with heightened risk ratings and neutralization behavior to the true threat-cue and former threat-cue.



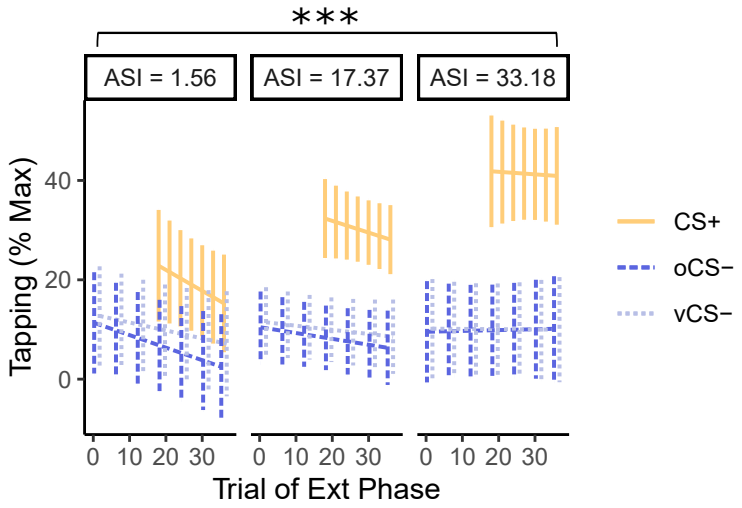
Panels show model estimates for the mean +/-1 SD of anxiety sensitivity scores. Categorical panels are for illustration purposes only; in statistical analyses; anxiety sensitivity was entered as a continuous variable. Asterisks refer to significance of anxiety sensitivity × stimulus interaction effects on task measures. vCS-: v-shaped safety cue, oCS-: ring-shaped safety cue, CS+: threat cue, GS1-3: generalization stimuli. *p<.05, **p<.01, ***p<.001.

Figure 3. Anxiety disorders associated with heightened risk ratings and neutralization behavior to the former threat-cue.



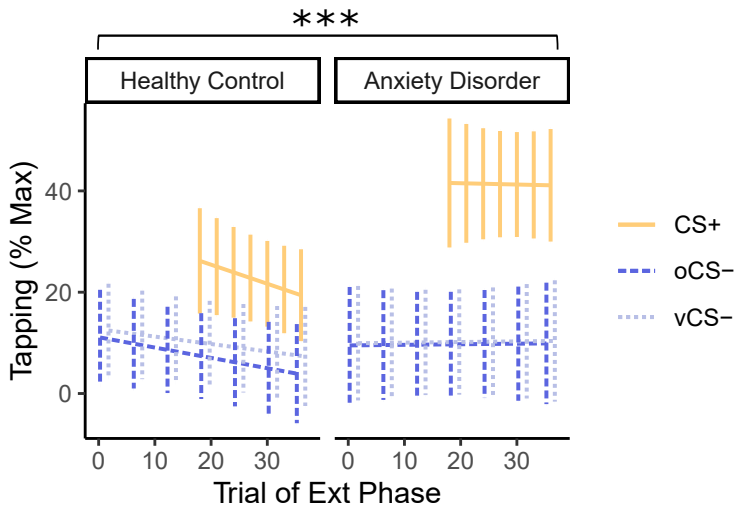
Asterisks refer to significance of anxiety disorder × stimulus interaction effects on task measures. vCS-: v-shaped safety cue, oCS-: ring-shaped safety cue, CS+: threat cue, GS1-3: generalization stimuli. *p<.05, **p<.01, ***p<.001.

Figure 4. Slowed extinction of neutralization behavior across trials in elevated anxiety sensitivity.



Panels show model estimates for the mean +/-1 SD of anxiety sensitivity scores. Categorical panels are for illustration purposes only; in statistical analyses; anxiety sensitivity was entered as a continuous variable. Asterisks refer to significance of anxiety sensitivity × trial on neutralization behavior (i.e., tapping), in models with the form *Task measure ~ Trial * Stimulus * ASI.* Choice trials for CS+ are introduced in the latter half of the Extinction phase; therefore, estimates for these later trials are shown. ASI: Anxiety Sensitivity Index – 3; vCS-: V-shaped safety cue, oCS-: ring-shaped safety cue, CS+: threat cue. *p<.05, **p<.01, ***p<.001.

Figure 5. Slowed extinction of neutralization behavior across trials in anxiety-related disorders.



Asterisks refer to significance of anxiety sensitivity × trial on neutralization behavior (i.e., tapping), in models with the form *Task measure ~ Trial * Stimulus * Group (AD, HC)*. Choice trials for CS+ are introduced in the latter half of the Extinction phase; therefore, estimates for these later trials are shown. AD: anxiety-related disorder; HC: healthy comparison; vCS-: V-shaped safety cue, oCS-: ring-shaped safety cue, CS+: threat cue. *p<.05, **p<.01, ***p<.001.