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Testing a novelty-based extinction procedure for the reduction of conditioned avoidance

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ABSTRACT

Background and objectives: Excessive avoidance towards non-dangerous cues is a key diagnostic criterion across anxiety-related disorders. Despite current therapies being successful in reducing such avoidance, relapse rates remain high. Based on recent findings, according to which learned fear responses were reduced after the presentation of the fear stimulus with a novel-neutral event (*novel-based extinction*), we tested whether novel-based extinction could diminish conditioned avoidance.

Methods: Forty-six participants completed a Pavlovian acquisition procedure during which two pictures of a spider were presented, one of which (CS^+) was always followed by a shock (US), while the other (CS^-) was never followed by a US. Next, participants learned that they could avoid the shock by pressing a computer button. An extinction and response procedure followed. During this phase, the control group was presented with both CSs that were not followed by the US. The experimental group encountered both CSs, but the CS^+ was followed by a neutral event (i.e., presentation of a tone). Return of avoidance (i.e., button presses) and fear (i.e., US-expectancies and fear-ratings) towards both CSs was tested after three unexpected presentations of the US.

Results: Similar levels of return of avoidance and explicit fear were found for both groups.

Limitations: We collected no physiological measures of fear and we assessed only the short-term effects of our manipulation.

Conclusions: Our results do not support the hypothesis that novelty-based extinction reduces avoidance responses. This study can serve as a first exploration of novelty-based extinction for reducing avoidance and explicit measures of fear.

1. Introduction

Avoidance towards dangerous cues is necessary for adaptive functioning. Alas, often excessive avoidance is expressed towards largely safe cues (e.g., social groups, doorknobs, dizziness). In such cases, avoidance loses its adaptive role and can transform into a symptom of an anxiety-related disorder (e.g., social anxiety disorder, obsessive-compulsive disorder, panic disorder). Given the significant impact of anxiety-related disorders in the lives of the sufferer and the society (Greenberg et al., 1999; Konnopka, Leichsenring, Leibing, & König, 2009), the reduction of pathological avoidance is an issue of high scientific and societal value.

Research and interventions for anxiety-related disorders have mainly focused on Pavlovian processes (Treanor & Barry, 2017). For example, an evidence-based treatment for reducing anxiety symptomatology is exposure therapy. A common laboratory model of this clinical intervention is fear extinction (for a detailed comparison between exposure therapy and extinction, see Scheveneels, Boddez, Vervliet, & Hermans, 2016). Fear extinction entails the presentation of an initially innocuous stimulus (e.g., a picture of a spider; Conditioned Stimulus or CS) that was previously paired with an evolutionary dangerous stimulus (e.g., a shock; Unconditioned Stimulus or US), without the US. To reduce fear and avoidance, extinction is often combined with response prevention (ExtRP; Voss, Mejta, & Reid, 1974), so as to make sure that the participant is confronted with the fearful stimulus (see Rachman, Radomsky, & Shafran, 2008 for the role of avoidance is extinction therapy). However, avoidance behavior can persist after extinction (Lovibond, Chen, Mitchell, & Weidemann, 2013) and causes a return of fear (Uijen, Leer, & Engelhard, in press; Vervliet & Indekeu, 2015).

The failure to reduce avoidance in the long term can be explained by referring to the ambiguous meaning of the CS at the end of the ExtRP procedure. Research in both animal and humans (Bouton, 1993, 2000, 2002) suggests that the mere presentation of the CS without the US does not lead to the unlearning of the initial CS-US associations but rather to the formation of a new *extinction memory* (i.e., CS-noUS associations)

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Table 1
Experimental phases. Fear ratings were collected before and after each phase. The number of trials in each phase is presented in brackets.

Fear Conditioning	Avoidance Conditioning	Response Prevention and Extinction		Reinstatement Test	Reextinction Test
CS+ (2) CS- (2)	CS+ (8) CS- (8)	CS+ (12) CS- (12)	US (3)	CS+ (2) CS- (2)	CS+ (4) CS- (4)

that fights for dominance over the initial *acquisition memory* (i.e., CS-US associations). Based on these results, it can be argued that the effects of ExtRP could be enhanced by reducing the ambiguity of the CS meaning at the end of fear extinction.

New research has provided evidence towards this direction. In two experiments, Dunsmoor, Campese, Ceceli, LeDoux, and Phelps (2015) have shown that *novelty-based extinction*, where a CS is associated during an extinction procedure with a novel, neutral event rather than a non-event, is sufficient in reducing the return of extinguished fear responses as were measured in terms of freezing in animals or skin conductance responses in humans. Dunsmoor et al. (2015) argued that the pairing of the CS^+ with a novel stimulus, rather than just the absence of any event, made the extinction memory stronger, reducing the return of fear.

Inspired by these findings, we sought to investigate whether the combination of the novelty-based extinction procedure with response prevention could block the return of avoidance. Human participants underwent an avoidance learning procedure where they learned to avoid a CS by pressing a computer button. Subsequently, participants were separated into two groups, with one group undergoing a standard ExtRP and the other group undergoing a novelty based extinction in combination with response prevention. The return of avoidance and subjective fear was measured after the presentation of unexpected USs (i.e., *reinstatement* procedure; Bouton, 2002). We expected that the novelty-based extinction group (NERP) would exhibit less avoidance, indicated by the number of button presses, and less return of fear, as indicated by US-expectancies and fear ratings, during the reinstatement phase compared to the ExtRP group.

2. Materials and methods

2.1. Participants

Forty-six healthy individuals (33 females; mean age, SD: 22.33 years 2.51), participated in the study in exchange of student credits or 8 euros. Participants were randomly and equally assigned to the NERP and the ExtRP group. All procedures have been approved by the Ethics Committee Board of Utrecht University (FETC16-054). Regarding the sample size, we decided that because no prior studies have been conducted with our design, the minimal interesting effect for our study would be a medium effect size. Please note that for a Cohen's *f* of .25 (medium effect size), 2 groups (NERP and ExtRP), 2 measurements (CS^+ and CS^-), alpha of 0.05, and power of .80, the minimal total size should be at least 34 individuals. Due to the new experimental paradigm, we had decided to collect more data due to potential participants having to be excluded from further analyses due to unsuccessful manipulation (see below).

2.2. Material

2.2.1. Self reports

Participants rated their expectancy of a US occurrence during each CS presentation on a scale anchored from −5 (certainly no electric stimulus) to +5 (certainly an electric stimulus). Fear levels for each CS were evaluated using a continuous scale anchored from 0 (not afraid at all) to 10 (very afraid). Participants also rated the surprisingness of the neutral tone, in case they had heard it during the computer task, in a continuous scale from −5 (not surprising at all) to 5 (much surprising). Lastly, participants rated their motivation to complete the computer task and fill in the questionnaires in two different rating scales ranging form −5 (really low) to 5 (really high).

Participants filled in the following questionnaires: STAI-S and STAI-T (Spielberger, Gorsuch, & Lushene, 1970), Intolerance of Uncertainty (IOU; Bruin, Rassin, Heiden, & Muris, 2006), the Anxiety Sensitivity Index (ASI; Peterson & Reiss, 1993), and the neuroticism scale of the Eysenck Personality Questionnaire (EPQ-N; Eysenck & Rachman, 1975).

2.2.2. Stimuli

Pictures of 2 spiders (items 1200 and 1201 from Lang, Bradley, and Cuthbert (1999); 13 cm × 10.5 cm) served as CSs. A picture of a manikin figure (4 cm × 4 cm) was also presented on each trial (see below).

An electric shock administered to the middle phalange of the index and middle fingers of the participants' non-dominant hand served as a US (Engelhard, Uijen, Seters, & Velu, 2015). The US was generated by a Coulbourn Transcutaneous Aversive Finger Stimulator (E13-22). The intensity of the shock was individually set to a level that was “highly annoying but not painful” (Krypotos, Effting, Arnaudova, Kindt, & Beckers, 2014).

Similar to Dunsmoor et al. (2015), a short bleep sound of 60 db served as the neutral event presented in the NERP (see below).

2.3. Procedure

For a schematic depiction of the experimental procedure see Table 1.

Prior to the beginning of the main experiment, participants read the information brochure, signed the informed consent form, and filled in the STAI-S. Participants were then fitted to the shock electrodes and the shock intensity was determined.

The experiment started with the fear ratings of each CS. Then, on-screen and oral instructions informed participants that they would see pictures of two different spiders, one of which would sometimes be followed by a shock while the other would never be followed by a shock. Instructions stressed that participants had to figure out the contingencies between the CSs and the US. They could rate their expectancy of a US occurring by using the expectancy rating scale that would be presented at the beginning of each trial. They were then asked to put on the headphones. In order to not reveal the future presentation of the surprising tones in the NERP group, instructions mentioned that the headphones served the blocking of any background noise.

During the Pavlovian acquisition phase, each CS was presented twice at the center of the screen, with the manikin presented on the bottom of the screen. The manikin was present throughout the whole experimental task. This number of Pavlovian trials is in line with similar avoidance learning tasks (e.g., Vervliet & Indekeu, 2015). Also, our prior studies with similar instructions about the CS-US contingencies revealed that Pavlovian differentiation reaches high levels after only 2 trials (e.g., Krypotos et al., 2014). Each trial started with 3 s presentation of the CS and the manikin. Then, the US-expectancy scale was presented for 8 s. Participants could rate their expectancy in the first 5.5 s. In case of a CS^+ trial, the US was presented after 7.5 s from the point that the US expectancy scale was presented. After presentation of the US Expectancy scale (11s after trial onset), the CS was presented together with the manikin for 3.75 s. This last period was used for