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Enhancing extinction with response prevention via imagery-based counterconditioning: Results on conditioned avoidance and distress☆

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ABSTRACT

Background and objectives: Maladaptive avoidance is a core characteristic of anxiety-related disorders. Its reduction is often promoted using *extinction with response prevention* (ExRP) procedures, but these effects are often short-lived. Research has shown that pairing a feared stimulus with a stimulus of an incompatible valence (i.e., counterconditioning) may be effective in reducing fear. This laboratory study tested whether positive imagery during ExRP (i.e., imagery counterconditioning protocol) can also reduce avoidance.
Methods: In the counterconditioning procedure, participants imagined a positive sound. There were four phases. First, participants were presented with squares on a computer screen of which one (CS+) was paired with an aversive sound and another (CS-) was not. Second, they learned to avoid the negative sound in the presence of the CS+, via a key press. Third, they were assigned to either the *Counterconditioning* (that was asked to imagine a positive sound during ExRP) or *No Counterconditioning* group (standard ExRP). Finally, they performed a test phase that consisted of two parts: in the first part, avoidance responses were available for each CS and in the second part, these responses were prevented.
Results: The *Counterconditioning* intervention resulted in a short-lived reduction of distress associated with the CS+. However, groups did not differ in avoidance or distress during the test phases.
Limitations: US-expectancy ratings were collected only at the end of the experiment.
Conclusions: The results indicate that positive imagery during ExRP may be effective in reducing distress during the intervention. Explanations for the persistence of avoidance and fear are discussed.

1. Introduction

Anxiety-related disorders affect about one-third of the population during their lifetime (Bandelow & Michaelis, 2015). A widely implemented intervention for anxiety-related disorders is exposure with response prevention, which aims to reduce excessive avoidance and fear by diminishing threat expectancies via repeated encounters with the feared stimulus while avoidance responses are prevented (Hofmann & Smits, 2008; Vervliet, Craske, & Hermans, 2013). Such exposure provides patients with information to develop more realistic perceptions of the likelihood or intensity of the feared outcome (e.g., someone may laugh during a presentation, but the entire audience will not laugh). The experimental proxy of exposure-based therapy is extinction training with response prevention (ExRP) (see Scheveneels, Boddez, Vervliet, & Hermans, 2016), in which an individual is repeatedly exposed to a fear-conditioned stimulus (CS+) in the absence of a negative outcome (i.e., unconditioned stimulus; USneg). Presumably, this creates a 'safety memory' (CS + - no USneg) that competes with the original threat memory (CS + - USneg) during future CS + encounters (Craske, Treanor, Conway, Zbozinek, & Vervliet, 2014).

Exposure therapy is generally effective for anxiety-related disorders (Cuijpers, Cristea, Karyotaki, Reijnders, & Huibers, 2016), but 40–60% of patients do not achieve clinical relief of symptoms (Arch & Craske, 2009; see; McGuire, Lewin, & Storch, 2014) and concerns remain regarding the long-term reduction of anxiety symptomatology (Van Dis et al., 2020). Furthermore, a significant number of patients may refuse or drop out of exposure-based treatment (e.g., Haby, Donnelly, Corry, & Vos, 2006; Issakidis & Andrews, 2004).

A core characteristic of anxiety-related disorders is the maladaptive avoidance of feared objects and/or situations (American Psychiatric

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Association, 2013). Avoidance behaviors can prevent individuals from accessing evidence that may disconfirm fear-related beliefs (Barlow, 2002), and thus, may contribute to the persistence of irrational fears (e.g., Krypotos, Effting, Kindt, & Beckers, 2015). Crucially, experimental evidence suggests that avoidance (i) is resistant to extinction-based procedures; (ii) may persist following the reduction of pathological fear, and (iii) may motivate a subsequent return of fear (Lovibond, Chen, Mithcell, & Wiedemann, 2013; Van Uijen, Leer, & Engelhard, 2018). The mere removal of the US_{neg} in extinction-based procedures is likely insufficient to promote a dominant activation of the safety memory over the threat memory and may simply promote uncertainty regarding future threat (see Dunsmoor, Campese, Ceceli, LeDoux, & Phelps, 2015). Evidence that uncertainty can promote avoidance behaviors among anxious individuals (Lommen, Engelhard, & van den Hout, 2010) suggests that such responses may occur as a precaution against anticipated threat during future encounters with the feared stimulus. Thus, there remains a need to investigate how to best address maladaptive avoidance responses.

Recent research provides some indication that counterconditioning, which involves pairing a CS+ with a stimulus of an incompatible (e.g., positive) valence (Bouton & Peck, 1992), may be effective in reducing both avoidance and fear (see Keller, Hennings, & Dunsmoor, 2020; Newall, Watson, Grant, & Richardson, 2017). Pairing of the CS+ with a positive stimulus can reduce negative CS + valence (e.g., Engelhard, Leer, Lange, & Olatunji, 2014; Raes & de Raedt, 2012), which is an important motivator of avoidance and fear (Dirikx, Hermans, Vansteenwegen, Baeyens, & Eelen, 2004; Zbozinek, Hermans, Pernoveau, Liao, & Craske, 2015). Importantly, the reduction of negative CS + valence likely does not occur merely as a result of general positive affect (van Dis, Hagenaars, Bockting, & Engelhard, 2019). Furthermore, pairing a CS+ with a US_{pos} presumably creates a new memory directly linking the CS + to a non-threat stimulus, which may violate threat expectancies and weaken CS + associated uncertainty (Engelhard et al., 2014; Kang, Vervliet, Engelhard, van Dis, & Hagenaars, 2018). This suggests that counterconditioning may hold promise in reducing avoidance via a new “safety” memory and by reducing the accessibility of the threat memory. Recent evidence suggests that safety memories formed by counterconditioning procedures may be stronger than those of extinction, which may facilitate its subsequent retrieval (Keller & Dunsmoor, 2020).

Yet, the presence of a positive object during repeated exposure to a CS + may reinforce ‘safety behaviors’. For example, a meaningful token that is held during repeated exposure to a feared stimulus may become associated with the absence of a negative outcome and may serve as a reminder of safety in future encounters. Safety behaviors are typically performed to diminish or neutralize the threatening aspects of the feared CS+ (van den Hout, Reininghaus, van der Stap, & Engelhard, 2012). It is not uncommon for patients to engage in such subtle behaviors during therapy (e.g., Tang et al., 2007). Some have posited that, similar to avoidance, safety behaviors may contribute to the persistence of irrational fears by preventing individuals from accessing fear-disconfirming evidence (Salkovskis, Clark, Hackmann, Wells, & Gelder, 1999; Wells et al., 1995). However, despite clinical concerns of the impact on the long-term effectiveness of exposure-based interventions (Meulders, van Daele, Volders, & Vlaeyen, 2016), safety behaviors may be beneficial when used cautiously in therapy (e.g., Rachman, Radomsky, & Shafran, 2008; van den Hout, Engelhard, Toffolo, & van Uijen, 2011; van den Hout et al., 2012).

In light of evidence that safety behaviors may not be as detrimental as previously thought, counterconditioning may be useful to address anxiety-related avoidance responses. However, research demonstrating that distress may be heightened when encountering the CS+ in absence of the safety behavior should not be discounted (see Craske et al., 2008). For this reason, the present study investigated a modified counterconditioning procedure that substituted the use of a physical positive stimulus with positive imagery.[1] Imagery plays a powerful role in maintaining anxiety-related symptoms (Craske et al., 2009; Grupe & Nitschke, 2013), and it is unsurprising that imagined stimuli may serve in place of actual stimuli (for reviews see Dadds, Bovbjerg, Redd, & Cutmore, 1997, and Mertens, Krypotos, & Engelhard, 2020; Krypotos, Leer, Mertens, & Engelhard, 2019). Given the interdependence of memories of the past and anticipations of the future (Schacter & Addis, 2007), positive imagery during exposure may be particularly useful in promoting more positive (or less negative) future encounters with a CS+, thus assisting the reduction of avoidance and fear. This is in line with findings that safety behaviors may be useful in reducing the aversive nature of exposure-based interventions (see Meulders et al., 2016).

Therefore, the present study investigated whether an imagery-based counterconditioning procedure can enhance the effects of standard ExRP in terms of avoidance and distress. The present study employed a **Pavlovian acquisition** phase, in which participants learnt to associate a CS with a US_{neg} (CS+) while another CS remained unpaired (CS-). In a subsequent **Instrumental phase**, participants learnt to avoid the US_{neg} (via a spacebar press) during presentations of the CS+, and not the CS-. In the **Intervention phase**, participants were assigned to either engage in mental imagery of a positive sound during ExRP (i.e., *Counterconditioning*) or to undergo standard ExRP (i.e., *No Counterconditioning*). In the final **Test phases**, each CS was presented while avoidance responses were made available to participants (Test phase 1) or not (Test phase 2). It was expected that, compared to *No Counterconditioning*, the *Counterconditioning* group would exhibit less avoidance of the CS+ during Test phase 1, and less distress associated with the CS+ in Test phase 1 and Test phase 2.

2. Method

2.1. Participants

Participants were recruited via advertisements at <hidden>the University of Utrecht and the Applied University of Utrecht. Participants indicating a (history of) psychiatric, anxiety or post-traumatic disorder, a medical condition (i.e., epilepsy or heart condition), hearing impairment, color-blindness, (possible) pregnancy, use of attention, reaction or memory-altering medication, or participation in a similar study of the same lab were excluded.

An a-priori power analysis in G*Power (Erfelder, Faul, & Buchner, 1996) indicated that the study required a sample of 52 participants to attain a medium *f* effect size of 0.20, an alpha level of 0.05 and a power of .80. An additional four participants were recruited per condition to account for potential exclusions. The study was approved by the local ethical committee (FETC16-068) and was preregistered after 35 out of the total 60 participants had been tested and before the data had been inspected. All study material are available (https://osf.io/uvx62/?view_only=72cd709c0a9c409484b58817c6333283).

Sixty students (50 females, 10 males; $M_{age} = 21.48$, $SD_{age} = 2.03$) participated in the study in exchange for course credit or 8 euros. They

[1] While it can be argued that the manipulation reflects operant conditioning rather than counterconditioning, it is important to note that participants were merely instructed when to imagine the positive sound. Operant conditioning on the other hand involves performing a behavior to influence the environment and the learning occurs through the consequence generated by the environment.

were randomly assigned to the *Counterconditioning* or *No Counterconditioning* group (counterbalanced). Fourteen participants were excluded due to no fear conditioning in the Acquisition phase (i.e., no distress associated with the CS + or greater distress associated with the CS-). An additional three were excluded for a lack of contingency awareness following the Acquisition phase (i.e., US_{neg} expectancy scores was not greater for the CS + than the CS-).[2]

2.2. Stimuli

Two colored squares (green and orange) of 100 × 100 pixels were used as the CSs and were counterbalanced across participants. A similar white square was used during the practice rounds. Six sounds from the International Affective Digitized Sounds (IADS-2; Bradley & Lang, 2007) were used as potential USs. Three unpleasant (index numbers 275, 276, and 279) and three pleasant (index numbers 110, 220, and 311) sounds were selected based on valence and arousal ratings. They were human sounds that were not too similar to each other (e.g., baby laughing and woman screaming). The sounds were presented in blocks (unpleasant vs. pleasant), which were counterbalanced across participants. The US_{neg} and US_{pos} were the sounds rated as most unpleasant and pleasant by each participant. If more than one sound had the same rating, the US_{neg}/US_{pos} was selected at random.

2.3. Measurements

Unpleasantness of the (imagined) USs was rated using an 11-point scale ranging from −5 (*very unpleasant*) to 0 (*neutral*) to 5 (*very pleasant*). Vividness of the imagined sound was rated using an 11-point scale ranging from 0 (*not at all*) to 10 (*extremely*). Mood was indicated on a 100 cm visual analogue scale (VAS) with the extreme ends labelled as '*negative*' and '*positive*'.

Expectancy of the US_{neg} (i.e., "How much did you expect the sound at the end of the previous phase?") was rated on an 11-point scale ranging from −5 (*expecting no sound for sure*) to 0 (*uncertain*) to 5 (*expecting the sound for sure*). Distress associated with each CS (i.e., "How distressed or anxious do you feel at the moment?"; see Gazendam, Kamphuis, & Kindt, 2013) was rated on an 11-point scale ranging from 0 (*not at all distressed or anxious*) to 10 (*very distressed or anxious*). Avoidance was measured by the cumulative number of space bar presses during each phase.

The Betts' Questionnaire Upon Mental Imagery (QMI; Sheehan, 1967) is a 35-item questionnaire assessing mental imagery ability that was administered for exploratory purposes. Participants indicated how vividly they were able to imagine various situations (e.g., *image of a friend*) on a 7-point scale (1 = *Perfectly clear and as vivid as the actual experience,* 7 = I *think about it but cannot imagine it)*. A total sum imagery ability score was calculated, with greater scores representing weaker imagery ability.

2.4. Procedure

A schematic overview of the experimental design is presented inTable 1. Participants first read the information letter and provided written informed consent. They were then presented with the six sounds and rated the (un)pleasantness of each sound. The most unpleasant (US_{neg}) and pleasant (US_{pos}) sounds were presented once more and participants provided each sound with a title. Participants then indicated their current mood.

The main computer task began with a practice round, involving two presentations of the white CS square. Each trial began with a 5 s presentation of the CS, after which the distress scale appeared for 7.5 s.

Table 1
Overview of the experimental design.

Pre-Acquisition	Acquisition Phase	Instrumental Phase	Intervention Phase	Test Phase 1	Test Phase 2
CS+ (1)	CS+/US_{neg} (6)	CS*+/US_{neg}^ (6)	CS+/US_{pos} (16)	CS*+ (4)	CS+ (4)
	CS+ (2)				
	CS- (8)	CS+/US_{neg} (2)	CS- (16)	CS* - (4)	CS- (4)
CS- (1)			CS+ (16)		
		CS*- (8)			
			CS- (16)		

Note. Numbers within the parentheses indicate the number of trials. CS + represents the CS square that was paired with the US_{neg}, and the CS- represents the CS square that was never paired with the US_{neg}. US_{neg}: presentation of most unpleasant sound as rated by each participant (US_{neg}), US_{pos}: imagination of the most pleasant sound as rated by each participant (US_{pos}), *: presentation of the lightbulb, ^: Avoidance response availability where US_{neg} presentation was conditional upon whether participants pressed the space bar or not.

Participants could rate their distress in the first 5 s of the scale presentation. The inter-trial-intervals were randomized and were between 4 and 7 s (plus an additional 6.3 s in trials where the US_{neg} was not presented - to control for the length of the US_{neg} sound). The trials in all subsequent phases followed the same structure (adapted from Krypotos & Engelhard, 2018; see Fig. 1).

Participants then began the **Habituation phase**. The CS+ and CS- were each presented once, and participants rated their distress level during each presentation. At the end of the phase, they indicated US_{neg} expectancy for each CS. Next, the Pavlovian **Acquisition phase** began. The CS+ and CS- were randomly presented eight times each. There were 6 pairings of CS+ with the US_{neg} (80% contingency). There were no more than two subsequent presentations of each CS and no more than one unpaired presentation of the CS+. At the end of the phase, participants indicated US_{neg} expectancy for each CS.

Participants were then instructed that in the following phase (i.e., **Instrumental phase**) they could cancel the US_{neg} by pressing the spacebar within the first 5 s of the CS presentation. They were instructed to only press the spacebar when a lightbulb appeared on the screen, they expected the US_{neg} to follow, *and* they wanted to avoid it. This was, firstly, to ensure that participants would not press the spacebar during CS- trials and, secondly, to clarify that they were only to press the spacebar because they wanted to avoid the US_{neg} rather than because they simply saw the lightbulb. There was first a practice round involving two presentations of the white CS square. In the Instrumental phase, the CS+ and CS- were presented eight times each (80% contingency). For six of the trials, the CSs were presented with the lightbulb, and the US_{neg} followed the CS + if the spacebar was not pressed. For the other two trials, the CSs were not accompanied by the lightbulb and the US_{neg} was presented after the CS+, regardless of whether the spacebar was pressed. This was done to demonstrate that the US_{neg} still followed the CS+ (e.g., Engelhard, van Uijen, van Seters, & Velu, 2015). At the end of the phase, participants rated US_{neg} expectancy for each CS.

Next, participants underwent the **Intervention phase**. Participants in the *Counterconditioning* group were asked to recall the US_{pos} as vividly and detailed as possible (see Appendix A), and to indicate how vivid and (un)pleasant the imagined sound was. They were then instructed to imagine the US_{pos} as vividly as possible after every CS + presentation. Participants in the *No Counterconditioning* group were simply told that "The experiment will now continue". The Intervention phase involved 16 presentations of the CS+ and CS- each. At the end of the phase, participants in the *Counterconditioning* group again rated vividness and (un)pleasantness of the imagined US_{pos}. All participants rated US_{neg} expectancy for each CS.

Participants then completed two test phases, each involving four

[2] The results of the complete data set were in the same direction as the results reported here.

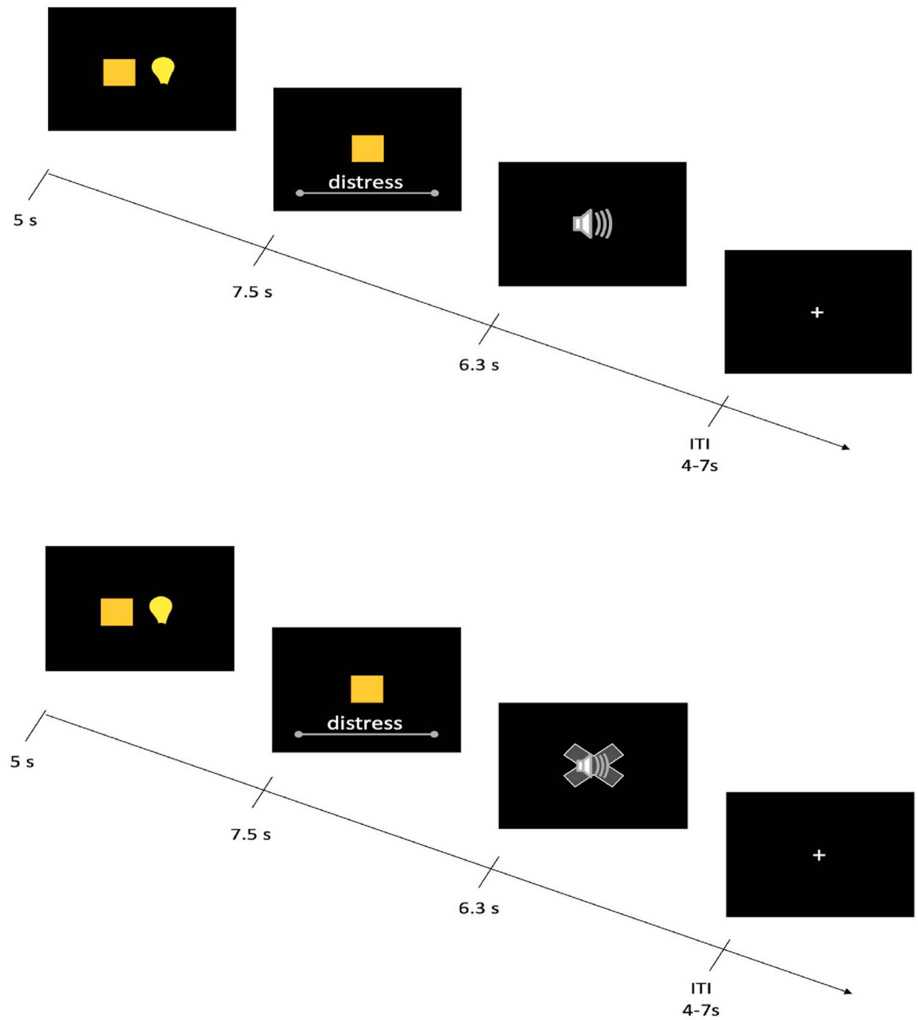

Fig. 1. Structure of CS + trial in the Acquisition (top) and Instrumental phases (bottom). In trials where the USneg was not presented, the ITI was increased by 6.3s to control for the length of the sound. In the Instrumental phase, the presentation of the USneg was conditional upon whether participants pressed the spacebar (i.e., avoidance response) during the first 5 s presentation of the CS+ with the lightbulb.

presentations of the CS+ and CS- each. In **Test phase 1**, the CSs were presented along with the lightbulb (i.e., indicating the availability of an avoidance response). In **Test phase 2**, the CSs were presented alone to investigate group differences when avoidance responses were prevented. The US_{neg} was not presented in either of the test phases. Following each test phase, participants rated US_{neg} expectancy for each CS.

All participants again indicated their current mood and then provided their age and gender. Next, they answered manipulation check questions pertaining to the intervention phase in interview format (i.e., “Did you think of the negative sound?“; “Did you think of the positive sound?“; “What do you think the study is about?“) and completed the QMI (Sheehan, 1967). Lastly, participants were debriefed, thanked, and compensated.

2.5. Statistical analyses

Between-group differences in USneg unpleasantness, imagery ability and age were tested with independent samples *t*-tests, and sex differences with a chi-square test. To test the vividness and pleasantness of the imagined US_{pos}, separate repeated measures ANOVAs were conducted on pre and post-intervention vividness and (un)pleasantness ratings.

Separate 2 CS (CS + vs. CS-; within-subject) x 2 Group (*Counterconditioning* vs. *No Counterconditioning*; between-subject) repeated measures ANOVAs were conducted on avoidance responses. In line with previous studies (e.g., Krypotos & Engelhard, 2019; Vervliet & Indekeu, 2015), avoidance data was analyzed by first computing the proportion of avoidance responses separately for each stimulus and for the Instrumental phase and Test phase 1. Similar ANOVAs were conducted for the distress ratings, with Trial as an additional within-subject factor, for each phase separately. Trial level was adjusted according to phase (see Table 1). Further 2 CS (CS + vs. CS-; within-subject) x 2 Group (*Counterconditioning* vs. *No Counterconditioning*; between-subject) repeated measures ANOVAs were conducted on US_{neg} expectancy ratings for each phase, separately. Greenhouse-Geisser corrections were used in the case of heterogeneity violations. Significant interactions were further explored with post-hoc tests using Bonferroni corrections.

In addition to the above analyses, the data was analyzed using Bayes factors with the BayesFactor R package (Morey & Rouder, 2015) and JASP (Love et al., 2015). The prior distributions had a Cauchy distribution with a mean of zero and scale factor of 0.707 for the alternative hypothesis (as done in Krypotos & Engelhard, 2018). Sensitivity analyses using a scale factor of 1 for the Cauchy distribution were conducted. As the direction of the results remained the same, the paper presents the results with the scale factor of 0.707. Bayes factors that provides relative evidence that the data comes from the alternative, compared to the null, hypothesis is denoted at BF_{10} and BF_{01} for the reverse.

2.5.1. Exploratory analyses

To explore potential effects of mood on avoidance responses, distress and US_{neg} expectancy ratings, 2 (CS: CS + vs. CS-) x 2 (Group: *Counterconditioning* vs. *No Counterconditioning*) RM-ANOVAs with mood as a covariate were conducted for Test Phases 1 and 2, separately. All pre-registered exploratory analyses were non-significant (see Appendix B).

3. Results

Both groups perceived the US_{neg} as unpleasant ($M = -4.48$, $SD = 0.66$), $t(40.79) = 0.22$, $p = .829$, $d = 0.07$, $BF_{01} = 3.27$. Groups did not differ in imagery ability, $t(40.26) = -0.28$, $p = .783$, $d = 0.09$, $BF_{01} = 3.23$, age, $t(38.07) = 0.63$, $p = .531$, $d = 0.19$, $BF_{01} = 2.83$, or sex, $\chi^2(1) < 1$, $BF_{01} = 2.78$.

Participants in the *Counterconditioning* group, perceived the US_{pos} as significantly less pleasant at the end of the intervention phase ($M = 2.94$, $SD = 1.87$) compared to the start ($M = 3.70$, $SD = 1.15$), $t(21) = 2.37$, $p = .028$, $d = 0.51$, $BF_{10} = 2.16$. Similarly, the US_{pos} was imagined less vividly at the end of the intervention ($M = 6.30$, $SD = 2.38$) compared to the start ($M = 7.31$, $SD = 1.73$), $t(21) = 2.91$, $p = .008$, $d = 0.62$, $BF_{10} = 5.82$.

3.1. Avoidance

Avoidance proportions in the Instrumental phase and Test phase 1 are presented inFig. 2.

Compared to the CS-, participants pressed the space bar more often during presentations of the CS+, CS: $F(1, 41) = 571.22$, $p < .001$, $\eta2G = 0.90$, $BF_{10} > 1000$, in both groups, CS × Group: $F(1, 41) = 1.36$, $p = .250$, $\eta2G = 0.02$, $BF_{10} = 1.13$.

In Test phase 1, participants still avoided the CS + more than the CS-, CS: $F(1, 41) = 59.64$, $p < .001$, $\eta2G = 0.39$, $BF_{10} > 1000$, similarly across groups, CS × Group: $F(1, 41) = 0.26$, $p = .614$, $\eta2G = 0.003$, $BF_{01} = 3.03$. There was only a marginally significant reduction in avoidance responses associated with the CS+ from the Instrumental phase to Test phase 1, $F(1, 41) = 3.86$, $p = .056$, $\eta2G = 0.03$, $BF_{10} = 1.35$, across both groups, $F(1, 41) = 0.01$, $p = .928$, $\eta2G = 0.00$, $BF_{01} = 3.45$. Together this suggests that avoidance responses persisted across both groups, despite a small reduction in both conditions.

3.2. Distress ratings

Distress ratings across all phases are presented in Fig. 3. Contrary to expectation, the CS+ ($M = 2.85$, $SD = 2.49$) was associated with significantly more distress than the CS- ($M = 2.03$, $SD = 2.17$), $F(1, 41) = 4.62$, $p = .038$, $\eta2p = .101$, $BF_{10} = 1.75$, in the Habituation phase. The BF, however, did not provide conclusive evidence for this difference. This pattern was observed across both groups, $F(1, 41) = 0.04$, $p = .840$, $\eta2p = .001$, $BF_{01} = 3.36$.

Across the Acquisition phase, participants reported greater distress during CS + than CS- presentations, CS × Trial: $F(2.66, 109.06) = 26.89$, $p < .001$, $\eta2G = 0.06$, $BF_{10} > 1000$, in both groups, CS × Trial × Group: $F(2.66, 109.06) = 0.40$, $p = .729$, $\eta2G < 0.001$, $BF_{01} = 90.91$.

Similarly, across the Instrumental phase, participants reported greater distress during CS + than CS- presentations, CS × Trial: $F(3.22, 132.02) = 33.67$, $p < .001$, $\eta2G = 0.08$, $BF_{10} > 1000$, and this did not differ between groups, CS × Trial × Group: $F(3.22, 132.02) = 0.80$, $p = .504$, $\eta2G = 0.002$, $BF_{01} = 50$.

In the Intervention phase, participants reported greater distress associated with the CS + than the CS-, CS × Trial: $F(2.97, 121.77) = 19.39$, $p < .001$, $\eta2G = 0.05$, $BF_{10} > 1000$. However, this effect differed across groups, CS × Trial × Group: $F(2.97, 121.77) = 5.11$, $p = .002$, $\eta2G = 0.01$, $BF_{10} = 4.67$. Further analyses revealed that distress associated with the CS- did not differ across groups, $F(1, 41) = 0.22$, $p = .640$, $\eta2p = .01$, $BF_{01} = 2.63$, but that the CS+ was associated with significantly less distress in the *Counterconditioning* ($M = 1.35$, $SD = 1.15$) compared to the *No Counterconditioning* group ($M = 3.42$, $SD = 2.32$), $F(1, 41) = 13.98$, $p < .001$, $\eta2_p = .25$, $BF_{10} = 50.43$. In the *Counterconditioning* group, the CS+ was only associated with significantly more distress than the CS- during the first trial, $F(1, 21) = 6.07$, $p = .022$, $\eta2G = 0.22$, $BF_{10} = 4.41$. On the other hand, the CS+ was associated with significantly greater distress than the CS- in the *No Counterconditioning* group for all trials, except trial 16, $F(1, 20) = 2.34$, $p = .142$, $\eta2p = .11$, $BF_{01} = 1.38$. Collectively, the results suggest that, compared to standard ExRP, positive imagery during ExRP resulted in reduced CS distress differentiation during the Intervention phase.

During Test phase 1, the CS+ was associated with greater distress than the CS-, CS × Trial: $F(1.89, 77.49) = 6.33$, $p < .003$, $\eta2G = 0.01$, $BF_{10} = 0.61$. This effect did not differ across groups, CS × Trial × Group: $F(1.89, 77.49) = 0.38$, $p = .671$, $\eta2G = 0.0006$, $BF_{01} = 12.5$.

Similarly, in Test phase 2, the CS+ was associated with greater distress than the CS-, CS × Trial: $F(2.43, 99.63) = 12.68$, $p < .001$, $\eta2G = 0.01$, $BF_{10} = 2.12$, and this did not differ across groups, CS × Trial × Group: $F(2.43, 99.63) = 0.61$, $p = .577$, $\eta2G = 0.0006$, $BF_{01} = 14.29$.

3.2.1. US-expectancy ratings

Expectancy ratings across all phases are summarized in Fig. 4 below.

In the Acquisition phase, participants learnt to expect the US_{neg} following the CS + but not the CS-, CS: $F(1, 41) = 2091.26$, $p < .001$, $\eta2G = 0.97$, $BF_{10} > 1000$. This effect was observed across groups, CS ×

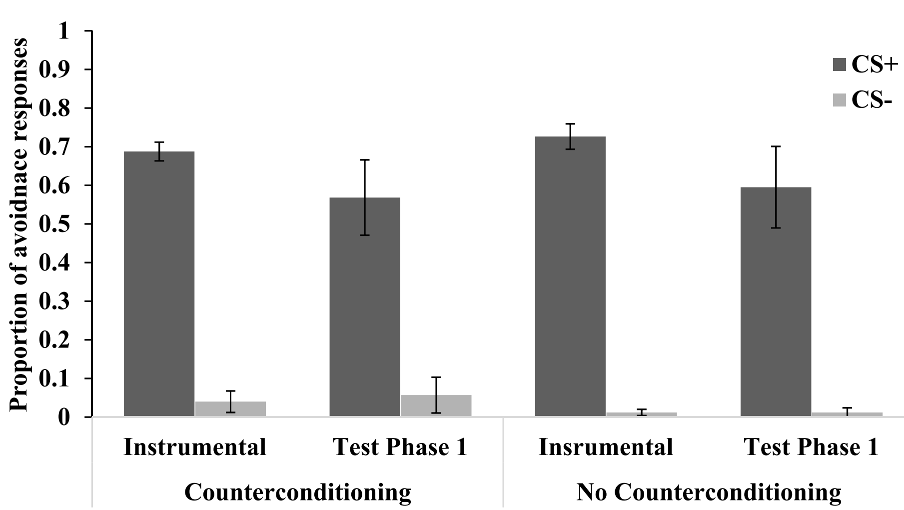

Fig. 2. Proportion of avoidance responses for each CS and for each group during the Instrumental and Test phase 1. Standard errors are indicated by the error bars.

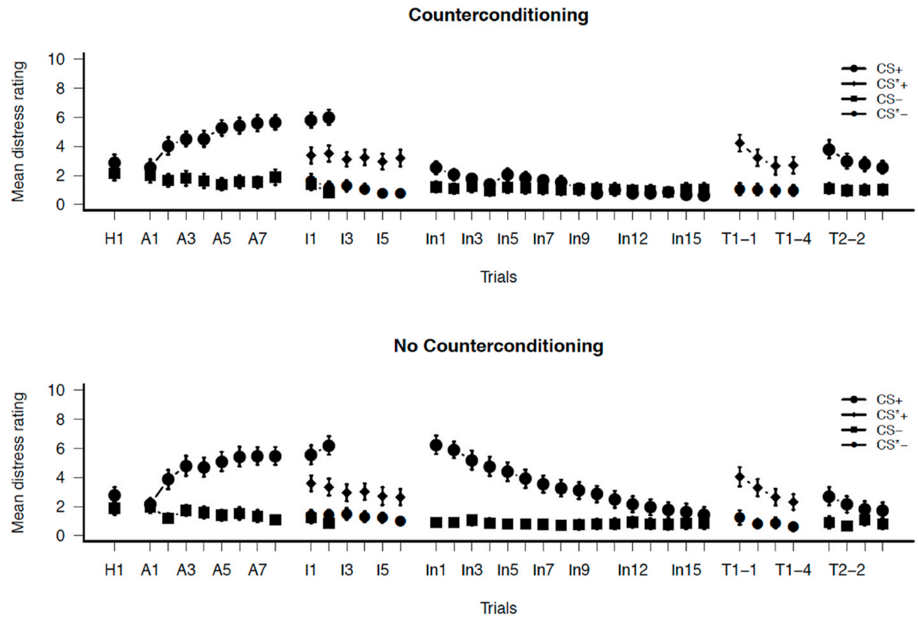

Fig. 3. Mean distress ratings for each CS and for each group during the different phases. The trials in which the CSs were presented with the lightbulb can be identified by the asterisk (*) in the legend of the figure. Standard errors are indicated by the error bars.

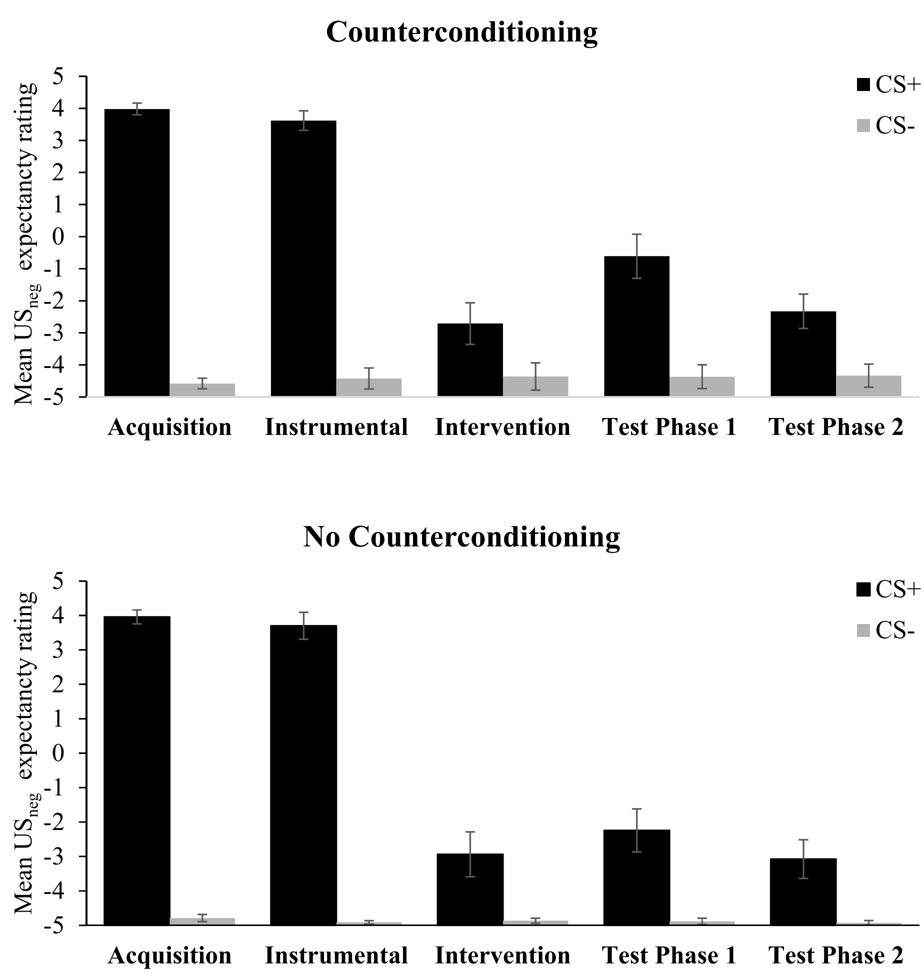

Fig. 4. Mean US_{neg} expectancy ratings for each CS and for each group across the different phases. Standard errors are indicated by the error bars.

Group: F (1, 41) = 0.33, p = .569, η2G = 0.01, BF_{01} = 2.86.

In the Instrumental phase, participants still expected the US_{neg} to follow the CS + but not the CS-, CS: F (1, 41) = 646.04, p < .001, η2G = 0.90, BF_{10} > 1000. Again, this effect was observed in both groups, CS × Group: F (1, 41) = 0.76, p = .387, η2G = 0.01, BF_{01} = 1.72.

At the end of the Intervention phase, participants reported greater US_{neg} expectancy for the CS + than the CS-, CS: F (1, 41) = 12.04, p = .001, η2G = 0.13, BF_{10} = 112.76, an effect that did not differ by group, CS × Group: F (1, 41) = 0.07, p = .788, η2G = 0.0009, BF_{01} = 3.13.

In Test phase 1, participants still expected the US_{neg} to follow the CS + but not the CS-, CS: F (1, 41) = 46.12, p < .001, η2G = 0.33, BF_{10} > 1000, in both groups, CS × Group: F (1, 41) = 1.40, p = .244, η2G = 0.01, BF_{01} = 1.85.

Similarly, in Test phase 2 participants expected the US_{neg} to follow the CS + but not the CS-, CS: F (1, 41) = 25.81, p < .001, η2G = 0.20, BF_{10} > 1000, across groups, CS × Group: F (1, 41) = 0.04, p = .849, η2G = 0.00, BF_{01} = 1.69.

4. Discussion

We investigated whether positive imagery could enhance the effects of ExRP. Results demonstrated that attenuation of CS + avoidance, distress, and US_{neg} expectancy did not differ between the *Counterconditioning* and *No Counterconditioning* groups. In line with previous research (e.g., Van Uijen et al., 2018; Vervliet & Indekeu, 2015), avoidance of the CS + persisted following both interventions.

The results did however reveal that participants in the *Counterconditioning* group reported significantly less distress associated with the CS+ during the Intervention phase, as compared to the *No counterconditioning* group. This suggests that positive imagery may reduce the distressing nature of extinction-based procedures, without hampering the attenuation of avoidance, distress, or harm expectancy responses. Two alternative explanations remain plausible. First, positive imagery during standard ExRP may have served as a distraction, which previous research suggests may result in greater reduction of fear compared to only an exposure-based intervention (Oliver & Page, 2003). Second, studies have demonstrated that changes to attention may reduce anxiety (e.g., Amir, Weber, Beard, Bomyea, & Taylor, 2008). Actively engaging in the imagery task may have functioned as a cognitive control task that shifted attention from threat and reduced distress responses. It remains an empirical question of how exactly imagery during an extinction with response prevention procedure reduces distress.

The study further demonstrated that although US_{neg} expectancy decreased during the Intervention phase, threat uncertainty associated with the CS + persisted in the test phases for both groups (see Fig. 4), suggesting that formed threat expectancies likely remained prominent. Thus, it is possible that avoidance may have persisted due to the persisting US_{neg} expectancy. Previous research has demonstrated that individuals scoring high on neuroticism may engage in avoidance as a 'better safe than sorry' strategy when experiencing threat uncertainty (Lommen et al., 2010). The present study did not examine neuroticism or anxiety sensitivity, so we cannot rule out that such a mechanism motivated the persistence of avoidance. It is worth noting that previous research employing similar paradigms have demonstrated reductions in US_{neg} expectancy during the instrumental phase (Krypotos & Engelhard, 2018, 2019; Vervliet & Indekeu, 2015), which is contrary to the high expectancy ratings observed in the present study. This may potentially be accounted for by differences in design whereby the mentioned studies employed online ratings of US_{neg} expectancy, whereas expectancy was assessed in the present study after each phase. Such post-phase ratings may not adequately represent changes in expectancy and may reflect participants' uncertainty of whether the ratings should be made with consideration of the avoidance response.

Comparisons of the effects of extinction and counterconditioning procedures remain scarce with mixed findings. Previous findings suggesting the promise of counterconditioning in reducing avoidance employed methods different to that of the present study (e.g., Newall et al., 2017; Reynolds, Field, & Askew, 2016). The persistence of self-reported CS differentiation in the present study could be argued to be in line with research indicating that compared to standard extinction-based interventions, dual presentation of tasty food and music during exposure to a feared spider did not further reduce fear responses in individuals with spider phobia (De Jong, Vorage, & van den Hout, 2000), and providing monetary compensation did not further reduce pain-related fear (Meulders, Karsdorp, Claes, & Vlaeyen, 2015).

There are several plausible explanations for the persistence of avoidance. First, negative CS valence plays an important role in activating avoidance behaviors (Krieglmeyer, Deutsch, de Houwer, & de Raedt, 2010). Although some studies found that counterconditioning reduces negative CS valence more than an extinction procedure (e.g., Engelhard et al., 2014; van Dis et al., 2019), other studies found no such differences (Meulders et al., 2015), and the benefits of counterconditioning may not depend on a modification of negative CS valence (Kang et al., 2018; Meulders et al., 2015). As CS valence was not assessed in the present study, such an effect cannot be ruled out. Second, similar to how fear can return when encountering a feared stimulus in a context different from the extinction context (e.g., Bouton, 2002), avoidance may have persisted as a result of a context shift. That is, the availability of avoidance responses following ExRP represents a context that differs both from the context in which fear was initially required (i.e., no response prevention introduced) and the context in which extinction occurred (i.e., with response prevention) (see Treanor & Barry, 2017).

The present study has limitations. First, the CS+ was associated with significantly greater distress during the Habituation phase. As done in other research (e.g., Mueller, Sperl, & Panitz, 2019), this study may have benefitted from increasing the number of habituation trials. Given the non-threatening nature of the squares used as CSs, the present study instead used a single Habituation trial. As distress in the Habituation phase did not differ across groups, any potential influence should have affected both groups in a similar manner. Second, as previously discussed, including online expectancy ratings (or a physiological measure) may have permitted making inferences about the effect of the interventions on threat expectancy. However, in order for the present study to be more feasible in terms of time duration, only distress ratings were reported online.

It is also worth considering possible directions for future research. First, the study included a non-clinical community sample. Research in non-clinical samples has demonstrated that traits such as neuroticism may affect fear responses (e.g., Lommen et al., 2010), suggesting that it is worth considering whether the findings of the present study extend to more anxiety sensitive non-clinical samples as well as clinical populations. These populations generally show impaired extinction learning (e.g., Duits et al., 2015), and perhaps the use of counterconditioning procedures may be more robust compared to unaffected populations where extinction learning is not impaired. Second, future studies could use physiological responses (e.g., skin conductance) to investigate whether positive imagery during ExRP has an influence on such responses as well.

The present study has potential clinical implications. Patients who refuse or drop out of exposure-based treatment may find confronting fear-provoking stimuli too challenging. The reduced distress observed during the Intervention phase of the present study provides initial evidence that positive imagery during exposure may make it easier for clinical populations to approach such therapeutic interventions. Thus, positive imagery as an adjunct may be viewed as a useful 'coping tool' that can give patients some level of agency during exposure. This proposition is in line with the increased perception of control over anxiety elicited by adjunct distraction tasks (Oliver & Page, 2003). Furthermore, the reduced distress during exposure may allow an individual to recall encounters with a feared stimulus as less distressing, which may reduce negative anticipations of the future and thus motivate more positive subsequent encounters (see Schacter & Addis, 2007).

Despite the potential clinical implications of our study, it is important to note that a direct translation of our study should be done with caution as there remains a risk of long-term detrimental effects. As this is the first study investigating the use of positive imagery in a counterconditioning design, the research line should be further developed prior to any translation to clinical populations.

Author statement

All authors contributed to the conceptualization, methodology, and writing of the paper. LH collected the data and performed the statistical analyses under the supervision of AMK.

Declaration of competing interest

All authors declare no conflicts of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jbtep.2020.101601.

Appendix A

Instructions for the Counterconditioning group during the Intervention phase (translated)

“The experiment will now continue. You should now imagine the “_” (title of the positive sound) sound you’ve heard before. You are to do this as vividly and in as much detail as possible. Try to imagine the sound as though you are hearing it in the ‘here and now’, as if you are hearing it at this moment. While you hear the sound, imagine that you feel happy and relaxed, and that you continue to breathe normally. Focus on the sensations that you feel. Can you imagine the sound vividly? Press ENTER when you have the sound and your reactions to it in mind as clear and as detailed as possible.”

“The experiment will now continue. The purpose is to imagine the “_” (title of the positive sound) sound as vividly and in as much detail as possible every time you see the “_” (color of the CS+) square. As a reminder, you will see the word ‘imagine’ appear during the first few trials. Imagine the sound in the ‘here and now’, as if you are hearing it at that moment, and imagine the reactions that it invokes in you. Hold the image vividly in mind until you no longer see the square on the screen and you see a ‘+’ appear in the middle of the screen.”

Appendix B

Exploratory analyses

Mood differences was not a significant covariate of avoidance responses in Test Phase 1, $F(1, 40) = 0.21$, $p = .650$, $\eta 2_p = .01$, $BF_{10} = 0.26$. Furthermore, it was not a significant covariate of neither distress (Test phase 1: $F(1, 40) = 0.02$, $p = .902$, $\eta 2_p = .00$, $BF_{10} = 0.32$; Test phase 2: $F(1, 40) = 0.03$, $p = .854$, $\eta 2_p = .00$, $BF_{10} = 0.33$) nor expectancy ratings (Test phase 1: $F(1, 40) = 0.19$, $p = .662$, $\eta 2_p = .01$, $BF_{10} = 0.34$; Test phase 2: $F(1, 40) = 1.741$, $p = .195$, $\eta 2_p = .04$, $BF_{10} = 0.28$).

Given the repeated measures design of the study, it was not possible to perform the moderation analyses using PROCESS as initially documented in the preregistration. Instead, the moderation analyses were performed using another SPSS add-on, namely MEMORE (Montoya & Hayes, 2017). Imagery ability was not found to predict CS differentiation in terms of avoidance, distress (average distress per CS[3]) or expectancy ratings in Test phase 1, all p's > 0.675. Similarly, it did not predict CS distress or expectancy differentiation in Test phase 2, all p's > 0.504. Importantly, there were no significant effects of group across measures and test phases when controlling for imagery ability, all p's $> .242$.

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