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Return of fear after retrospective inferences about the absence of an unconditioned stimulus during extinction

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ABSTRACT

We examined whether the effect of an extinction phase can be influenced retrospectively by information about the cause of the absence of the unconditioned stimulus (US) during that phase. Participants were subjected to a differential fear conditioning procedure, followed by an extinction procedure. Afterwards, half of the participants were presented with information about a technical failure, which explained why the US had been absent during the extinction phase. The other participants received information that was unrelated to the US. During a subsequent presentation of the target conditioned stimulus (CS), only the former group of participants showed renewed anticipatory skin conductance responding and a return of US expectancy. The results are in accordance with a propositional account of associative learning and highlight the importance of retrospective reasoning as a cause of relapse after exposure therapy.

The decrease in conditioned responding following unpaired presentations (CS only) of a previously reinforced stimulus (CS–US) is referred to as extinction. The fact that extinction has been studied extensively can be explained by its relevance to clinical practice (Hermans, Craske, Mineka, & Lovibond, 2006). Clinical procedures such as exposure treatment can be seen as analogues of extinction procedures. Therefore, broadening our understanding of extinction can help us to further refine exposure.

Several authors have focused attention on the cognitive processes that underlie extinction effects (e.g., Bouton, 1993, 2002; Hermans et al., 2006; Lovibond, 2004). Most theories postulate the existence of associations in memory and explain extinction in terms of a change in the strength of the association between the CS and the US (Rescorla & Wagner, 1972) or through the emergence of a new inhibitory association (Bouton, 1993, 2002). Another class of theories describes the extinction process in terms of the formation and evaluation of propositions (De Houwer, 2009; Lovibond, 2003; Mitchell, De Houwer, & Lovibond, 2009). According to the propositional account, the extinction procedure allows participants to verify that the CS is no longer followed by the US. In most cases, this observation will lead to the proposition that the CS is no longer a good predictor of the US and that future presentations of the CS will not be followed by the US. The latter proposition is thought to be responsible for the behavioural extinction effect.

Both associative and propositional models can explain that extinction effects tend to be context specific, in the sense that a context change after extinction readily leads to renewal. When the extinction trials take place in another room than that in which the original CS–US pairings occurred, they have little effect on the CR that the CS evokes in the original context (Vansteenwegen et al., 2005). Association formation models account for this by assuming that the associations that are formed during the extinction procedure and that produce the extinction effect are active only in the context in which they are formed (Bouton, 1993, 2002). On the other hand, propositional models account for the context specificity of extinction by postulating that people might not use the extinction trials to infer that there has been a *general* change in the CS–US relation (Lovibond, 2004). That is, if there are reasons to believe that the absence of the US during the extinction phase was due to a third factor that was present only during the extinction trials, they might doubt the validity of a general inference, and allocate the change in the CS–US relation to that third factor. A change in context might signal the presence of such a third factor and thus raise doubts about whether the CS–US relation will be different when the extinction context is removed.

Interestingly, according to propositional models, the truth of propositions can also be revised retrospectively, that is, on the basis of new information that is given after the initial proposition has been formed. In human causal learning literature, there are myriad

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demonstrations of the effect of retrospective revaluation (Dickinson & Burke, 1996; Mitchell, Killedar, & Lovibond, 2005). In the context of fear conditioning, Davey's research on US revaluation supports the notion of retrospective revaluation (see Davey, 1992, 1997, for overviews). Davey and colleagues demonstrated that a change in the evaluation of the US can lead to a substantial change in the CR evoked by the CS. Importantly, the revaluation of the US can occur completely independent of CS–US occurrences and can be installed through direct experience (White & Davey, 1989) or instructions (Davey & McKenna, 1983). These findings demonstrate that a retrospective change in the *content* of the US representation can affect subsequent responding to the CS. However, until now, it has not been examined whether retrospective inferences on the absence of the US might lead to a return of CR or US expectancy after extinction.

The aim of the present study is to examine the effect of retrospective inferences on US absence after extinction. Similar to the work of Davey, this type of retrospective revaluation pertains only to the US and not to the CS. However, in contrast with Davey, the retrospective revaluation does not involve the content of the US (e.g., the degree to which it is aversive or threatening) but refers to the absence of the US during a past extinction phase. Based on the propositional approach, we would expect that also in this case retrospective inferences will lead to a change in the evaluation of the CS–US relationship. More specifically, we expect that an explanation for the absence of the US in a past extinction phase will reinstall US expectancy and conditioned responding on subsequent CS presentations.

It is important to examine the effect of retrospective inferences on the absence of the US after extinction because similar processes could operate in a clinical setting. For example, people could infer after exposure therapy that the phobic object was not followed by an aversive event during the therapy (e.g., they were not bitten by the dog) because therapy had taken place under specific circumstances (e.g., during summer; people might think, for example, that dogs are relaxed and generally non-aggressive during that time of year). Following the propositional account, this assumption alone could lead to return of fear when those specific circumstances are not longer believed to be present (e.g., it is no longer summer).

Our research question is also theoretically important. Whereas propositional models predict that retrospective inferences can modulate extinction, it is difficult to see how such effects can be explained by associative models. According to these models, learning (i.e., changes in associative strength) can occur only if the CS is physically present (e.g., Rescorla & Wagner, 1972) or when the CS representation is activated by the physical presence of another stimulus that previously co-occurred with the CS (e.g., Dickinson & Burke, 1996). Hence, verbal information about a cause that never physically co-occurred with the CS or US should not influence the strength of the CS–US association and should thus not influence the extent to which the CS evokes a CR.

Because of practical and ethical concerns, we examined this hypothesis in a laboratory setting. Participants were subjected to a differential conditioning procedure, in which one of two cues (CS+) was paired with the US during acquisition, whereas another cue (CS−) was never paired with the US. The effect of conditioning was measured through indexing both anticipatory skin conductance responses (SCRs) and US expectancy for both CSs. Both groups also experienced an extinction phase during which both CSs were presented without the US. After the extinction phase, one group of participants was told that there had been a technical problem because of which the US had not been presented for some time, but that the problem had now been solved by the experimenter. This information allows participants to infer that the absence of the US during extinction was due to that technical failure rather than to a change in the relation between the CS and US. Because the technical problem had been solved, they should expect the US after the next presentation of the CS+ and thus show a conditioned response to the CS+. We refer to this group of participants as the retrospective inference group (RIG).

To exclude that changes in extinction effects were due to the mere fact of giving an instruction after the extinction trials, another group of participants (control group; CG) was provided with control information that did not refer to the US. These participants were told that there had been a technical problem (no reference to US) which had now been solved by the experimenter. After the presentation of this information, both the RIG and the CG were presented with a CS− presentation, followed by a non-reinforced CS+ presentation (test phase). The fixed order served to prevent order-effects, with the CS− eliciting a stronger response when preceded by an unexpectedly non-reinforced CS+ (Lovibond, 2003; as in Vervliet, Vansteenwegen, Baeyens, Hermans, & Eelen, 2005).

Based on the propositional account, we expected that the RIG, but not the CG, would show a return of CR and US expectancy for the CS+ in the test phase.

Method

Participants

Thirty-eight undergraduate students (seven men) at Ghent University participated in this experiment in exchange for course credits or eight Euros. Mean age was 18.84 ($SD = .97$). Four participants were excluded from further data-analysis because their ratings on the trait version of the Spielberger State-Trait Anxiety Inventory (STAI-T) (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) exceeded the sample mean by more than 2.5 *SD*. One participant was excluded because his score on the Beck Depression Inventory (BDI; Beck, Steer, & Brown, 1996) exceeded the sample mean by more than 2.5 *SD*. Allocation to the RIG and CG was randomised. Eighteen participants were part of the RIG group, 15 participants were part of the CG. Mean age was similar in the RIG ($M = 18.72$, $SD = .89$) and CG ($M = 18.67$, $SD = .90$), $t < 1$. Also, there was a similar gender distribution in both groups (three and four men respectively in the RIG and CG groups), $\chi^2 = .49$, *ns*. BDI (RIG: $M = 5.28$, $SD = 3.03$; CG: $M = 4.07$, $SD = 2.60$) and STAI-T (RIG: $M = 35.61$, $SD = 4.55$; CG: $M = 33.13$, $SD = 8.00$) scores did not differ significantly between groups, $t(31) = 1.22$, *ns* (BDI) and $t(31) = 1.12$, *ns* (STAI-T).

Material

Experimental stimuli

All stimuli were presented centrally on a computer monitor with a resolution of 1024 × 768 pixels. The background colour was black. Two coloured slides (335 × 312 bitmap files) served as conditioned stimuli. One slide was purple, the other one was green. One of these slides was sometimes (i.e., during acquisition) followed by the US (CS+) while the other one (CS−) was never followed by the US. The allocation of the slides to the function of CS+ and CS− was counterbalanced. A 170 ms 95 dB(A) white noise served as US. The noise was presented binaurally with Philips headphones. The volume of the white noise was checked by technical staff before the start of the study. Using a sound level metre (Brüel and Kjær's Type 2250; Nærum, Denmark) the dB(A) level of the white noise was measured in the ear pads of the headphones.

US expectancy ratings

US expectancies were assessed retrospectively for the CS+ and the CS− separately (as in Vansteenwegen et al., 2005; Vervliet et al., 2005). Participants were asked to indicate the evolution of their US expectancies for the CS+ and the CS− on separate graphs. The *X*-axis