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The role of safety signals in fear extinction: An analogue study

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ABSTRACT

Background and objectives: Safety signals are conditioned inhibitory stimuli that indicate the absence of unconditioned stimuli. It is not clear whether the presence of safety signals is detrimental or beneficial in extinction-based interventions. The purpose of this study was to evaluate the effect of safety signals on autonomic and expectancy fear-related responses.
Methods: Following the conditional discrimination paradigm (AX +, BX-), undergraduate students (N = 48) underwent an aversive conditioning procedure, while safety signals were experimentally created. Participants were randomly assigned to one of two conditions during extinction: presence or absence of safety signals.
Results: Significant reductions of fear-related responses were found in both groups. Expectancy measures showed that the presence of safety signals did not interfere with reduction of fear related responses at follow-up.
Limitations: The analogue nature of the study affects its ecological validity. There are some methodological issues.
Conclusions: Safety signals did not interfere with extinction learning. Attention may be a mechanism associated with the maintenance of fear responses.

1. Introduction

Pavlovian conditioning has served extensively as an explanatory model for the development of fear reactions and anxiety disorders. Consequently, extinction-based interventions constitute the basis for the treatment of the aforementioned problems. At a clinical level, exposure therapy represents the extension of extinction procedures aimed at fear reduction. The effectiveness of exposure therapy for the treatment of a diversity of anxiety disorders has been widely documented (Norton & Price, 2007), although, its mechanisms of action are still not well established (Myers & Davis, 2007).

When anxious individuals have to face feared stimuli or situations, they tend to attenuate distress by escaping from the Conditioned Stimulus (CS) or the Unconditioned Stimulus (US). When that is not possible, they resort to safety behaviors, which lead to safety signals informing them of the reduced likelihood of the occurrence of the US, and temporally reducing distress. For instance, when perceiving a threat, a person who fears dogs may call someone for help (safety behavior). The moment that person comes, he or she becomes a safety signal for the individual who fears dogs. In turn, that safety signal causes fear to decrease. Although related, there is a difference between safety signals and safety behaviors, which has not been clearly established in the literature. While the former refer to the inhibitory informational value of a stimulus, the latter refer to the instrumental function of a response such as the use of medication, cell phones, etc., (for a description see Barlow, 2002; Telch & Lancaster, 2012).

Although there has been a considerable amount of research on this topic (Helbig-Lang & Petermann, 2010), most of the studies which have rendered contradictory results have focused on the effect of safety behaviors on fear reduction (Rachman, Radomsky, & Shafran, 2008; Sy, Dixon, Lickel, Nelson & Deacon, 2011) rather than on the role of safety signals per se.

In a clinical context, Sloan and Telch (2002) found greater fear reactions in post-test and follow-up measures in claustrophobic patients who used safety behaviors during an exposure procedure (e.g., opening a window, standing close to the exit or

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communicating with the therapist), compared to those who did not. In the same vein, Powers, Smits, and Telch (2004) reported that knowledge of the availability of safety behaviors was as counterproductive as their actual use.

Conversely, several studies suggest that use of safety behaviors does not interfere with extinction. Rachman et al. (2008) proposed that the judicious use of safety behaviors (i.e., during initial phases of therapy and gradually disposed thereafter) might lead to higher treatment adherence. In a study with claustrophobic patients, Deacon, Sy, Lickel, and Nelson (2010), found that use of safety behaviors during exposure was not detrimental in extinction learning. This same pattern of results has been reported in fear of contamination (Rachman, Shafran, Radomsky, & Zysk, 2011), and fear of spiders (Hood, Antony, Koerner, & Monson, 2010). Finally, Sy et al. (2011), were unable to replicate the results of the study by Powers et al. (2004) on the effects of availability of safety behaviors.

Safety signals and behaviors are supposed to play an important role in the maintenance of anxiety disorders through two possible mechanisms. From a cognitive perspective, safety behaviors prevent the disconfirmation of dysfunctional beliefs regarding the occurrence of a US (Salkovskis, 1991). For instance, an individual experiencing a panic attack may think: "By sitting down I prevented a heart attack". From an associative perspective, safety signals exert a negative associative strength that cancels the positive association of the CS as a predictor of the US (Rescorla & Wagner, 1972).

Safety signals are defined as conditioned inhibitory stimuli (CS-) that signal the non-occurrence of the US (Hermans, Craske, Mineka, & Lovibond, 2006). Safety signals are supposed to transfer their inhibitory property to CS, thus reducing conditioned responses (CR) (Jovanovic et al., 2005). CS- are related to a phenomenon known as *protection from extinction* (Resorla, 2003). It was named after the observation that CS presentations accompanied by a CS- during extinction elicit stronger CR at follow-up (when presenting the CS without the CS-), as compared to CS presentations alone (during extinction and follow-up).

Lovibond, Davis, and O'Flaherty (2000) conducted two experiments aimed at evaluating the effect of safety signals in extinction. In a laboratory setting they paired shock with conditioned stimuli (auditory and visual), while another stimulus was intended to indicate the omission of shock (i.e., safety signal). Expectancy measures and autonomic responses suggested the presence of a safety signal during extinction was associated with increased CRs at follow-up, compared with its absence (*protection from extinction*). However, results are difficult to interpret for the following reasons. First, the safety signal was not experimentally created as a CS-. As a result, it was not possible to determine that the supposedly safety signal transferred its inhibitory property to the CS and caused reduced CRs. The procedure left open the alternative that the reduction of the CR was the result of external inhibition (phenomenon that takes place when a novel stimulus is presented during extinction, and provokes a transient decrease of a CR [Pavlov, 1941]). Conditioned inhibition and external inhibition denote different processes. The reduction of a CR due to conditioned inhibition is the result of associative learning. On the other hand, the reduction of a CR due to external inhibition is likely the product of attentional processes (Jovanovic et al., 2005); not a consequence of learning. Such distinction is clinically relevant since patients seem to experience fear reduction upon the presence of specific learned stimuli (conditioned inhibitors such as the voice of the therapist). They do not seem to respond to novel stimuli that are uncertain regarding their effectiveness to reduce distress (external inhibitors such as a random background noise). Therefore, if the presence of safety signals during extinction are to be evaluated in experimental conditions, they need to be configured as conditioned inhibitors instead of external inhibitors. This could be considered a true analogue of a clinical context.

An additional difficulty interpreting the results of Lovibond et al.'s (2000) experiment comes from the fact that it was conducted in a single session that included acquisition, extinction and follow-up phases. The short time that elapsed between the phases may reflect changes in performance, not necessarily on learning. Findings in the field of neurobiology indicate that memory consolidation takes at least 24 h (Monfils, Cowansage, Klann, & LeDoux, 2009; Walker, Brakefield, Hobson, & Stickgold, 2003).

Based on conditioned inhibition research (Rescorla & Wagner, 1972), Myers and Davis (2004) developed a procedure called conditional discrimination that allows configuring safety signals as CSs-. It involves stimuli A, B, and X. A is excitatory, B inhibitory, and X both excitatory (when in presence of A) and inhibitory (when in presence of B). Upon the presentation of AX, an individual predicts the occurrence of an US, whereas BX signals its absence. After an AB presentation, it is expected a reduction of the CR (compared to AX) because B transfers its inhibitory property to A. The purpose of presenting X during training (i.e., AX and BX) is that A and B are perceived as two distinct stimuli when they are presented together. If X were not present during training, AB would be perceived as a third stimulus, and B's inhibitory property could not be evaluated. It is intended that upon an AB presentation, individuals perceive two different stimuli that happen to occur together. It is noteworthy that the reduction caused by AB is not the product of external inhibition since the introduction of an AC compound (C being a novel stimulus) provokes greater CR compared to those provoked by an AB presentation. Contrasting CRs produced by AB with those produced by AC allows to determine whether the reduction is due to associative learning (conditioned inhibition) or to attentional non-learning related processes (external inhibition).

Conditional discrimination has been used with rodents (Myers & Davis, 2004), monkeys (Winslow, Noble, & Davis, 2008), and humans (Jovanovic et al., 2005, 2009). It has the benefit of enabling the experimental configuration of safety signals as CSs-. As far as we know, in previous studies, a CS- (created following the conditional discrimination paradigm) has not been presented along a CS during extinction.

The aim of this study was to evaluate the effect of safety signals (defined as CS-) in extinction, as measured by autonomic and expectancy fear-related responses. Participants underwent a conditional discrimination procedure, and were randomly assigned to one of two extinction conditions: presence or absence of safety signals. Acquisition, extinction, and follow-up sessions were conducted on days one, two, and three, respectively. It was hypothesized that the presence of safety signals during extinction would result in reduced fear responses compared to their absence. Additionally, it was expected that the presence of safety signals during extinction would provoke greater CRs at follow-up (upon CS alone presentations), compared to its absence (during extinction).

2. Method

2.1. Participants

Undergraduate students (N = 55) between 20 and 23 years were recruited after signing an informed consent form approved by the University Ethics Committee. Exclusion criteria were diagnoses of mental disorders (as reported by participants), visual disabilities, and receiving a pharmacological or psychological treatment at the time of the study. Of the 55 individuals, 6 dropped out of the study (5 of them did not even attend the first session, and another one did not perceive the electrocutaneous stimulation [US]), and 1 was excluded for an Attention Deficit Disorder diagnosis labeled during