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Gradients of fear: How perception influences fear generalization☆,☆☆

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ABSTRACT

The current experiment investigated whether overgeneralization of fear could be due to an inability to perceptually discriminate the initial fear-evoking stimulus from similar stimuli, as fear learning-induced perceptual impairments have been reported but their influence on generalization gradients remain to be elucidated. Three hundred and sixty-eight healthy volunteers participated in a differential fear conditioning paradigm with circles of different sizes as conditioned stimuli (CS), of which one was paired to an aversive IAPS picture. During generalization, each subject was presented with one of 10 different sized circles including the CSs, and were asked to categorize the stimulus as either a CS or as novel after fear responses were recorded. Linear mixed models were used to investigate differences in fear generalization gradients depending on the participant's perception of the test stimulus. We found that the incorrect perception of a novel stimulus as the initial fear-evoking stimulus strongly boosted fear responses. The current findings demonstrate that a significant number of novel stimuli used to assess generalization are incorrectly identified as the initial fear-evoking stimulus, providing a perceptual account for the observed overgeneralization in panic and anxiety disorders. Accordingly, enhancing perceptual processing may be a promising treatment for targeting excessive fear generalization.

1. Introduction

The ability to transfer past learning to novel situations empowers organisms to act in a consistent manner in the face of ever-changing surroundings. Clearly, such capacity to generalize has a strong evolutionary advantage, as variations in context won't necessary result in chaotic unpredictability. However, when generalization occurs in an inflexible or excessive manner, it can become problematic. In post-traumatic stress disorder, a wide range of events (with overlapping characteristics to the initial trauma) is capable of triggering strong fear responses. Similarly, a key component of panic disorder and generalized anxiety disorder is the tendency to respond fearfully to a multitude of stimuli and situations. As such, fear generalization has been proposed central to the pathogenesis of these disorders (Bouton, Mineka, & Barlow, 2001; Dunsmoor & Paz, 2015; Dymond, Dunsmoor, Vervliet, Roche, & Hermans, 2014; Lissek, 2012). Accordingly, both in generalized anxiety disorder and panic disorder wider fear generalization gradients have been observed compared to controls (Lissek et al., 2014, Lissek et al., 2010; but see, Tinoco-González et al., 2015). In those studies, fear generalization was investigated in a context of Pavlovian conditioning (Pavlov, 1927), where a neutral stimulus [Conditioned Stimulus (CS), e.g., circle] starts to elicit a preparatory response [conditioned response (CR), e.g., fear] after it has been paired with a motivationally-relevant stimulus (unconditional stimulus, US, e.g., pain). During the generalization phase, fear is recorded during exposures to ‘novel’ stimuli that have never been associated with the US before (i.e., generalization stimuli or GSs), and that vary in physical similarity to the CS (e.g., circles of various size). Within this context, variations in fear

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responses are attributed to detected perceptual differences where the degree of physical resemblance to the initial fear-evoking stimulus determines the strength of the elicited fear response (Ghirlanda & Enquist, 2003).

Differences in fear generalization between patients and healthy controls have been attributed to cognitive strategies, as greater risk aversion (a more compelling better-safe-than-sorry strategy) has been shown in patients (Hartley & Phelps, 2012). The idea is that the overgeneralization in patients reflects a tendency to behave overly anxious in new situations. However, Laufer, Israeli, and Paz (2016) recently demonstrated that GAD patients demonstrated larger reductions in perceptual discrimination acuity (i.e. between GS and CS) after both positive and aversive conditioning compared to controls, and that these findings were not due to pre-existing differences in discrimination acuity (Laufer et al., 2016). Accordingly, Struyf, Zaman, Vervliet, & Van Diest, (2015) suggested, based on the observation that fear conditioning impaired the ability to perceptual discriminate GSs from the initial fear-evoking stimulus (CS) (Laufer & Paz, 2012; Resnik, Sobel, & Paz, 2011; Schechtman, Laufer, & Paz, 2010; Zaman et al., 2015), that anxiety patients are more sensitive to these fear learning-induced reductions in discrimination acuity. Thus, not only are patients more likely to avoid potential risks, they are also more likely to incorrectly perceive a different-but-similar stimulus as the initial fear evoking stimulus (CS), thereby producing an overgeneralized fear response. As a consequence, overgeneralization can be driven by biased cognitive strategies, altered perceptual processes, or a combination of both. Struyf et al. (2015) argued that without the concurrent assessment of both subject's perception and their fear response, one cannot exclude the possibility that not only fear overgeneralization, but fear generalization in general is in essence a byproduct of an inability to discriminate. The fact that such a hypothesis cannot be discarded on the basis of the literature indicates that there is a lacuna with regard to the role of perception in fear generalization. Insight into these different mechanisms could guide the development of better patient-tailored treatment protocols, such as the implementation of perceptual discrimination training protocols in cognitive behavioral therapy (Ehlers & Clark, 2000). The latter has been suggested by Ehlers and Clark (2000) and demonstrating the role of perceptual discrimination in generalization would provide essential support for the value of such protocols in cognitive behavioral therapy.

Several studies have attempted to investigate whether generalization occurs to clear discriminable generalization stimuli (Dunsmoor, Mitroff, & LaBar, 2009; Guttman & Kalish, 1956; Holt et al., 2014), but there is currently no study that, in a context of fear generalization, attempted to scrutinize the role of conditioning-induced perceptual alterations on conditioned fear responses. Hence, the current experiment added a stimulus categorization task to a typical generalization task, in order to link fear gradients directly to perceptual acuity. In a differential conditioning paradigm, circles of different sizes were used as CSs (Lissek et al., 2008), of which one was paired to an aversive IAPS picture (Lang, Bradley, & Cuthbert, 2008) [which have been previously used to elicit fear responses (Bernat, Patrick, Benning, & Tellegen, 2006; Lenaert et al., 2014)]. During generalization, each subject was presented to one test stimulus (either a CS or a GS) and was asked to categorize the stimulus as a CS or GS after risk rating (US-expectancy rating) was assessed. Note that exposing each participant to only one test stimulus implied that we were able to test generalization in its most essential form, i.e. no extinction learning during the generalization test phase due to exposure to multiple non-reinforced stimuli. Consequently, a large group of participants had to be tested in order to provide sufficient information with regard to each stimulus on the generalization dimension. Hence, only a subjective measure of fear was recorded. However, trial-by-trial shock expectancy ratings have been shown to provide a robust measure of fear learning, with demonstrated external validity for anxiety disorders (Boddez et al., 2013). We expected that a significant proportion of the GSs would be misidentified as the CS+ (the CS that had been paired to the US), and that this would boost fear responses to these stimuli. In addition, we investigated whether highly anxious individuals (based on STAI-T) exhibit more overgeneralization in comparison to low anxious individuals and whether this would be driven by a perceptual bias. Since elevated trait anxiety represents a vulnerability for clinical anxiety (Chambers, Power, & Durham, 2004) and clinical anxiety has been associated with larger reductions in perceptual acuity (Laufer et al., 2016), we hypothesized that highly anxious participants compared to low anxious participants demonstrate a perceptual bias (i.e., a reduced discrimination acuity) that drives differences in generalization gradients.

2. Material and methods

2.1. Participants

Three hundred and sixty eight students (mean age = 18.47 years, SD = 1.83, 309 women) participated in exchange of course credits. The study was approved by the local university ethics committee.

2.2. Stimuli and apparatus

Ten rings of gradually varying diameters (from 5.08 to 11.94 cm, each type increasing by 15%) represented 2 CSs and 8 GSs (see Fig. 1B). The rings were presented as white lines against a black background (Lissek et al., 2008). Counting from the smallest to the largest ring, the fifth ring served as CS+ and the first ring as CS−. The US was an individually selected aversive picture of the International Affective Picture System (IAPS; (Lang et al., 2008)). Three pictures of varying levels of arousal (i.e., mild, moderate and severe) were adopted (Fig. 1A). The categories were determined by previously obtained arousal ratings in young adults (Grühn & Scheibe, 2008). The most aversive US was an image of a bloodied corpse [arousal rating 7.77; valence rating 1.77; ratings range from 1 to 9 (calm-excited; unpleasant-pleasant)]. The moderate US was a picture of a disabled child (arousal rating 5.86; valence rating 3.14). The mild aversive US was represented by a picture of a holstered gun (arousal rating 4.92; valence rating 3.65). 65.4% of participants selected the most aversive US, 33.2% selected the moderate US and 1.4% selected the mild aversive US. Stimulus presentations were controlled by Affect4 software and presented on computer screen (Spruyt, Clarysse, Vansteenwegen, Baeyens, & Hermans, 2010).

All CS/GS presentations were accompanied by a US-expectancy rating scale on the bottom of the screen (1 s following stimulus onset). The scale ranged from 0 (“certainly no picture”) to 10 (“certainly a picture”), with 5 labeled as “uncertain”. Participants were instructed to respond by mouse-clicking on the corresponding point of the rating scale. After clicking the scale a red dot appeared to highlight the selected rating. The scale and the circle disappeared 300 ms later. In other words, all CS/GSs were shown 1300 milliseconds plus the response time. The US occurred immediately (for 1500 ms) after the disappearance of the circle or not.

Trait anxiety was measured via STAI-T, a 20-item questionnaire that assesses an individual's tendency to appraise situations as threatening and to respond with anxiety. STAI-T was administered after the experiment. The validated Dutch version was used (Van der Ploeg, Defares, & Spielberger, 2000). STAI-T scores ranged