Behaviour Research and Therapy 107 (2018) 53–63

Contents lists available at ScienceDirect

Behaviour Research and Therapy

journal homepage: www.elsevier.com/locate/brat

Excessive generalisation of conditioned fear in trait anxious individuals under ambiguity

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ARTICLE INFO

Keywords:
Fear conditioning
Trait anxiety
Generalisation
Rules
Ambiguity
Threat appraisal

ABSTRACT

Trait anxiety has been widely accepted as a vulnerability factor for the development of anxiety disorders. However, few studies have examined how trait anxiety may affect fear generalisation, which is believed to be a core feature of anxiety disorders. Using a single-cue conditioning paradigm, the current study found a range of discrete generalisation gradients in both expectancy ratings and skin conductance, which were highly consistent with participants' reported abstract rules. Trait anxious participants showed the same level of threat expectancy to the conditioned cue as low anxious participants. However they showed over-generalisation to novel test stimuli, but only when they failed to identify a clear rule. This result suggests that over-generalisation of fear may be a special case of the more general principle that trait anxiety is associated with excessive threat appraisal under conditions of ambiguity.

1. Introduction

The etiology of anxiety disorders is thought to involve a range of contributing factors including traumatic experiences, pre-existing vulnerabilities, and excessive threat appraisal (Britton, Lissek, Grillon, Norcross, & Pine, 2011; Mineka & Zinbarg, 2006). One way to examine the mechanisms involved is to conduct laboratory studies with anxious patients or non-clinical participants with a known vulnerability marker such as high trait anxiety (Watson & Clark, 1984). Fear conditioning has served as a well-controlled laboratory task to examine learning about both sources of danger and safety (e.g., Mineka & Zinbarg, 2006; Scheveneels, Boddez, Vervliet, & Hermans, 2016; Vervliet & Raes, 2013). Although traditionally interpreted as an automatic reflexive process, increasing evidence suggests that human conditioning is closely associated with symbolic cognitive processes such as language, reasoning and conscious beliefs (e.g., Mitchell, De Houwer & Lovibond, 2009; Weidemann & Lovibond, 2016). Therefore, fear learning serves as a promising paradigm for understanding the interplay between vulnerability, aversive experiences and cognitive appraisal in generating pathological anxiety.

Studies of fear conditioning in clinically anxious patients and healthy controls have found that anxious patients show higher level of psychophysiological responses to cues that signal an aversive outcome such as electric shock (e.g., Orr et al., 2000), especially when a single-cue conditioning paradigm is used (Lissek et al., 2005; but see; Duits et al., 2015). This suggests that anxious patients have heightened conditionability to stimuli that signal danger, potentially explaining the elevated, maladaptive fear to threat cues. Anxious patients also show increased fear responding to safety cues (e.g. Grillon & Davis, 1997), which may explain excessive fear responses to innocuous cues among anxious patients. Non-associative mechanisms have also been proposed to play a role in maladaptive fear acquisition, such as failure of physiological habituation or enhanced sensitization to cues (see Clemens & Selesnick, 1967; Lissek et al., 2005). Recently, evidence has been found for over-generalisation of fear in anxious patients. After differential training to a threat cue (CS+) and a safety cue (CS−), anxious patients show higher levels of fear responding to all test stimuli intermediate between CS+ and CS−, and also elevated responses to CS− (Lissek et al., 2008; 2010; 2014). These studies not only suggest excessive fear generalisation as a major feature of anxiety disorder, but also suggest elevated fear towards safety cues from over-generalisation of fear from CS+ (Grillon & Morgan III, 1999; Haddad, Pritchett, Lissek, & Lau, 2012; see also; Dymond, Dunsmoor, Vervliet, Roche, & Hermans, 2015).

Despite this evidence for maladaptive fear learning in patients with current anxiety disorders, it cannot be distinguished whether maladaptive learning is a consequence of anxiety disorders, or whether it is a vulnerability factor for their development. In addition, clinical samples introduce a great deal of comorbidity as well as sequellae of their clinical condition. Hence, it is important to study individuals at risk of developing anxiety disorder, and examine if they show similar maladaptive patterns (Lonsdorf & Merz, 2017). Trait anxiety is a stable

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https://doi.org/10.1016/j.brat.2018.05.012
Received 16 January 2018; Received in revised form 13 May 2018; Accepted 29 May 2018
Available online 30 May 2018
0005-7967/

predisposition to show negative emotional responses across situations, and has been widely proposed as a risk factor for developing anxiety disorders (e.g., Chambers, Power, & Durhama, 2004; Gershuny & Sher, 1998; Jorm et al., 2000). Despite the evidence highlighting over-generalisation of fear in anxiety disorders (Lissek et al., 2008; 2010; 2014), there is scarce evidence regarding fear generalisation in individuals high in trait anxiety, and mixed results have been found. Haddad et al. (2012) examined how trait anxiety affects fear responses to safety cues. Participants were presented with one CS+ and two CSs-, where one CS− was perceptually similar to CS+ (i.e., similar CS−) and the other one not (i.e., dissimilar CS−). A higher level of EMG eyeblink startle to the similar CS− was observed among highly anxious individuals, but not to the dissimilar CS−. The results provided some evidence that anxious individuals show greater fear generalisation from CS+ to a similar CS−. The authors argued that such results could not be explained by a general elevated fear response to safety cues, otherwise an increase in responding should have been observed to both safety cues.

However there have also been other studies that did not find any effect of trait anxiety on fear generalisation. After differential training, Torrents-Rodas et al. (2013) presented stimuli intermediate between both CSs along the stimulus dimension. Although the high anxious group showed higher risk ratings (i.e., shock expectancy ratings) to stimuli most similar to the safety cue compared to the low anxious control group, there were no significant differences in the shape of the generalisation gradients between anxiety groups, and all groups showed similar ratings to stimuli most similar to CS+. Furthermore, no differences were found in the psychophysiological responses to the generalisation cues. The authors therefore concluded not finding evidence that trait anxiety has any effect on fear generalisation. Using a similar paradigm, Arnaudova, Krypotos, Effting, Kindt, and Beckers (2017) also found no trait anxiety effect on fear generalisation.

One common feature of these studies was the use of a differential conditioning paradigm with CS+ and CS− located at the extreme ends of the stimulus dimension. All test stimuli were intermediate between the two CSs, with stimuli closest to CS− being most perceptually similar to CS−, and stimuli becoming more similar to CS+ in a linear fashion towards the direction of CS+ along the stimulus dimension. Two possible factors may explain the null effect of trait anxiety in this paradigm. First, it has been argued that the typical differential fear conditioning paradigm represents a 'strong situation', consisting of clear threat and safety cues (Lissek, Pine, & Grillon, 2006). In this case, most participants would show adaptive fear responses to the cues, making it difficult for any potential individual differences to be observed in fear acquisition (Beckers, Krypotos, Boddez, Effting, & Kindt, 2013). In contrast, maladaptive fear responses may be more likely to occur in a 'weak situation' comprised of a more ambiguous experimental configuration (e.g., blocking, where the casual status of the blocked stimulus becomes ambiguous; Boddez et al., 2012). Secondly, the nature of the paradigm being used may contribute to the null effect for trait anxiety. Torrents-Rodas et al. (2013) argued that the test stimuli between CS+ and CS− had an unknown threat value, leaving them ambiguous. However, since the test stimuli differed from each other in a linear fashion along the dimension, it would be straightforward for participants to infer the threat value of each test stimulus based on their similarity to CS+ or CS−. This could arguably disambiguate the generalisation task and turn the experimental configuration into a 'strong situation', reducing the opportunity to detect any potential individual differences in fear generalisation.

The current study sought to examine if trait anxiety has any effect on fear generalisation, using a single-cue conditioning paradigm. Participants were trained with a single stimulus paired with shock (CS+), and were then tested on a range of stimuli that varied in their similarity to CS+ along a perceptual dimension. The major advantage of this paradigm is the ambiguity it provides compared to differential conditioning, as there is no reference cue and hence less information available to guide generalisation (see Homa, Sterling, & Trepel, 1981). This would create a 'weak situation', especially for novel stimuli that were dissimilar to CS+, thus providing an opportunity to examine the effect of trait anxiety on fear generalisation. The study also took advantage of recent developments in the literature to examine whether any interactions between trait anxiety and explicit reasoning processes may affect fear generalisation.

Previous studies have found that reasoning plays an important part in human fear generalisation (Ahmed & Lovibond, 2015; Boddez, Bennett, van Esch, & Beckers, 2016; Dunsmoor & Murphy, 2015; Vervliet, Kindt, Vansteenwegen, & Hermans, 2010). Furthermore, recent work in our laboratory has highlighted individual differences in inductive reasoning in fear generalisation. In these studies, participants were categorized into different subgroups according to the rules they reported inferring and using in test (Ahmed & Lovibond, 2018; Lee, Hayes, & Lovibond, 2018; Wong & Lovibond, 2017). The results showed a high level of consistency between the shape of generalisation gradients and the inferred rules. More interestingly, the gradients in each rule subgroup (e.g., linear or similarity-based) were distinctive from each other. These results not only suggest that abstract rules affect the shape of generalisation gradients, but also that the overall generalisation gradient in humans can be misleading, as it may comprise a combination of different gradients formed from different rules. Accordingly, in the current study we categorized participants into different subgroups according to the rules they reported in a post-experimental questionnaire. We examined the effect of trait anxiety on both overall generalisation gradients and gradients for individual rule subgroups in order to investigate whether trait anxiety may have different effect on generalisation in different rule subgroups.

2. Method

2.1. Participants

Undergraduate students were recruited as participants who received either course credit or AUD $15 for participation. Participants were prescreened by the DASS-21 (Lovibond & Lovibond, 1995). The DASS-21 is a short version of the original DASS (Depression Anxiety Stress Scales), designed to discriminate between three different constructs: anxiety, depression and tension/stress. Both the DASS and the DASS-21 have been shown to have good psychometric properties (Antony, Bieling, Cox, Enns, & Swinson, 1998; Brown, Chorpita, Korotitsch, & Barlow, 1997; Henry & Crawford, 2005; Lovibond, 1998). Participants with a DASS anxiety score of 4 or below were recruited to the low anxious (LA) control group, while those with a DASS anxiety score of 18 or above were assigned to the high anxious (HA) group. We followed the sample size in Torrents-Rodas et al.'s (2013) study, which was approximately 40 participants in each group. The recruitment strategy was to continue recruiting until there were 40 participants in each group who met inclusion criteria (e.g., acquisition of CS−US contingency; see Results for more detail). This led to a total recruitment of 113 participants, with 33 excluded. The final sample comprised 80 participants (43 females) with a mean age of 21.1 years (SD = 3.8).

2.2. Apparatus and materials

Participants were tested individually in an experimental room. A 64-cm computer monitor was used to present the experimental instructions and stimuli. A computer equipped with MatLab software (with Psychophysics Toolbox extensions; Brainard, 1997; The MathWorks Inc., 2014) was located outside the experimental room, which generated the stimuli presented to the participants and recorded the expectancy ratings, while another computer controlled AD instruments equipment to record the skin conductance data via GRASS® silver disc electrodes at a sampling rate of 1000/s throughout the experiment.

A symmetrical stimulus dimension was used to minimize any intensity biases (see Wong & Lovibond, 2017; Ahmed & Lovibond,