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Higher threat avoidance costs reduce avoidance behaviour which in turn promotes fear extinction in humans

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ABSTRACT

Theoretical models specifying the underlying mechanisms of the development and maintenance of anxiety and related disorders state that fear responses acquired through classical Pavlovian conditioning are maintained by repeated avoidance behaviour; thus, it is assumed that avoidance prevents fear extinction. The present study investigated behavioural avoidance decisions as a function of avoidance costs in a naturalistic fear conditioning paradigm. Ecologically valid avoidance costs - manipulated between participant groups - were represented via time-delays during a detour in a gamified computer task. After differential acquisitions of shock-expectancy to a predictive conditioned stimulus (CS+), participants underwent extinction where they could either take a risky shortcut, while anticipating shock signaled by the CS+, or choose a costly avoidance option (lengthy detour); thus, they were faced with an approach-avoidance conflict. Groups with higher avoidance costs (longer detours) showed lower proportions of avoiders. Avoiders gave heightened shock-expectancy ratings post-extinction, demonstrating 'protecting from extinction', i.e. failure to extinguish. Moreover, there was an indirect effect of avoidance costs on protection from extinction through avoidance behaviour. No moderating role of trait-anxiety was found. Theoretical implications of avoidance behaviour are discussed, considering the involvement of instrumental learning in the maintenance of fear responses.

Anxiety disorders and posttraumatic stress disorder (PTSD) are frequent mental disorders (overall lifetime prevalence around 30%, Kessler, et al., 2005) characterized by high disease burden (Whiteford et al., 2013), high health care costs (Olesena, Gustavsson, Svensson, Wittchen, & Jönsson, 2012), and excessive avoidance of fear-eliciting stimuli and situations (American Psychological Association, 2013; Barlow, 2002). Despite the importance of avoidance to these mental disorders, little is known about the impact of avoidance on fear extinction (e.g., Rachman, Craske, Tallman, & Solyom, 1986; Starr & Mineka, 1977; Vervliet, Craske, & Hermans, 2013). Fear conditioning theories argue that fear to a previously neutral stimulus arises from classical Pavlovian fear conditioning – a neutral stimulus is paired with an aversive unconditioned stimulus (US), turning the neutral stimulus into a conditioned stimulus (CS); thereafter, the CS elicits a conditioned fear response (CR), in the absence of the US. Crucially, subsequent avoidance behaviour evoked by presentations of the CS interferes with fear extinction (i.e. the CR will not decline), an effect that has recently been called *protection from extinction* (Lovibond, Davis, & O'Flaherty, 2000).

Fear conditioning theories represent key etiological models for the development and maintenance of anxiety disorders and PTSD. Patients affected by PTSD (Orr et al., 2000) or social anxiety disorder (Hermann, Ziegler, Birbaumer, & Flor, 2002) exhibit heightened conditioned fear responses during acquisition. Furthermore, delayed extinction learning is evident in PTSD (Blechert, Michael, Vriends, Margraf, & Wilhelm, 2007), social anxiety disorder (Hermann et al., 2002) and panic disorder (Michael, Blechert, Vriends, Margraf, & Wilhelm, 2007). Moreover, PTSD patients avoid trauma reminders (Pfaltz, Michael, Meyer, & Wilhelm, 2013), obsessive compulsive disorder patients avoid situations at risk for contamination (Rachman, 2004) and social phobia patients avoid large gatherings of people (Bögels et al., 2010; Schneier, Rodebaugh, Blanco, Lewin, & Liebowitz, 2011). As past research showed that anxiety and PTSD symptomatology lie on a continuum to subthreshold and less severe symptoms prevalent in the general

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population, those findings are also relevant for relatively unselected, non-clinical samples (e.g., Angst, Merikangas, & Preisig, 1997; Carter, Wittchen, Pfister, & Kessler, 2001; Zlotnick, Franklin, & Zimmerman, 2002).

Although experimental studies investigating the role of avoidance behaviour in the context of fear have been conducted in animals over the past decades (e.g. McCue, LeDoux, & Cain, 2014; Skinner, 1948, 1953; Solomon & Wynne, 1953; Venable & Kelly, 1990), human subject research has started only recently (e.g. Lovibond, Saunders, Weidemann, & Mitchell, 2008; Pittig, Pawlikowski, Craske, & Alpers, 2014a; Pittig, Pawlikowski, Craske, & Alpers, 2014b; Pittig, Schulz, Craske, & Alpers, 2014c; van Meurs, Wiggert, Wicker, & Lissek, 2014). This contrasts with the pervasiveness of avoidance symptoms in the clinical picture of anxiety disorders and their subclinical manifestations. Recently innovative experiments have been undertaken that tried to improve the understanding of the protection from extinction effect and the role of avoidance costs in humans. Spearheading this development, Lovibond, Mitchell, Minard, Brady, and Menzies (2009) developed an operationalization of the protection from extinction effect: All participants first underwent differential fear acquisition (pairing geometric figures with either a shock, CS+, or no shock, CS−) before learning to avoid the CS+ through a specific button press on a response pad. Two groups were then formed during extinction: the avoidance group had the option to continue using the avoidance button while this button was deactivated in the control group. Subjective ratings of US-expectancy as dependent variable, a self-report measure associated with physiological fear responses in human conditioning studies (see Lovibond & Shanks, 2002; Lovibond et al., 2008), revealed that the avoidance group had higher US-expectancy ratings for the CS+ than the control group during a subsequent test phase involving CS+ and CS− trials without avoidance option in both groups. This manifests the key consequence of avoidance: protection from extinction and restitution of conditioned fear. Hence, the avoidance response functions as a safety behaviour, assuring the non-occurrence of an aversive event; thus, avoidance responses are negatively reinforced by reduced US-expectancy, paving the way for future avoidance behaviour and prevention of extinction (Lovibond, Chen, Mitchell, & Weidemann, 2013).

While this work is productive with respect to a laboratory model of a clinically prevalent process, some questions remain. Lovibond et al.'s participants did not experience any costs for avoiding the CS+. Hence, participants engaged in this behaviour whenever possible. However, daily live avoidance does accrue significant costs: detours on the way to work to avoid tunnels or bridges, or stairs taken to avoid elevators represent costs whereas cancelled social events due to anxiety represent omission of benefits. Thus, newer laboratory analogue studies started to model such costs and missed benefits: Pittig, Brand, Pawlikowski, and Alpers (2014a) coupled advantageous choices (higher virtual monetary gains) to the CS+ and disadvantageous choices to conditioned safety signals (CS−) by integrating the Iowa gambling task (Bechara, Damasio, Damasio, & Anderson, 1994) into their conditioning experiment; one study testing avoidance behaviour in spider phobics (Pittig et al., 2014a), one in social phobics (Pittig et al., 2014b). Results showed that during extinction, participants accepted reduced rewards in order to avoid the CS+ in addition to demonstrating protection from extinction. Furthermore, Pittig et al. (2014c) showed that healthy students with high trait anxiety exhibit particularly pronounced avoidance behaviour. However, as noted by the authors, the hypothetical nature of rewards implicated in gambling tasks might not generalize to real rewards (Pittig et al., 2014c), just as monetary risk might not well represent avoidance costs in anxiety disorders. Addressing the latter concern, van Meurs et al. (2014) replaced monetary costs by temporal delay based avoidance costs. Specifically, the researchers used a virtual farmer paradigm, pairing one type of geometric shape with an electric-shock (CS+), using other resembling shapes as generalization stimuli. The goal of the game was to gather as much crop as possible; participants could either choose to maximize their performance (taking a shortcut to home) or accept poorer performance (taking a detour); though, the shortcut was associated with an electric shock. The authors showed that stronger fear conditioning generalization was associated with enhanced maladaptive avoidance of safe generalization stimuli. As detour length was held constant in van Meurs et al. (2014) task, a parametric manipulation of avoidance costs has yet to be implemented in a decision making design studying avoidance and extinction. Furthermore, ecological validity of the avoidance decisions and the resulting costs (in the form of meaningful consequences for the participant) needs to be included.

The present study combined the strengths of Lovibond et al. (2009) and van Meurs et al. (2014) designs. Similar to the design by Lovibond et al. (2009), four phases were included in the present study: an acquisition, an avoidance learning, an extinction, and a test phase. In line with van Meurs et al. (2014) and in contrast to Lovibond et al. (2009), participants were not pre-allocated to avoidance vs. non-avoidance groups: they could choose trial wise between a shortcut and a lengthy detour (representing avoidance costs) during extinction - thus, converting the task into a behaviourally relevant decision making paradigm. Extending past designs, avoidance costs were manipulated in terms of varying detour length between participants, pre-assigning participants to different *duration groups*. In order to establish ecologically valid avoidance costs, participants were informed that they could leave as soon as the experiment was finished – effectively linking detour choices to higher personal costs in terms of time expenditure in the laboratory.

Three main hypotheses were tested: First, it was hypothesized that with increasing avoidance costs (represented by a longer detour; *duration groups*), participants would be more likely to choose the shortcut despite being confronted with the US-predicting CS+. Second, individuals actively avoiding the CS+ during extinction (*the avoidance group*) were expected to show heightened US-expectancy ratings at a later test trial (=protection from extinction effect), compared to individuals choosing the shortcut and facing the CS+ (*non-avoidance group*). Third, we expected that, as a consequence, there would be an indirect effect of avoidance cost on protection from extinction through avoidance behaviour (mediation analysis). In addition, we explored whether trait anxiety affected behavioural choice (see Pittig et al., 2014c) and the protection from extinction effect, only tentatively expecting an effect, as choice variance was suspected to be narrowed for the long and the short detour conditions.

1. Method

1.1. Participants

Ninety-two women participated in the study in exchange for course credit or monetary compensation (7€). Exclusion criteria were self-reports of psychotropic medication, psychosis, substance abuse/dependency, bipolar disorder, serious medical conditions, or history of traumatic head injury. Seven participants were excluded: two due to use of psychotropic medication, two due to health problems, and three due to technical problems during the experiment. Thus, in total, 85 participants were included in the analysis (mean age = 24.01, $SD = 7.84$). The study was approved by the local ethics committee; participants gave their informed consent and