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From avoidance to approach: The influence of threat-of-shock on reward-based decision making

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A B S T R A C T

Potential threat can prime defensive responding and avoidance behavior, which may result in the loss of rewards. When aversive consequences do not occur, avoidance should, thus, be quickly overcome in healthy individuals. This study examined the impact of threat anticipation on reward-based decisions. Sixty-five participants completed a decision-making task in which they had to choose between high- and low-reward options. To model an approach-avoidance conflict, the high-reward option was contingent with a threat-of-shock cue; the low-reward option was contingent with a safety cue. In control trials, decisions were made without threat/safety instructions. Overall, behavioral data documented a typical preference for the profitable option. Importantly, under threat-of-shock, participants initially avoided the profitable option (i.e., safe, but less profitable choices). However, when they experienced that shocks did actually not occur, participants overcame initial avoidance in favor of larger gains. Furthermore, autonomic arousal (skin conductance and heart rate responses) was elevated during threat cues compared to safety and non-threatening control cues. Taken together, threat-of-shock was associated with behavioral consequences: initially, participants avoided threat-related options but made more profitable decisions as they experienced no aversive consequences. Although socially acquired threat contingencies are typically stable, incentives for approach can help to overcome threat-related avoidance.

1. Introduction

Individuals often need to choose between behavioral options which are linked to either positive or negative outcomes. If one's choice, however, can result in rewards and aversive events at the same time, an approach-avoidance conflict emerges (Cacioppo & Berntson, 1994; Corr, 2013; Miller, 1959). Adaptive action selection then requires balanced decisions between approaching rewards and avoiding harm (Lejuez et al., 2002). In this approach-avoidance framework, the anticipation of consequences is important to organize goal-directed behavior and a priori information about potential threat versus safety is crucial to decide which behavior is most functional. Decisions may therefore be guided by emotional stimuli that convey information about potential threat. Fundamental motivational neural circuits are assumed to organize this influence of emotional information on approach and avoidance behavior (Lang & Bradley, 2010). This model received much support from studies measuring physiological response parameters (e.g., reflex-based motor and autonomic nervous system activity; Bradley, Codispoti, Cuthbert, & Lang, 2001); as well as neuro-imaging studies (e.g., Lang & Davis, 2006). However, surprisingly little is known about potential avoidance biases on more complex behavioral decision-making.

In behavioral decision-making tasks there is often either one positive or one negative outcome. In reward-based decisions, for example, individuals typically show increased selections of profitable options, which are associated with higher or more frequent rewards (e.g., Balleine & Dickinson, 1998; Richards, Plate, & Ernst, 2013). In contrast, individuals will consistently avoid options associated with a single aversive outcome (e.g., an aversive electrical stimulation; Dymond, Schlund, Roche, De Houwer, & Freegard, 2012; Glotzbach, Ewald, Andreatta, Pauli, & Mühlberger, 2012; Lovibond, Mitchell, Minard, Brady, & Menzies, 2009; Ly & Roelofs, 2009).

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In approach-avoidance conflicts, however, rewards and aversive consequences directly compete. There is growing interest in how competing reward- and threat-related consequences are integrate to guide behavioral decision making (Aupperle, Melrose, Francisco, Paulus, & Stein, 2015; Botvinick & Braver, 2015; Hayes, Duncan, Xu, & Northoff, 2014; Pittig, Brand, Pawlikowski, & Alpers, 2014; Pittig, Schulz, Craske, & Alpers, 2014; Schlund et al., 2016; Sierra-Mercado et al., 2015; Talmi & Pine, 2012). For example, whereas healthy individuals will avoid aversive stimuli when competing rewards are absent, too small, or uncertain, they may tolerate the same aversive stimuli and switch towards approach behavior when sufficiently rewarded (Aupperle, Sullivan, Melrose, Paulus, & Stein, 2011; Sierra-Mercado et al., 2015; Talmi, Dayan, Kiebel, Frith, & Dolan, 2009). A reversed switch or “tipping point” towards consistent avoidance has been found for decisions associated with stable rewards, but increasing threat. Healthy individuals switch from approaching the reward to threat avoidance when the increasing threat exceeds the reward value (e.g., Schlund et al., 2016).

Similar decision making has been observed in anxious individuals when more profitable options were linked to individually fear-relevant stimuli. Spider fearful individuals, for example, initially avoided options associated with the presentation of spider pictures, but tolerated such confrontations when gaining higher rewards with these choices (similar with socially anxious individuals in response to angry facial expressions; see Pittig, Alpers, Niles, & Craske, 2015; Pittig, Brand, et al., 2014; Pittig, Pawlikowski, Craske, & Alpers, 2014). Thus, considering both competing rewards and aversive outcomes is crucial for adaptive goal-directed behavior and imbalances may be associated with psychopathology.

Decision making crucially depends on the anticipation of consequences, which in turn requires that individuals effectively learn about environmental contingencies. This is particularly true for the learning and anticipation of aversive events, as these may harm the organism's physical integrity (Johnson, Blumstein, Fowler, & Haselton, 2013). As a model of such learning processes, much research has employed Pavlovian fear conditioning paradigms, in which formerly neutral stimuli acquire emotional properties through pairing with aversive events such as electric stimulations, heat pain, or monetary loss (Craske, Hermans, & Vansteenwegen, 2006; Duits et al., 2015). Importantly, a recent study provided first evidence that fear conditioning experiences may guide subsequent decisions and result in the development of pathological avoidant decisions. Specifically, a former neutral stimulus was paired with an aversive outcome during fear conditioning. In a subsequent decision task, participants avoided options that were linked to this fear conditioned stimulus, even if these decisions resulted in monetary costs and were not anymore linked to the aversive consequences (Pittig, Schulz, et al., 2014; Experiment 1). In addition, this costly avoidance was elevated in individuals with high trait anxiety (Pittig, Schulz, et al., 2014; Experiment 2). These findings demonstrate how behavioral decisions are biased towards costly avoidance by direct fear learning experience.

However, human fear learning may also occur without direct experience of an aversive event. The mere verbal instruction about potential aversive outcomes has been shown to establish a fear-relevant association that reliably provokes defensive responding (i.e., elevated skin conductance responses, heart rate deceleration, and potentiated startle reflexes; e.g., Bradley, Moulder, & Lang, 2005; Bublatzky, Guerra, Pastor, Schupp, & Vila, 2013; Grillon, Ameli, Woods, Merikangas, & Davis, 1991) and facilitates sensory processing of environmental information (e.g., Baas, Milstein, Donlevy, & Grillon, 2006; Bublatzky & Schupp, 2012; Bublatzky, Flaisch, Stockburger, Schmälzle, & Schupp, 2010; Cornwell et al., 2007). Importantly, the acquisition of human avoidance behavior may be similarly triggered by stimuli that acquired threat associations either by direct experience or mere verbal instructions (Cameron, Roche, Schlund, & Dymond, 2016; Dymond et al., 2012). Despite increasing evidence showing the relevance of instructed threat learning for anxiety and stress-related disorders (e.g., Muris & Field, 2010; Robinson, Vytal, Cornwell, & Grillon, 2013), surprisingly little is known about its impact on the individuals' behavior and decisions in approach-avoidance conflicts.

The present study therefore combined verbal threat instructions and a reward-based decision-making task to test the impact of anticipated threat on reward-directed decisions. Participants had to choose between two decks of cards, which were differently reinforced by monetary incentives and contingent with instructed threat-of-shock or safety cues. Building upon previous research, differential positive reinforcement should favor more frequent choices of the high reward options (e.g., monetary gains; Bechara, Damasio, Tranel, & Damasio, 1997; Pittig, Schulz, et al., 2014). On the other hand, instructed threat of aversive events may lead to behavioral avoidance (Dymond et al., 2012) and enhanced defense activation when confronted with a threat cue (i.e., enhanced SCR and heart rate deceleration; Bradley et al., 2005; Olsson & Phelps, 2004). Regarding the interaction of decision making and threat-of-shock, we hypothesized that choices associated with potential threat would be avoided initially (Pittig, Schulz, et al., 2014). However, behavioral avoidance should gradually diminish with increasing experience of reward contingencies and the omission of the aversive consequence. The actual absence of the instructed aversive consequences should further help to overcome behavioral avoidance (see Pittig, Brand, et al., 2014; Pittig, Schulz, et al., 2014), and may support extinction learning (see Bublatzky, Gerdes, & Alpers, 2014).

2. Methods

2.1. Participants

Sample size was based on power analyses conducted with G-Power (Faul, Erdfelder, Lang, & Buchner, 2007), which indicated that 62 participants were required to detect all relevant behavioral effects at a medium effect size (power = 0.80, α error = 0.05, medium effect sizes; assumed correlation of repeated measures in repeated measures ANOVA = 0.40). Because of randomized assignment to two groups, group sizes varied slightly (n = 31 and 34). Sixty-five healthy participants (39 females; 60.0%) were recruited from the University of Mannheim. Their age was between 18 and 41 ($M = 24.3$, $SD = 4.2$). Participants were informed about the general study procedure before providing informed consent according to University of Mannheim ethics guidelines and received course credits for participation. Participants were assigned to two groups (i.e., initial non-threat instruction vs. initial threat/safety instruction), which did not differ in age (see Cauffman et al., 2010), sex distribution, or anxiety and depression scores.[2]

2.2. Procedure

Participants completed questionnaires on anxiety and depression (State-Trait Anxiety Inventory, Spielberger, Gorsuch, Lushene, & Vagg, 1983; Anxiety Sensitivity Index, Peterson & Reiss, 1992;

[2] No group differences were observed for Age: $t(63) = 0.03$, $p = 0.975$; Sex: $\chi^2(1, N = 65) = 0.04$, $p = 0.839$; Symptoms of depression (Beck Depression Inventory; BDI-II): $t(63) = 0.07$, $p = 0.945$; State anxiety (State-Trait Anxiety Inventory − State version; STAI-State): $t(63) = 0.31$, $p = 0.754$; Trait anxiety (STAI−Trait): $t(63) = 0.40$, $p = 0.687$; Anxiety sensitivity (Anxiety Sensitivity Index; ASI): $t(63) = 1.30$, $p = 0.198$.