The (shared) features of fear: Towards the source of human fear responding

Yannick Boddez[1,2], Martin Finn[1], Jan De Houwer[1]

[1]Department of Experimental Clinical and Health Psychology, Ghent University

[2]Center for the Psychology of Learning and Experimental Psychopathology, KU Leuven, Leuven, Belgium

Correspondence concerning this article can be addressed to Yannick Boddez, Ghent University, Henri Dunantlaan 2 B-9000 Ghent Belgium. E-mail: Yannick.Boddez@UGent.be

Abstract

Little is known about why people behave the way they do in threatening situations. Some theories invoke a transfer of responses from unconditioned stimuli (US) to conditioned threat signals (CS), but this principle goes astray, because responses to the US and CS can differ substantially. The idea that we introduce here is that the pattern of responses to a newly established CS does not come from the US, but (at least partly) transfers from how one (learned to) respond(s) to previously encountered stimuli with threat value. So, we conceptualize threat value as a stimulus feature that allows responses to transfer between stimuli that share this feature (in the same way as, for example, overlap in color or shape can support transfer). In contrast to prevailing views, this new perspective focuses on the relation between the CS and already established threat signals rather than on the relation between the CS and the US. We discuss how this shared features perspective on human fear responding can inspire future directions in both the laboratory and clinical practice.

Keywords: fear, fear conditioning, evaluative conditioning, anxiety disorders, generalization, transfer

1. Introduction

Fear is a symptom of prevalent psychiatric disorders (Wittchen et al., 2011) and often leads to severe impairments in quality of life (Olatunji, Cisler, & Tolin, 2007). Nonetheless, despite a century of research (Vervliet and Boddez, 2021), fearful responding still has not revealed all its secrets. Perhaps most crucially, little is known about why people behave the way they do in threatening situations. Influential learning models (e.g., Rescorla and Wagner, 1972) have focused on mechanisms that drive association formation in memory, but are surprisingly underdeveloped when it comes to accounting for variation in the form of conditioned (fear) responses (Honey, Dwyer, & Iliescu, 2020). The terms "fear memory" and "fear responding" are sometimes even used interchangeably, which may testify to how little attention this matter has received so far (for discussions see Boddez, Moors, Mertens, & De Houwer, 2020; also see Miller, Barnet, & Grahame, 1995).

2. A shared features perspective on evaluative conditioning

Recently, the shared features perspective on evaluative conditioning was proposed (De Houwer & Hughes, 2016; De Houwer & Hughes, 2020; Hughes, De Houwer, Mattavelli, & Hussey, 2020), which we extend to preparatory fear responding in this paper. The shared features perspective on evaluative conditioning provides a novel view on why stimulus pairings (e.g., between a neutral picture and a liked picture) can result in changes in evaluative responding (e.g., more positive responses to the neutral picture). Previously, it had already been found that evaluative responses can transfer from one stimulus to other stimuli that share a feature with this stimulus (e.g., color or shape; Boddez, Bennett, Van Esch, & Beckers, 2017). For example, a newfound appreciation of a cubistic painting by Picasso (e.g., due to an inspiring lecture on art) can extend to other cubistic paintings (Boddez, Descheemaeker, Mertens, Truyts, & Van de Cruys, 2019). The theoretical innovation of the shared features perspective lies in the suggestion that, in an evaluative conditioning

procedure, the conditioned stimulus (CS) and the unconditioned stimulus (US) share spatiotemporal features (i.e., they are presented at the same location and at the same time). As such, these spatiotemporal features can be seen as shared features (Hughes et al., 2020) that may allow evaluative responses to transfer between the two stimuli (in the same way as, for example, overlap in color or shape could support transfer). In other words, evaluative conditioning can be seen as a transfer of valence due to shared spatiotemporal features (De Houwer, Richetin, Hughes, & Perugini, 2019)[1]. This perspective is therefore part of a philosophical tradition that aims to reduce the laws of association – in this case the law of contiguity and the law of similarity – to each other (Weiner, 2012).

3. A shared features perspective on human fear conditioning

However, the shared features perspective on evaluative conditioning seemingly runs aground when applied to preparatory fear responses. Other than in evaluative conditioning, (some of) the responses under investigation in the fear conditioning procedure can differ substantially between the CS and the US. For example, a mouse jumps and screams when receiving an electric shock but freezes and keeps quiet when confronted with a CS that signals this shock (Domjan, 2018). Similarly, humans can respond with an expectancy and a slowed-down heartbeat to the presentation of a CS, whereas a US would elicit neither of these. Hence, it is inappropriate to think of fear in terms of a transfer of responses from the US to the CS as the result of the sharing of spatiotemporal features (Moors, 2017).

We highlight one candidate-pathway out of this deadlock. The development of fear conditioning, but not of evaluative conditioning, relies on statistical contingency (Baeyens, Vansteenwegen, Hermans, & Eelen, 2001; De Houwer, Mattavelli, & Van Dessel, 2019; Hofmann, De Houwer, Perugini, Baeyens, & Crombez, 2010). Contingency depends not only

[1]In contrast to prevailing views, one could therefore conceptualize conditioning effects as a subset of shared features or generalization effects rather than to consider the latter as a subset of the former (Boddez et al., 2017).

on trials in which the CS and the US are paired (i.e., on shared spatiotemporal features), but also on trials in which the stimuli are not paired. Statistically speaking, there is a contingency relation between two stimuli if the chance of the presence of one stimulus depends on the presence of the other stimulus. Hence, the CS becomes a predictor for the occurrence of the US. Because in fear conditioning studies, the US is aversive, the CS acquires a threat value, that is, it comes to signal the impeding presence of an aversive event. The new idea that we introduce here is that (a) *threat value* can be conceptualized as a stimulus feature[2] and (b) a transfer of responding can occur between stimuli sharing this feature. This idea can help to explain why people behave the way they do in threatening situations: The pattern of responses to a stimulus with threat value (e.g., a fear conditioned CS) does not just come out of the blue, but (at least partly) transfers from how one (learned to) respond(s) to previously encountered stimuli with threat value. So, in contrast to prevailing views, the focus here is on the relation between the CS and already established threat signals (i.e., the fact that they share the feature of having threat value) rather than on the relation between the CS and the US. In the sections below, we will elaborate on some further questions evoked by this proposal.

4. A symbolic account of the shared features effect

Until now, we did not discuss why shared features allow for a transfer of responding between stimuli. As discussed by Hughes et al. (2020), one of the ways to explain the shared features effect is to see it as an instance of symbolic behavior. Without going into detail, this symbolic perspective – which has its roots in relational frame theory (Dymond and Roche, 2013; Hayes, Barnes-Holmes, and Roche, 2001; Törneke, 2010) – holds that feature overlap leads to transfer when participants treat the shared feature as a cue or *symbol* for an *equivalence* relation between the stimuli that share the feature. In the case of human fear conditioning, threat value - so, being in a contingency relation with an aversive stimulus - would symbolize

[2] In other words, a feature or property of a fear-conditioned stimulus is that it entertains a contingency relation with an (aversive) unconditioned stimulus. This feature is common to fear-conditioned stimuli in general.

that the CS is equivalent to already established threat signals or predictors of aversive events. Accordingly, people would treat the CS as equivalent to established threat signals, much in the same way as how people are able to treat an icon of a saint as equivalent to an actual saint (e.g., kneel and ask for forgiveness).

An interesting aspect of the symbolic account is that it also serves to explain fear acquisition via instructions (Mertens, Boddez, Sevenster, Engelhard, & De Houwer, 2018). In that case it is the symbolic act of language (e.g., the sentence "the light is a predictor of the shock") via which equivalence between the instructed CS and established predictors of aversive events is established. As such, the instructions may endow the instructed CS with the response pattern that is attached to already established predictors of aversive events. Suppose that you find yourself in a conversation during which your superior verbally threatens you with job loss (i.e., tells you that something aversive might be upcoming). The current perspective holds that this verbal information can make you treat the situation as if you are confronted with established threat signals (e.g., with the sound of a bear). This response pattern may entail adaptive responses (e.g., looking for help), but also maladaptive responses (e.g., staying on edge during nighttime – as you would do when a bear is around – might further deteriorate job performance).

5. Tracing the roots of the behavioral repertoire

Two further questions still need answering. A first question concerns how to conceptualize the already established predictors of aversive events. One can think of this source of responding as a class or category of stimuli that is defined by the feature of threat value (in the same way as a stimulus class might be defined by, for example, a shape, color, or country of origin)[3]. When a stimulus becomes a member of this class, it will be treated in the same

[3] Note that the above-discussed shared features perspective on evaluative conditioning assumes class size to be minimal. In that case, the class size is defined by spatiotemporal features that are shared by just two stimuli: the CS and the US.

way as other stimuli in this class[4]. Variation in behavioral expression of fear responding may therefore be rooted in the (level of) differentiation in subcategories. That is, within the higher-level category of stimuli with threat value, nested subcategories (e.g., social versus physical threat) that come with different response patterns (e.g., keeping quiet versus screaming) may develop. As there is an infinite number of ways to carve up higher-level categories in subcategories, this may not only account for within-individual variation in fear responding across situations, but also for variation between individuals in the same situation.

A second question concerns where the initial response pattern comes from so that it can be transferred to new stimuli that become a member of the stimulus category. Some theorists have argued that responses towards (subcategories of) stimuli with threat value are evolutionary established. For example, Bolles (1972) proposed that each species exhibits its own specific defensive reactions when confronted with a threat signal. In a similar vein, it has been proposed that threat signals evoke attentional capture in a hard-wired way (Vuilleumier, 2005).

We do not exclude the theoretical possibility that a subset of the responses towards threat signals may be evolutionary established or even hard-wired. Still, we want to emphasize that the repertoire of (conditioned) fear responding may be more flexible than typically proposed. More precisely, we propose that certain responses towards threat signals may be added (e.g., praying) or removed (e.g., respiratory irregularities; Van Diest, Bradley, Guerra, Van den Bergh, & Lang, 2009). This implies that different learning histories can give rise to (individual) differences in dealing with (subcategories of) threat signals. As such, these learning histories provide an additional source of variation in responding (on top of individual

[4] Relational Frame Theory stipulates that the environmental context controls which responses transfer (Cfunc, Stewart, Barret, McHugh, Barnes-Holmes, & O'Hora, 2013; see Hayes & Hayes, 1989 for the original conceptual argument). Thus, in terms of this framework, the specific form of a preparatory fear response (e.g., keeping quiet versus screaming) will be shaped by features of the context in which it occurs (e.g., situational variables pointing towards social versus physical threat).

differences in ways to carve up higher-level categories in subcategories – see above). Two learning pathways deserve discussion here.

First, changes in the response pattern to stimuli with threat value may be rule-governed (Törneke, 2010). For example, patients may be told to pray, to breath calmly, or to sing about their worst fears when confronted with a threat signal (Hayes, 2005) and subsequently display these instructed responses also to newly learned threat signals. A second possibility entails that the changes in responding are contingency shaped (Törneke, 2010). For example, one may have experienced that certain responses reduce the probability of a threat becoming reality (Pittig, Wong, Glück, and Boschet, 2020) and transfer these responses to new situations that acquire threat value.

6. Added value of the shared features perspective on human fear conditioning

We will now illustrate how the shared features perspective can bring together existing knowledge in a unifying framework and how it may lead to new treatment directions. Let us first consider some basic learning effects like acquisition and extinction. Remember that we do not aim to account for how people learn about contingencies, but for why they respond the way they do when confronted with predictors of aversive events.

As said, contingency refers to the statistical relation between the presence of two stimuli. The probability of the US given the CS can be manipulated by the experimenter. The CS can be paired with the US on every trial (i.e., continuous reinforcement), on some of the trials (i.e., partial reinforcement) or on none of the trials. Research has established that the intensity and probability of fear responding is a positive function of the reinforcement rate (e.g., Domjan, 2018; Dunsmoor, Bandettini, and Knight, 2007) — at least when other determinants of fear responding are kept equal (Boddez et al., 2020). Of particular interest from the current perspective is that research has also established that the strength of shared features effects is positively related to the extent of feature overlap with the original event

(i.e., the generalization gradient; Dymond, Dunsmoor, Vervliet, Roche, & Hermans, 2015; Ghirlanda & Enquist, 2003; Zaman et al., 2020). As such, the high response strength after continuous reinforcement can be seen as strong transfer from (highly similar) established predictors. The relatively weaker and absent responding after partial and non-reinforcement can on their turn be understood as instances of weak and absent transfer due to the defining feature of the stimulus class (i.e., the statistical contingency with an aversive US) being weaker or absent for such stimuli, respectively. In other words, the effects of reinforcement rate on fear responding can be interpreted as a generalization gradient across the stimulus dimension of threat value magnitude.

Building on the same principle, extinction, the decrease in responding due to CS-only trials (Bouton, 2002; Pavlov, 1927; Vervliet, Craske, & Hermans, 2013), would be caused by removal of the feature that is common between the CS and established predictors of aversive events. As the contingency between the CS and the aversive US is removed, there will be less response transfer from established predictors of aversive events and hence less conditioned responding.

As a final note on heuristic value, we would like to make the link with a phenomenon that has recently attracted attention in the fear conditioning literature. Recent studies have established that making participants emit an avoidance action towards a stimulus that has never been paired with something aversive can make that people come to display fear of this stimulus (e.g., Engelhard, van Uijen, van Seters, & Velu, 2015; van Vliet, Meulders, Vancleef, & Vlaeyen, 2021). From the present perspective, the idea would be that fear transfers from stimuli previously paired with avoidance to the stimulus that is paired with avoidance (i.e., avoidance action as shared feature). If these previously avoided stimuli are feared stimuli, then one would indeed predict a transfer of fear.

We now move to the clinical implications of our perspective. The current perspective may help to make patients understand why they respond the way they do through psycho-education. In this context, it may be of note that our perspective partly dovetails with the classic example of clinicians telling their patients that, as humans, we are equipped to deal with threats like predators, but that it can be maladaptive to transfer these response patterns to some of the threats that are characteristic of today's society (e.g., job insecurity; Keijsers, van Minnen, Verbraak, Hoogduin, & Emmelkamp, 2017). In other words, treating all predictors of aversive events as equivalent (e.g., irrespective of controllability of the outcome) may interfere with effective goal accomplishment.

On top of psycho-education, patients may benefit from changes in the response pattern. As we discussed above, the current perspective maintains that the behavioral pattern displayed in response to a predictor of something aversive is not merely a given, but that it can be altered. As such, therapists could aim to tweak the pattern so that it causes less suffering (e.g., by offering new rules such as that one should breath calmly). These more adaptive response patterns could also be practiced with specific predictors (e.g., in a fear conditioning task) during therapy, after which transfer to other predictors can be encouraged (Stokes & Baer, 1977). In addition, one could also try to reduce transfer of maladaptive response patterns between subcategories of predictors of aversive events (Ginat-Frolich, Klein, Katz, & Shechner, 2017; Lommen et al., 2017) by highlighting relevant differences between them (e.g., in terms of controllability over the aversive event). So, the shared features perspective on fear conditioning implies that in clinical practice one cannot only focus on undermining CS-US contingencies (as in exposure therapy; Craske, Treanor, Conway, Zbozinek, & Vervliet, 2014) or on changing the value of the US (as in US devaluation; Dibbets, Poort, & Arntz, 2012), but also on changing elements of the response pattern evoked by (subcategories of) stimuli with threat value. We therefore hope that the shared features

perspective on human fear responding will inspire future research in both the laboratory and clinical practice.

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