Running Head: SYMBOLIC OR DERIVED GENERALIZATION

Symbolic or Derived Generalization of Fear and Avoidance in Humans: A Systematic Review

ACCEPTED: *Journal of Contextual Behavioural Science*

Leandro S. Boldrin[1, *], Martyn Quigley[2], and Simon Dymond[2, 3]

[1] Department of Experimental Psychology, São Paulo University, Brazil.

[2] School of Psychology, Swansea University, United Kingdom.

[3] Department of Psychology, Reykjavík University, Iceland.

***Correspondence**: Leandro S. Boldrin, Department of Experimental Psychology, Institute of Psychology, São Paulo University, Av. Prof. Melo Moraes, 1721, Cidade Universitária, São Paulo, SP, Brasil - CEP 05588-030. leandro.sboldrin@gmail.com

Funding:

LSB was supported by the National Council for Scientific and Technological Development (CNPq, grant #149766/2018-1) and the Coordination of Superior Level Staff Improvement (CAPES, grant #88887.750009/2022-00).

Data Availability:

Additional data may be provided upon request to the corresponding author.

Declarations of interest: None

Abstract

Fear and avoidance responses acquired in the presence of one event often generalize to other symbolically related cues or events, increasing the range of potential threatening stimuli capable of evoking defensive responses. In this way, symbolic or derived generalization of fear or avoidance occurs when physically dissimilar, arbitrary stimuli come to occasion conditioned fear or avoidance responses without further training. Despite being a well-studied domain of obvious translational and clinical relevance, a systematic review of this literature has not yet been conducted. We systematically searched Web of Science and PsycINFO databases for empirical articles on the symbolic generalization of fear and avoidance in humans. Following screening, 31 articles were identified that described studies conducted with a wide range of variables and procedures, relatively small samples sizes, and often lacking justification for participant recruitment and the use of task mastery criteria. We conclude by discussing how research on the symbolic generalization of fear and avoidance in humans can provide a valid and reliable contextual behavioral model for studying and treating anxiety related disorders.

Keywords: fear, avoidance, transfer, transformation, derived, generalization, equivalence, relational frame theory, anxiety, humans

1. Introduction

Fear of potential sources of threat and the anxious avoidance of real or perceived danger are generally adaptive, evolutionary defensive responses (LeDoux & Daw, 2018; Öhman, 2008). Fear and avoidance may, however, escalate when a range of stimuli or situations, not necessarily real dangers, come to occasion these responses. In so doing, an instance of learning or exposure to this evolutionary process can result in debilitating fear and avoidance, and yield diagnosis with an anxiety or related disorder (Craske et al., 2011).

Recently, translational research with humans aimed at understanding how this adaptive process becomes maladaptive and spreads or over-generalizes has received increased empirical scrutiny (Ball & Gunaydin, 2022; Dymond et al., 2015, 2018). Reasons for the increased empirical attention likely include the acknowledged validity of behavioural paradigms for illuminating clinically relevant processes (Krypotos et al., 2015; Vervliet & Raes, 2013), the reliable translation from empirical findings directly to therapeutic interventions (Cooper et al., 2022; Waters & Pine, 2016), and input from the respective research contributions of Pavlovian and operant conditioning paradigms with long traditions of clinically oriented research (Beckers et al., 2023; Brewer et al., 2024; Dymond, 2019; Pittig et al., 2018). To that end, it may be helpful to systematically assess the burgeoning literature on clinically relevant fear and avoidance generalization to inform treatment development and identify gaps in knowledge. The aim of the present study was therefore to review this literature by focusing on one form of generalization, symbolic generalization or the spread of symbolic, untrained, emergent, or derived fear and avoidance responses, in humans.

1.1. Fear and avoidance conditioning and generalization

Fear and avoidance conditioning and generalization have typically been investigated using Pavlovian and operant conditioning paradigms (Brewer et al., 2024; Crosbie, 1998; Dymond et al., 2015, 2019; Lonsdorf et al., 2017, 2019; Wong et al., 2022). In Pavlovian differential human fear conditioning, an initially neutral stimulus (conditioned stimulus or CS+) such as a tone or an abstract figure, is paired with an intrinsically aversive stimulus (the unconditioned stimulus or US) such as an electric shock or a loud noise. Another neutral stimulus, the CS-, may also be paired with the absence of the US. As a result of this pairing procedure, presentations of the CS+ alone, but not the CS-, become sufficient to elicit conditioned fear responses (CR), which are typically assessed using physiological arousal (e.g., skin conductance), self-report ratings (e.g., US expectancy), or response tendencies (e.g., freezing). In operant avoidance conditioning, responses (e.g., pressing a key on a keyboard) are allowed during CS+ presentations which prevents the subsequent presentation of the US. As a result, the probability of avoidance occurrence is increased as the procedure continues.

Both fear and avoidance conditioning are fundamental components in clinically relevant behavioral models which provide important insights into the causes, maintenance, and treatments of anxiety disorders (e.g., Beckers et al., 2023; Dymond, 2019). Consider, for example, a patient who comes to a therapy session and reports feeling extreme fear, dizziness, and fainting in situations where they are exposed to blood (i.e., hematophobia). To prevent these responses, this patient has avoided situations signaling blood such as horror movies, medical procedures, and injured people. During a therapy session the patient reveals previously experiencing a serious car accident (US) involving blood, wounds, and injuries (CSs), which could account for the emergence of the patient's behaviors and symptoms (CRs/avoidance) and provide targeted pathways for therapeutic intervention.

Stimuli that share perceptual or symbolic similarity with CSs that elicit fear may also elicit fear and avoidance responses themselves, without further pairing (Dymond & Roche, 2009; Dymond et al., 2015, 2018). The resulting spread or generalization of fear and avoidance increases both the range of potential threatening stimuli capable of evoking defensive responses and fosters an overgeneralization of these responses – that is, they are no longer limited to the original learning situation. For instance, returning to the example of a patient who has experienced a car accident, the sight of similar cars or intersections resembling where the accident occurred, being asked to "go for a drive" or the very thought of driving again are all capable of eliciting fear and avoidance. Left unconstrained, these generalization processes may lead the patient to avoid all driving and withdraw from future opportunities aimed at disconfirming the catastrophic predictions of this overgeneralization tendency.

To date, reviews of this literature on fear and avoidance generalization have tended to focus on perceptual or stimulus generalization where learning spreads via physical similarity (e.g., Cooper et al., 2022; Dunsmoor & Paz, 2015; Dymond et al., 2015; Fraunfelter et al., 2022) and conceptual generalization where learning spreads via pre-existing learned semantic or conceptual categories (e.g., Dunsmoor & Murphy, 2015). Other forms of generalization have not yet been subject to systematic review. Previous reviews of this burgeoning literature have also been narrative in nature, with an emphasis on theoretical developments and clinical implications (Dymond et al., 2018; Dymond & Roche, 2009). Little is known, therefore, about the systematic features and methodological strengths and weaknesses of the extant literature on this unique form of generalization of fear and avoidance. Here, we present the first formal systematic review of this literature.

1.2. Symbolic generalization and derived stimulus relations

As described above, most of the extant empirical work on fear and avoidance generalization has focused on perceptual or conceptual generalization (Beckers et al., 2023; Dunsmoor & LaBar, 2013; Dymond et al., 2015). That is, the range of CSs tested for the spread of the effects of fear learning have included circles of differing size, facial photographs morphed into one another along a continuum, or Gabor patches varying in visual intensity for studies of perceptual generalization and images of animals or tools, amongst others, for tests of conceptual generalization. Such stimuli often rely on pre-experimentally acquired learning about perceptual features and the assumed presence of conceptual knowledge systems to explain how unfamiliar CSs come to resemble multiple, generalized forms of potential threats. As such, this literature fails to address more symbolic forms of fear and avoidance generalization from research that combines de novo conditioning with the learning of "concept-like" associations between arbitrary (physically dissimilar) stimuli.

One reason for the research interest in symbolic generalization is that it may offer a functional account of why people diagnosed with anxiety disorders often do not recognize a traumatic history (or a history of direct conditioning) that led to their symptoms (e.g., Brewer et al., 2024; Belisle et al., 2024; Dymond & Roche, 2009; Dymond et al., 2015; Friman & Dymond, 2020). For instance, the client in our previous example of hematophobia could also report fear and avoidance in the presence of events not involved in the car accident but indirectly related as equivalent to stimuli that were involved (e.g., blood), including pharmacies, hospitals, injured people, and even talks or thoughts about accidents. In this way, a direct history of conditioning is not necessary with all potential stimuli capable of evoking defensive fear and avoidance responses in humans.

The learning and deriving of arbitrary stimulus relations has been the focus of behavioural psychologists interested in language and cognition (Dymond & Roche, 2009). This research has shown that novel, untrained responses, like fear and avoidance, may emerge from a subset of directly trained fear or avoidance responses. That is, when language-able humans learn a series of arbitrary interrelated conditional discriminations involving physically dissimilar stimuli, the stimuli involved often become related to each other in ways not explicitly trained (Sidman, 1994). For example, when conditional relations A-B and B-C are trained between the arbitrary stimuli A, B, and C (e.g., abstract figures or nonsense words), new relations that were not directly trained can emerge according to the properties of reflexivity (A-A, B-B, and C-C), symmetry (B-A and C-B), transitivity (A-C), and equivalence (C-A).

Furthermore, once the relations are established, responses conditioned in the presence of one stimulus will also occur in the presence of other stimuli of the same class, a phenomenon referred to as "transfer or transformation of function" (e.g., de Rose et al., 1988; Dymond & Rehfeldt, 2000).

As a means of promoting interaction with fields outside of contextual behavioural psychology, the term "symbolic generalization" has been proposed to refer to the transfer or transformation of clinically relevant responses like fear and avoidance (Dymond et al., 2018). Used in this way, these middle-level terms may foster wider dissemination of behaviour-analytic concepts and principles and reinvigorate translational work on this important topic. For these reasons, we will use the terms "symbolic generalization" and "transformation of functions" interchangeably throughout the present review.

Stimuli can also be related in other ways than equivalence (Hayes et al., 2001). Some examples are opposition (A is opposite to B), comparison (A is bigger than B), difference (A is different from B), spatiality (A is in front of B), hierarchy (A and B are contained in C), and causality (if A then B). In these cases, the relations are conceptualized as relational frames and the defining properties are mutual entailment (if A → B then B → A; e.g., if A is smaller than B then B is bigger than A), combinatorial entailment (if A → B and B → C then A → C and C → A; e.g., if A is more than B and B is more than C then A is more than C and C is less than A), and the transformation of stimulus functions. The former property states that functions conditioned in the presence of one stimulus of the relational frame will transform (or change) the functions of the other stimuli according to the type of relation established between them (Dymond & Rehfeldt, 2000). For example, suppose that the relations A same to B and B opposite to C are established. Then, it would be expected that responses trained in the presence of A would also occur in the presence of B which is related as same to A, but not in the presence of C which is related via combinatorial implication as opposite to A. So, a person with anxiety about social interactions may have learned that people are dangerous in some way and by derivation that isolation is the safest choice, an avoidance response that comes with high costs because while it "protects" from a supposed danger, it also restricts the person's social life.

The seminal texts on derived stimulus relations were published more than 50 years ago (Sidman, 1971) and 20 years ago (Hayes et al., 2001), respectively. Since then, many studies have been conducted on symbolic generalization of fear and avoidance (Dymond & Roche, 2009; Dymond et al., 2015, 2018). The studies manipulated a wide range of parameters (e.g., experimental design, CS/antecedent stimuli, US/consequence stimuli, outcome measures, type of derived relations, and participant characteristics) in a variety of experimental procedures. The basic procedure for investigating symbolic generalization of fear and avoidance is however straightforward and involves at least three stages. The first stage is the establishment of a requisite network of relations between stimuli such as equivalence or other derived relations. The second stage is the conditioning of fear and/or avoidance responses in the presence of at least one stimulus from the network. The third stage is a test, in the absence of the aversive event, that evaluates the symbolic generalization of fear and avoidance responses to remaining stimuli (i.e., those that did not undergo conditioning procedures but are indirectly related to the CSs). To date, this research has not yet been systematically mapped and organized.

To address this gap, we report here the first systematic review of fear and avoidance generalization involving symbolic or derived processes in humans. Previous narrative reviews have briefly summarized some of this literature (Dymond et al., 2015) or focused solely on the symbolic/derived associations involved in the spread of fear and avoidance (Dymond et al., 2018) but none has formally categorized this literature over an extended timeframe following a systematic search. The present review will address the following question: what are the characteristics of the procedures that were used for the establishment of derived stimulus relations, fear and avoidance conditioning, and symbolic generalization tests? Moreover, we sought to emphasize the methodological features of the extant literature and to identify gaps in research knowledge.

2. Method

The present systematic review followed the Preferred Reporting Items Systematic Reviews and Meta-analyses (PRISMA; Page et al., 2021) guidelines (Figure 1).

First, a search was conducted of Web of Science and PsycINFO databases. The search terms and combinations used were: (*fear* OR *avoidance*) AND (*equivalence* OR *relational* OR *relations* OR *symbolic*) AND (*transfer* OR *transformation* OR *derived* OR *generalization*). Duplicate records were removed from the results.

Next, articles found were screened for eligibility by reading the title and abstract and excluding those that were unrelated to derived fear and/or avoidance. The remaining articles were selected for full-text inspection against the following inclusion criteria: 1) employed a procedure (e.g., matching to sample) for the establishment (i.e., training and/or testing) of equivalence or other derived stimulus relations; 2) employed a fear- or avoidance-conditioning procedure with humans; 3) performed tests involving unreinforced trials to evaluate the derived spread or transfer of fear and/or avoidance responses. Articles satisfying the inclusion criteria were included in the review.

Finally, a subject specialist was consulted, and the references sections were checked to identify additional articles.

The search was conducted in July 2023 and new articles were tracked until May 31, 2024.

Insert Figure 1 About Here

3. Results

The search returned 1118 articles from the Web of Science and 532 from the PsycINFO database, respectively, yielding a total of 1650 records. Five articles were removed as duplicates and a further 1607 as their titles and abstracts indicated they were unrelated to derived fear and/or avoidance. Thirty-eight articles remained for full-text reading and 12 did not meet the inclusion criteria for the following reasons: four were reviews (Dymond et al., 2005; Dymond & Roche, 2009; Dymond et al., 2015; Dymond et al., 2018), two were unrelated to fear or avoidance (Garcia et al., 2016; Perez et al., 2017), and six did not employ either a fear- or avoidance-conditioning procedure (Eilertsen & Arntzen, 2020; Leech et al., 2018; Leech & Barnes-Holmes, 2020; O'Toole et al. 2007; Perez et al., 2019; Sandoz et al., 2021). Therefore, 26 articles were included in the review following database search. Finally, five additional articles were included after reference-checking (Bennett et al., 2015c; Markham et al., 2002), subject-expert consultation (Bennett et al., 2020; Glogan et al., 2023) and periodic alerts of new articles in the databases (Boldrin et al., 2024).

Insert Figure 2 About Here

As Figure 2 shows, the first article on derived fear/avoidance was published by Dougher et al. (1994) and publications have increased since 2006 to a maximum of four per year. Work on derived fear/avoidance was published most often in either the *Journal of the Experimental Analysis of Behavior* (JEAB) or *The Psychological Record* (PsycholRec), with these two behavior-analytic journals publishing almost 60% of the included articles. The remaining articles were distributed among nine other journals.

3.1. General characteristics

Thirteen variables were coded and described in two tables for the present review. Table 1 shows the general characteristics of the studies such as the derived responses investigated (fear or avoidance or both), participants (sample, number, sex/gender, age), experimental design, CS/antecedent stimuli, US/consequence stimuli, outcome measures, and relations involved.

Insert Table 1 About Here

3.1.1. Derived Responses. Nine of 31 studies (29%) included in the review investigated fear and avoidance responses, seven fear (23%), five avoidance (16%), four fear and avoidance extinction (13%), three avoidance extinction (10%), and two respectively studied fear extinction (6%) and approach and avoidance (6%).[1]

3.1.2. Participants. A total of 1171 participants (*Min* = 3, *Max* = 90, *M* = 30.03, *SD* = 26.71) were included across the 31 studies. The population mostly consisted of 1002 (86%) adult undergraduate students, 152 (13%) adults without further details provided, and 17 (1%) typically developing children. Minimum and maximum ages ranged from 18 to 26 (*M* = 19.50, *SD* = 2.34) and 24 to 65 (*M* = 33.21, *SD* = 10.24), respectively, for adults. Montoya-Rodriguez and Molina-Cobos (2017) was the only study with children and the ages ranged from 10 to 11 years. There were 737 (63%) female, 263 (22%) male, and 171 (15%) participants with no sex or gender specification. Interestingly, only three (10%) of the 31 studies (Bennett et al., 2015b; Glogan et al., 2023; Perez et al., 2021) provided full descriptive statistics about the sex or gender and age of participants (i.e., Range, Mean, SD).

Insert Figure 3 About Here

Figure 3 illustrates the distribution of the sample size (i.e., the number of participants) for all included articles. The wide base and thin top indicate that most studies were conducted with a relatively small number of participants. Specifically, the highest probability for the number of participants (wider section in the curve in Figure 3) is below 20 which means that studies including less than *N* = 20 participants were most likely. The largest number of participants included in a single study was 90 (Dymond et al., 2012) and only four studies (13%)

[1] The sum of the derived responses variable is greater than the number of included studies because Dougher et al. (1994) investigated both fear and fear extinction.

contained sample sizes greater than 80 (Bennett et al., 2015b; Donati et al., 2019; Dymond et al., 2012; Valdivia-Salas et al., 2022), thus indicating that some studies may be under-powered.

3.1.3. Design. The use of one, repeated measures-group (i.e., each participant tested under all conditions) was the experimental design employed in 15 of 31 studies (48%). Thirteen of these 15 studies (87%) used a post-test phase only and two studies (13%) used reversal of contingencies (Valverde et al., 2009, 2021). The two group, between-subjects design (i.e., each participant tested in only one of two or more conditions) was employed in 17 of 31 studies (55%).[2] Thirteen of these 17 studies (76%) compared different experimental conditions, and four studies (24%) compared experimental and control conditions (Dougher et al., 1994, Experiment 2; Dougher et al., 2007; Dymond et al., 2007; Perez et al., 2020).

3.1.4. Conditioned Stimulus (CS). Several studies selected abstract figures (16, 52%) or nonsense words (15, 48%) as relational stimuli or CSs. Colors (background, circles, cards) were employed in four (13%), shapes (3D animal-like objects, geometric, colored) in three (10%), letters/vowels in two (6%), and arm movement (joystick, robotic) in two studies (6%).

3.1.5. Unconditioned Stimulus (US). The different types of US used in the studies were organized into three groups: aversive, appetitive, and neutral.

Aversive USs comprised electric shock (12; 39%), unpleasant images (11; 35%), sounds (11; 35%), point loss (two; 6%), threatening terms (two; 6%), facial expressions of fear (two; 6%), aversive videos (one; 3%), and frowning emoticons (one; 3%). All 11 studies that used aversive images selected the stimuli from the IAPS database (Lang et al., 2008) and one study (9%) also employed images of spiders from a Google™ search (Dymond et al., 2014). Considering the aversive sounds, the female scream US from IADS (Bradley & Lang, 2007) was used in seven of 11 studies (64%). White noise, dissonant notes, metal scraping, and a

[2] The sum of the designs is greater than the number of included studies because Dougher et al. (1994) conducted two experiments, each with different designs: one-group was employed in Experiment 1 and two groups in Experiment 2.

range of high-pitched tones (ranging from 80 dB to 100dB, for 5 s duration) were each included in one study (9%).

Appetitive USs comprised pleasant images (six; 19%), sounds (one; 3%), earning of points (four; 13%), safety-related terms (two; 6%), facial expressions of happiness (one; 3%), videos (one; 3%), and smiling emoticons (one; 3%). Nonaversive images were all selected from the IAPS (six). Consonant notes were used as nonaversive sounds in one study (Perez et al., 2021).

Neutral USs comprised neutral images (one; 3%), videos (one; 3%), and messages (eight; 26%). Neutral images were selected from the IAPS (e.g., pictures of light bulb or umbrella) and neutral videos from the participant's assessment (Montoya-Rodriguez & Molina-Cobos, 2017). Messages referred to the cancelation of consequences (seven of eight studies; 88%) and correct/incorrect feedback (one of eight studies; 13%), respectively.

3.1.6. Outcome Measures. Pavlovian and operant outcome response measures included skin conductance responses (eight; 26%), key pressing (18; 58%), mouse clicking (five; 16%), and self-report ratings (14; 45%). Other less frequently employed outcome measures were heart rate (Valverde et al., 2021), response latency (Bennett et al., 2015b; Gannon et al., 2011; Valdivia-Salas et al., 2022), video selection (Montoya-Rodriguez & Molina-Cobos, 2017), and robotic arm movements (Glogan et al., 2023).

Ratings-based measures included US likelihood or expectancy (nine; 64%), pain-US expectancy (two; 14%), valence (three; 21%), fear of pain (two; 14%), and unpleasantness (three; 21%). Fear, threat, arousal, intensity, discomfort, disgust, preference, control, semantic differential (Osgood et al., 1957), and BIS/BAS scales (*Behavioral Inhibition System/Behavioral Activation System*; Carver & White, 1994) were also rated in one study (7%).

3.1.7. Relations. Twenty-five of the 31 included studies (81%) investigated derived fear or avoidance via equivalence relations. The class/relational sizes comprised two, 3-member (nine; 36%); two, 4-member (nine; 36%); two, 5-member (three; 12%); two, 6-member (two; 8%); three, 3-member (two; 8%); and three, 4-member (two; 8%).[3] Six other studies employed same and opposite (Bennett et al., 2015a; Dymond et al., 2007; Dymond et al., 2008; Roche et al., 2008), more than/less than (Dougher et al., 2007), and symmetry (Glogan et al., 2023) relations, respectively.

3.2. Procedures

Table 2 shows the experimental procedures for fear conditioning, avoidance conditioning, approach-avoidance conditioning, extinction, interventions, and tests employed across the 31 articles included in the review. Parameters such as the number of stimuli presentations, % CS-US contingency, response requirements, and learning/mastery criteria were also described in Table 2 for each procedure.

Insert Table 2 About Here

3.2.1. Fear Conditioning. Fear conditioning was undertaken in 24 of 31 studies (77%; see Table 2). Moreover, the differential CS-US procedure such that CS+ was followed by the US (CS+ → US^{av}) and the CS- was followed by either a blank screen or ITI (CS- → no US^{av}) were applied in 20 of these 24 studies (83%). One study employed a single-cue conditioning procedure (i.e., only CS+ → US^{av} contingencies) when evaluating the transformation of fear responses via more than and less than relations (Dougher et al., 2007). Differential context conditioning with contextual cues and appetitive USs (e.g., CTX + CS+ → US^{av} and CTX + CS- → US^{app}) were also employed in three studies (Bennett et al., 2020; Luciano et al., 2013, 2014).

[3] Two studies conducted with equivalence classes used two different class sizes (Perez et al., 2021; Valverde et al., 2009).

The number of CS+ and CS- trials ranged from one to 72 (M = 7.25, SD = 13.35) across the 24 fear conditioning procedures. The CS+ was followed by the US on 100% of conditioning trials in 17 studies (71%), 80% of the trials in four studies (17%), 75% of the trials in four studies (17%), and 50% of the trials in one study (4%), respectively.[4] Seventeen of 24 studies (71%) did not specify any criteria to demonstrate the establishment of conditioned fear responses. For those studies that did specify criteria, these included larger measures (e.g., SCRs, SCLs, HRs, ratings) to CS+ than to CS- stimuli (Dougher et al., 1994; Markham et al., 2002; Valdivia-Salas et al., 2022). Several studies used additional conditions such as criteria applied only in the last trial (Valverde et al., 2021), or criteria applied in more than half of the conditioning trials with a difference of at least 0.05 μS between average measures to CS+ and CS- (Luciano et al., 2013, 2014; Valverde et al., 2009). Dougher et al. (1994), Markham et al. (2002), and Valverde et al. (2009) opted for the participant-yield approach through visual inspection and counting the number of participants meeting criteria. Luciano et al. (2013, 2014), Valdivia-Salas et al. (2022), and Valverde et al. (2021) on the other hand employed large samples and statistically inferred the establishment of conditioned fear responses (Lonsdorf et al., 2017, 2019).

3.2.2. Avoidance Conditioning. Avoidance conditioning was found in 16 of 31 or 52% of the studies (see Table 2). Six of 16 (38%) of these studies (Boldrin & Debert, 2020; Boldrin et al., 2024; Gandarela et al., 2020; Garcia-Guerrero et al., 2014; Glogan et al., 2023; Valverde et al., 2021) employed the US-avoidance procedure such that responses in the presence of the CS+ canceled all upcoming US presentations (CS+ − R → US^{av} canceled) and responses in the presence of the CS- did not produce any programmed differential consequences (CS- − R → no US^{av}). Ten studies (63%) also included CS-escape, (Augustson & Dougher, 1997; Bennett et al., 2015a; Dymond et al., 2012), feedbacks indicating the cancelation of the US (Perez et al.,

[4] Dougher et al. (1994) and Valdivia-Salas et al. (2022) defined two different percentages of the CS-US contingency.

2020), or both CS-escape and feedbacks (Donati et al., 2019; Dymond et al., 2007, 2008, 2011, 2014; Roche et al., 2008) as consequences in the avoidance contingencies (CS+ − R → CS removed + US^{av} canceled; CS+ − R → feedback + US^{av} canceled; or CS+ − R → CS removed + message + US^{av} canceled).

Four different percentages of the CS-US contingency (i.e., the percentage of trials in which failure to respond was followed by the US) were defined between the studies: 100% CS-US contingency (11; 69%), 80% CS-US contingency (one; 6%), 75% CS-US contingency (five; 31%), and 40% CS-US contingency (one; 6%).[5] Fifteen of 16 (94%) studies trained the avoidance response until criteria were met (i.e., there was not a fixed number of trials). The only exception was Augustson and Dougher (1997) who defined six presentations of both CS+ and CS- stimuli in the avoidance training. Most studies (10 of 16; 63%) employed a fixed ratio schedule (FR) in which only one response was sufficient to cancel the US in each trial. Other values for the FR schedule were five (one; 6%), eight (four; 25%), and 20 (one; 6%) responses, respectively.

The criteria to demonstrate the establishment of the avoidance response was based on a minimum number of trials with responses in the presence of CS+ (N1) and a maximum number of trials with responses in the presence of CS- (N2), relative to the total of trials in which each stimulus was presented (NT1 and NT2). The proportion N1/NT1 for trials with the CS+ ranged from 0.7 (e.g., responses in at least seven of 10 trials) to 1 (e.g., responses in 10 of 10 trials). The proportion N2/NT2 for trials with the CS- ranged from 0 (e.g., responses in 0 of 10 trials) to 0.2 (e.g., responses in at most two of 10 trials). Two studies (Augustson & Dougher, 1997; Glogan et al., 2023) did not specify any criteria.

3.2.3. Approach-Avoidance Conditioning. Approach-avoidance conditioning was found in five of 31 or 16% of the studies (Bennett et al., 2020; Gannon et al., 2011; Luciano et

[5] Glogan et al. (2023) defined three different percentages of the CS-US contingency: 40%, 80%, and 100%.

al., 2013, 2014; Perez et al., 2021). One of the five studies (Gannon et al., 2011) employed only the US-approach-avoidance procedure such that a response R1 in the presence of CS+ canceled upcoming aversive US (CS+ − R1 → US^{av} canceled) and a different response R2 in the presence of CS- produced appetitive stimuli (CS- − R2 → US^{app}). Four studies (Bennett et al., 2020; Luciano et al., 2013, 2014; Perez et al., 2021) also applied contextual cues in the US-approach-avoidance procedure (e.g., CTX + CS+ − R1 → US^{av} canceled and CTX + CS- − R2 → US^{app}).

All five studies employed 100% CS-US contingency, fixed ratio one schedule (FR 1), and trained the approach-avoidance responses until criteria were met (i.e., a fixed number of trials was not defined).

The criteria to demonstrate the establishment of the approach-avoidance responses was based on a minimum number of trials with avoidance responses in the presence of CS+ (N1) and a minimum number of trials with approach responses in the presence of CS- (N2), relative to the total of trials in which each stimulus was presented (NT1 e NT2). The proportions N1/NT1 for trials with the CS+ and N2/NT2 for trials with the CS- ranged from 0.95 (e.g., responses in at least 19 of 20 trials) to 1 (e.g., responses in 20 of 20 trials). Some studies also applied additional criteria such as no approach in the presence of CS+ and no avoidance in the presence of CS- (Luciano et al., 2013, 2014), or more avoidance in trials with the CS+ compared to the CS- as well more approach in trials with the CS- compared to the CS+ (Bennett et al., 2020).

3.2.4. Extinction and Intervention Procedures. Extinction procedures was found in seven of 31 studies (23%) exclusively for the extinction of fear and avoidance responses (Boldrin & Debert, 2020; Boldrin et al., 2024; Dougher et al., 1994; Luciano et al., 2013; Roche et al., 2008; Vervoort et al., 2014) or just as a habituation phase for the participants (Dymond et al., 2012). Respondent (or Pavlovian) extinction with repeated CS+ and CS- presentations in the absence of the US (CS+ or CS- → no US^{av}) was applied in five of the seven studies

(Dougher et al., 1994; Dymond et al., 2012; Luciano et al., 2013; Roche et al., 2008; Vervoort et al., 2014). Operant extinction with avoidance or nonavoidance both followed by the ITI (CS+ or CS- − R → no US^{av}) was applied in two of the seven studies (Boldrin & Debert, 2020; Boldrin et al., 2024) and with avoidance or nonavoidance both followed by the US (CS+ or CS- − R → US^{av}) in one of the seven studies (Boldrin et al., 2024). Therefore, the US-withheld extinction procedure was employed in all seven studies and the US-noneliminable extinction procedure in one study (Boldrin et al., 2024, Experiment 1) to extinguish fear or avoidance responses. Luciano et al. (2013) also applied contextual cues and appetitive stimuli in the US-withheld extinction procedure (e.g., CTX + CS+ or CTX + CS- → no US^{av}).

The number of CS+ and CS- trials ranged from three to 15 (M = 7.60, SD = 4.51). Only three of seven studies (43%) specified the extinction criteria. The average difference in SCR between CS+ and CS- stimuli during the last three trials should be less than 0.05 μS in Luciano et al. (2013). Avoidance responses should not occur in four consecutive trials with both CS+ and CS- (or GSs related with CS+ and CS-) in Boldrin and Debert (2020) and Boldrin et al. (2024).

Procedures other than extinction were also employed to reduce the frequency of fear and avoidance responses. Therapy protocols (e.g., motivational, acceptance/defusion, and reappraisal exercises) were found in Luciano et al. (2014) and Donati et al. (2019). Montoya-Rodriguez and Molina-Cobos (2017) evaluated the alteration of aversive function by training a new relation in the equivalence class with earn of points, establishing coordination relations between stimuli from aversive and pleasant classes, and applying a value-focused exercise.

3.2.5. Test Procedures. Generalization tests were conducted with conditioned stimuli (CS+ and CS-) that underwent conditioning procedures and generalized stimuli (GSs) related to CSs via equivalence or other derived relations. The majority of studies (23 of 31; 74%) conducted the tests in extinction (US-withheld) on Pavlovian (e.g., CS1,..., CSn → no

US^{av}/US^{app}) or operant contingencies (e.g., CS1,..., CSn − R → no US^{av}/US^{app}). However, there was also a group of studies (12 of 31; 39%) that maintained the conditioning contingencies for the CS+ and CS- (steady-state generalization testing) as a way to minimize the effects of extinction (e.g., CS+ → US^{av}; CS+, CS- − R → US^{av}/US^{app} canceled).[6] Studies also used matching and self-report arousal tasks (Smyth et al., 2006), prompts to confirm expectations of the aversive US (Garcia-Guerrero et al., 2014) and instructions indicating that avoidance is possible (Bennett et al., 2015c) when conducting the tests.

The number of CSs/GSs trials ranged from one to 36 (M = 5.00, SD = 6.84). The percentage of CS/GS-US contingency considering the 12 studies holding US presentations during the tests was 50% (two; 17%), 75% (two; 17%), and 100% (eight; 67%).

The criteria to demonstrate symbolic generalization resembled that applied in conditioning phases. Larger measures (e.g., SCRs, SCLs, HRs, and ratings) to GSs related to the CS+ than to GSs related to the CS- were used as criteria in studies involving Pavlovian contingencies. Criteria for operant contingencies required minimum and maximum numbers (N1 and N2) of trials with responses in the presence of stimuli related to the CS+ or CS- (Class 1 or Class 2), relative to the total of trials in which each stimulus was presented (NT1 e NT2). The proportion N1/NT1 ranged from 0.33 to 1 and the proportion N2/NT2 ranged from 0 to 1. Twenty-two studies (71%) did not specify any criteria in at least one or more test phases.

4. Discussion

The present work systematically reviewed, for the first time, the literature on the symbolic or derived generalization of fear and avoidance. Thirty-one studies since 1994 were evaluated according to general characteristics (derived responses, participants, design, CS type, US type, outcome measures, and relations) and procedures (fear conditioning, avoidance

[6] Four studies (Dougher et al., 1994; Garcia-Guerrero et al., 2014; Luciano et al., 2013; Valdivia-Salas et al., 2022) conducted tests with both US-withheld and steady-state generalization testing procedures.

conditioning, approach-avoidance conditioning, extinction or interventions, and tests). Overall, while derived fear and avoidance are experimentally well-established phenomena, there was a great deal of methodological heterogeneity across the included studies.

The analysis of the number of participants (i.e., sample size) and experimental designs showed a tendency in the field to use small samples and one- or two-group designs, which might be a source of concern since some markers of the quality of the study such as statistical power and internal validity are reduced. Of course, the repeatability of measures inherent in one-group (within participant) designs is a source of experimental control and was by far the most employed research design of the included studies. Such repeated acquisition designs may make it difficult to generalize from samples to the population but are useful in identifying stimulus control and other factors influencing training performance, mastery criteria, etc. Such designs are characterized by testing each participant under all experimental conditions. Two conditions are most applied in studies on derived fear and avoidance, one supposedly related to the US (e.g., Condition 1) and the other unrelated to the US (e.g., Condition 2). For example, a conditioning procedure is first conducted by pairing one stimulus in Condition 1 with the US or establishing an avoidance response with this stimulus, whereas one stimulus in Condition 2 is only followed by the ITI or a blank screen. Assuming an experimental effect is observed in subsequent test phases such as Pavlovian elicitation or avoidance responses in the presence of stimuli in Condition 1 but not in Condition 2, then it provides supportive evidence of the transfer or transformations of stimulus function. However, applying a within-subjects design with two conditions like this but with few participants can compromise further inferential statistical analyses such that the internal validity is reduced, and conclusions weakened. Between-group designs, while useful when comparing outcomes of participants randomly assigned to differing training or testing conditions, can be limited if there is an absence of random assignment and adequate power (i.e., actual versus estimated sample size) capable of detecting statistically significant effects. This notwithstanding, the use of small samples of participants is common practice in behavior analysis, which has a focus on experiments with single-case experimental designs, and from where most of the derived fear and avoidance studies were found. It is important to note, however, that many included studies did not employ a particular type of single-case experimental design, such as reversal or multiple baseline designs, and thus did not conduct a reversal of conditions or apply further techniques to demonstrate experimental control (Kazdin, 1982). Of course, some research questions on derived fear and avoidance may not be readily amenable to investigation with single-case experimental designs but it was striking that no studies employed the gold standard design synonymous with behavior analysis. In the future, additional forms of experimental control such as reversal of contingencies (Valverde et al., 2009, 2021) and control groups (Dougher et al., 1994, Experiment 2; Dougher et al., 2007; Dymond et al., 2007; Perez et al., 2020) should be considered.

Abstract figures and nonsense words were predominantly employed as CSs, which was perhaps to be expected given that symbolic generalization implies arbitrary relations between stimuli. It was notable that animal-like objects (Bennett et al., 2015c) and joystick (Bennett et al., 2015b) and robotic arm movements (Glogan et al., 2023) were also employed in more recent work. The involvement of multi-sensory stimuli such as haptic stimuli may afford opportunities to further the understanding of the role of derived fear and avoidance in clinical disorders and movement-related conditions such as coping with chronic pain (Belanich & Fields, 1999; Tierney et al., 1995). Going forward, it may be helpful for future studies of derived fear and avoidance to incorporate auditory, visual, haptic, and gustatory stimulus relations during the derived relations training stage and to examine symbolic generalization across multi-sensory stimulus dimensions.

We found that electric shock and aversive images were most employed as USs in studies on derived fear and avoidance. While electric shock and aversive images are quite effective in the transfer (or transformation) of fear and avoidance at the basic research level, some restrictions make it difficult to replicate the procedures with clinical populations. For example, shocks can exacerbate symptoms for some individuals such as people with anxiety disorders or PTSD. Aversive images, although less physically invasive, can still trigger negative psychological reactions and must be carefully chosen to avoid harm. For this reason, many institutional review boards (IRBs) or ethics committees impose strict guidelines on the use of electric shocks, making their approval more difficult compared to other types of USs. Furthermore, electric shock seems rather artificial compared to situations usually feared by people in the real world. Aversive images, on the other hand, can better simulate real-life stressors (e.g. images of spiders for arachnophobia or social events for social phobia) and are more suitable for translational and applied research, of course, considering the necessary ethical precautions. Alternative USs could also be employed with clinical populations. For example, physical stimulation such as loud noises or mildly uncomfortable tactile sensations may be considered more ethically acceptable than electric shocks (Crosbie, 1998). Another innovative approach is virtual reality which allows the presentation of immersive but controlled aversive experiences (Botella et al., 2017; Freitas et al., 2021).

While a review of shock calibration procedures or the validation of aversive images used as USs was beyond the remit of the present paper (Beckers et al., 2023; Lonsdorf et al., 2017), it is worth noting that there is no direct comparison evaluating possible differences between these stimuli in the transfer (or transformation) of function. For example, are there more effective USs compared to others in producing transfer (or transformation) of fear and avoidance functions? Are there USs that can produce stronger responses, more like those derived by individuals in the real-world? The first question is especially interesting for studies in which transfer (or transformation) of function is a pre-requisite to evaluate other phenomena such as the transfer of extinction (e.g., Boldrin & Debert, 2020; Boldrin et al., 2024; Dougher et al., 1994; Roche et al., 2008; Vervoort et al., 2014) or the effectiveness of intervention protocols (e.g., Donati et al., 2019; Luciano et al., 2014). The second question could inform studies with more translational or applied purposes.

Studies should also focus on simultaneous physiological, motor, and verbal measures, even knowing the procedural challenges of this kind of strategy. A question still to be answered is to what extent physiological (e.g., skin conductance), motor (e.g., pressing a key), and verbal (e.g., US expectancy) measures agree with each other in the transfer or transformation of fear and avoidance functions (Dymond et al., 2011; Luciano et al., 2013, 2014). Until now, there are a significant amount of studies with simultaneous motor and verbal measures (Bennett et al., 2015a, 2015b, 2015c; Dymond et al., 2011, 2012, 2014; Donati et al., 2019; Garcia-Guerrero et al., 2014; Glogan et al., 2023; Perez et al., 2020), but few experiments with both physiological and motors (Luciano et al., 2013, 2014; Valverde et al., 2021) or physiological and verbal (Vervoort et al., 2014), and none involving all three types of modalities (i.e., physiological, motor and verbal). Studies aiming to evaluate the neurological substrates of derived fear and avoidance were also not found. Neurological measures (e.g., fMRI studies) are common in related areas such as perceptual generalization (Dymond et al., 2015) and could also reveal more about symbolic generalization. There are different components in derived fear and avoidance such that knowing more about the interaction between measures and neurological substrates could improve our comprehension of this complex phenomenon as well as facilitate the dialog between different theories (Dymond & Roche, 2009; Higgins & Morris, 1984; Krypotos et al., 2015; LeDoux et al., 2016).

Derived fear and avoidance should also be further investigated with other types of derived relations, because 81% of the investigations were carried out with equivalence relations. In this direction, Dymond et al. (2007, 2008) were the first to demonstrate the transformation of avoidance in same and opposite relation, Bennett et al. (2015a) incorporated verbal measures (valence, US expectancy) in the procedure, and Roche et al. (2008) evaluated the transformation of avoidance extinction. The transformation of fear and extinction of fear responses, the role of different types of CS and US stimuli, and even the participation of clinical populations in the experiments (e.g., comparison between phobic and non-phobic participants) are questions still to be investigated with same and opposite relations. The same can be recommended for more than - less than relations, which was only evaluated in one study (Dougher et al., 2007) to date. Future studies should also focus on other types of relations and complex forms of relational responding including relating relations and relating relational networks (Barnes-Holmes et al., 2017; Hayes et al., 2001).

The search also revealed procedures for investigating the approach-avoidance conflict. Gannon et al., (2011) evaluated the transfer of approach-avoidance responses in equivalence classes with one group design and yield-based analysis. Bennett et al. (2020) added contextual stimuli in the approach-avoidance contingencies, employed a two-group design, and performed statistical analysis. According to Gannon et al. and Bennett et al., future studies should evaluate the transfer of approach-avoidance as a function of the US strength, as well as perform physiological and self-reported measures (e.g., skin conductance and US expectancy). Future research could also examine different types of psychopathology, similar to previous studies involving approach-avoidance tasks for the investigation of social anxiety (e.g., Asnaani et al., 2014; Schlund, 2021), bulimia nervosa (e.g., Brockmeyer et al., 2019), obsessive-compulsive disorder (e.g., Weil et al., 2017), and alcohol dependence (e.g., Eberl et al., 2013). The approach-avoidance conflict is like ambivalent situations encountered in the real-world in which both a reward and some source of suffering, usually experienced as anxiety or distress, are present. For example, a person diagnosed with social phobia wants to make friends but avoids social interaction situations or wants to graduate from college but misses oral presentations. Therefore, procedures investigating the approach-avoidance conflict can help us to better understand the different aspects of anxiety or distress as they occur in the real world.

Studies also investigated the transfer or transformation of extinction. The transfer of extinction was evaluated in equivalence classes with fear responses (Dougher et al., 1994; Vervoort et al., 2014), avoidance responses (Boldrin & Debert, 2020; Boldrin et al., 2024), and both fear and avoidance responses (Donati et al., 2019; Garcia-Guerrero et al., 2014; Luciano et al., 2013, 2014). Transformation of extinction via same and opposite relations was also evaluated but only with avoidance responses (Roche et al., 2008). It is worth mentioning that studies have shown difficulties in establishing extinction before the analysis of the transfer (or transformation) of extinction, and do not agree on the effectiveness of direct extinction (i.e., extinction procedure with a CS that underwent respondent or operant conditioning procedure) and derived extinction (i.e., extinction procedure with a derived CS that did not undergo conditioning procedures). Therefore, more studies are needed to clarify these open questions. The transfer of extinction can be considered an analog treatment in which the patient is exposed to conditioned stimuli directly or indirectly related to the traumatic or feared event. For example, successive approximation between the patient diagnosed with social phobia and social situations (direct extinction), imagining, or talking in therapy about the fear of social interactions (derived extinction). Therefore, research on the transfer (or transformation) of extinction can help to understand the basic processes involved in treating anxiety disorders and how to improve the results.

Generative effects of extinction is another research avenue with potential clinical implications, especially, the reinstatement and renewal phenomena. Both phenomena refer to conditioned responses that were extinguished and reoccurred, in the first case due to one or more exposures to the US after extinction and in the second case due to changes in the contextual cues present during extinction (Lattal et al., 2013; Vansteenwegen et al., 2006). Both reinstatement and renewal have significant implications for understanding relapse in anxiety and trauma-related disorders. They may explain the persistence and recurrence of anxious symptoms even after successful treatment, whether due to changes in context (e.g., an individual with OCD has their fear of contamination reduced during exposure therapy conducted in the therapist's office, but the fear returns when entering a public restroom in a crowded shopping mall) or re-exposure to a stressful event (e.g., an individual recovering from alcohol abuse has been sober for months after following the treatment, but returns to drinking after an emotionally overwhelming event such as a fight with a family member or the death of a loved one). Combined with derived stimulus relations, reinstatement could be investigated by programming occasional presentations of the US in the final crucial test that evaluates the transfer or transformation of extinction. Renewal, in turn, could be investigated by presenting contextual cues (e.g., background colors or colored circles) that highlight the differences between the training, extinction, and testing phases for the participants (Luciano et al., 2013, 2014). Can reinstatement or renewal occur not only with directly conditioned stimuli but also with stimuli that are part of a derived relation network? Questions like these could move research on derived fear and avoidance closer to the translational and applied levels and even encourage innovative collaborations on relapse with researchers outside the current subdomain of behavior analysis.

Many studies did not specify mastery criteria, especially in fear conditioning (71% of the studies did not specify any criteria) and tests (71% of the studies did not specify any criteria in one or more test phases) procedures. In fear conditioning, specifically, stimuli are paired but without measuring the corresponding responses, which makes it impossible to apply some criteria and results must be assumed in many studies. There is also great variation in the mastery criteria applied across studies, including different proportions of responses and additional conditions, but no empirical knowledge on how different criteria applied in conditioning procedures can affect the occurrence and maintenance of derived fear and avoidance in subsequent tests phases. Moreover, there is a lack of consensus in the field on the mastery criteria that should define derived fear and avoidance. In the tests for the transfer of avoidance, for example, studies have employed 70% in six trials (e.g., Dymond et al., 2007, 2008; Roche et al., 2008), 75% in four trials (e.g., Boldrin & Debert, 2020; Gandarela et al., 2020), 100% in six trials (e.g., Donati et al., 2019), and one might ask which is the most appropriate? Therefore, future studies should specify mastery criteria more clearly and evaluate mastery criteria as an independent variable. Otherwise, mastery criteria will function merely as assumptions and the area will lose important knowledge.

Parameters and procedures have also been changed abruptly, as can be seen by comparing studies in Table 1 (parameters) and Table 2 (procedures). Often, a whole set of variables is changed in addition to the manipulation of the independent variable from one study to the next, so that, experimental continuity between studies is reduced over time. The set of variables may include CS and US stimuli, outcome measures, relations, contingencies, number of trials, percentages CS-US, response requirements, and mastery criteria. Studies should be more cautious about changing parameters, as well as specifically investigating how gradual changes in parameters can affect the results which could be achieved, for example, by directly comparing different types of USs, number of trials, percentages CS-US, response requirements, and mastery criteria. This practice could help to know more precisely the effects of each additional manipulation of parameters on the dependent variable, provide a basis for parameter choices, and facilitate comparison between the results of different studies over time.

At a translational level, Dymond et al. (2014), the only study that worked with clinical populations, evaluated the transfer of avoidance and threat-beliefs through equivalence relations with spider-phobic and nonphobic participants. Luciano et al. (2014) and Donati et al. (2019) assessed the effectiveness of laboratory-based analogs of cognitive treatments in reducing fear and avoidance in equivalence classes. An acceptance/defusion protocol (Assaz et al., 2018, 2023) composed of motivational exercises and components of acceptance and commitment therapy was used by Luciano et al. (2014). Donati examined a defusion (i.e., vocal repetition exercises; Masuda et al., 2004) and a reappraisal (i.e., a cognitive restructuring strategy; Gross, 1998) protocol, often used in the therapeutic setting to treat nonadaptive fear and avoidance behaviors. Still at a translational level, Montoya-Rodriguez and Molina-Cobos (2017) evaluated the alteration of aversive fear and avoidance functions in equivalence classes in children. The experiment, which used various videos as USs (e.g., cockroaches, earthquakes, scenes from horror films, cartoons), created an analog of symbolically generalized childhood fears and examined forms of treatment such that direct reinforcement of the aversive class, coordination between the reinforcing and aversive classes, and the inclusion of a value factor used in choosing the aversive class. Bennett et al. (2015b) and Glogan et al. (2023), in turn, evaluated the symbolic generalization of pain-related fear in equivalence classes and symmetry relations, respectively. For this purpose, joystick (Bennett et al., 2015b) and robotic arm (Glogan et al., 2023) movements were used as CS stimuli.

Overall, there is a considerable range of questions under investigation by translational research in the derived fear and avoidance field, but these investigations are still at an initial stage compared to those examining the basic processes. More studies with clinical populations, therapeutic protocols, and real-world analogs are required to support derived fear and avoidance as an ecologically valid model for studying anxiety disorders, particularly nonadaptive fear and avoidance of situations and events in which no direct aversive experiences can be identified. In this sense, research should also develop and evaluate new experimental paradigms for investigating symbolic generalization in complex situations that are more like the real world (Krypotos, 2018). One candidate is virtual reality (VR) technologies to simulate real-world scenarios, not only abstract stimuli, discrete trials, and key pressing experiments but also continuous measures and strong responses such as those experienced by anxious patients in the real-world (Botella et al., 2017; Freitas et al., 2021).

There are some limitations to this review and suggestion for future reviews. First, we considered tools to assess the risk of bias (e.g., ROBINS-1: Sterne et al., 2016; RoB 2: Sterne et al., 2019; WWC: WWC, 2020) but results were inaccurate because many questions were not applicable to the studies included in this review. So, the risk of bias analysis was discarded. Future reviews could test different tools for analyzing the risk of bias to find one that works better for studies on derived fear and avoidance. Including additional databases (e.g. Pubmed, Elsevier Scopus, and SciELO) and Google Scholar searching could also improve the procedures adopted in the present review. Another possibility for a future review is to expand the scope of the search by including studies with stimuli with pre-experimental meaning such that conditioning procedures will not necessarily be a requirement in these cases (Eilertsen & Arntzen, 2020; Leech et al., 2018; Leech & Barnes-Holmes, 2020; O'Toole et al. 2007; Perez et al., 2019, 2023; Sandoz et al., 2021).

5. Conclusion

Fear and avoidance are key components of anxiety and related disorders (American Psychiatric Association, 2013). One way fear and avoidance can spread and dramatically increase the range of potential threatening stimuli capable of evoking defensive responses is through symbolic generalization or derived processes in humans. Here, for the first time, we systematically reviewed the literature on symbolic generalization of fear and avoidance in humans and provided an overview of the gaps and suggestions for future research. Thirty-one articles have been published since 1994, a rate of one article per year, showing the symbolic generalization of fear and avoidance with a wide range of variables (derived responses, participants, design, CS type, US type, outcome measures, and relations) and procedures (fear conditioning, avoidance conditioning, approach-avoidance conditioning, extinction or interventions, and tests), such that symbolic generalization of fear and avoidance are experimentally well-established phenomena in the literature. Nevertheless, future studies should be more cautious about using small samples of participants in one- or two-group designs, procedures with no additional forms of control (e.g., control groups, reversal of contingencies, and pre-tests checking for pre-experimental effects), and the lack of information about participants and mastery criteria. Methodological heterogeneity across studies made it difficult to compare the results of different investigations; methodological guidelines and consistency of reporting should be prioritized in the field of derived fear and avoidance.

The field would also benefit from research involving other types of derived relations in addition to equivalence, populations different from undergraduate students (e.g., those with clinical disorders, children, elderly, etc.), CS stimuli other than abstract figures or nonsense words (e.g., multi-sensory stimulus), US stimuli other than electric shock or aversive pictures (e.g., USs more similar to those in the real world), and measures besides skin conductance or key pressing (e.g., simultaneous and neurological measures). There is also a need for more studies with therapeutic protocols and clinical analogs (e.g., the approach-avoidance conflict and the transfer or transformation of extinction), as well as evaluations of new experimental paradigms such as virtual reality technology to bridge the gaps between derived fear and avoidance research and the translational and applied levels. The approximation to the real-world is essential to support symbolic generalization of fear and avoidance as an ecologically valid behavioral model for studying anxiety disorders.

References

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). https://doi.org/10.1176/appi.books.9780890425596

Asnaani, A., Rinck, M., Becker, E., & Hofmann, S. G. (2014). The effects of approach-avoidance modification on social anxiety disorder: A pilot study. *Cognitive Therapy and Research*, *38*(2), 226–238. https://doi.org/10.1007/s10608-013-9580-x

Assaz, D. A., Roche, B., Kanter, J. W., & Oshiro, C. K. B. (2018). Cognitive defusion in acceptance and commitment therapy: What are the basic processes of change? *Psychological Record*, *68*(4), 405–418. https://doi.org/10.1007/s40732-017-0254-z

Assaz, D. A., Tyndall, I., Oshiro, C. K. B., & Roche, B. (2023). A process-based analysis of cognitive defusion in acceptance and commitment therapy. *Behavior Therapy*, *54*(6), 1020–1035. https://doi.org/10.1016/j.beth.2022.06.003

Augustson, E. M., & Dougher, M. J. (1997). The transfer of avoidance evoking functions through stimulus equivalence classes. *Journal of Behavior Therapy and Experimental Psychiatry*, *28*(3), 181–191. https://doi.org/10.1016/S0005-7916(97)00008-6

Ball, T. M., & Gunaydin, L. A. (2022). Measuring maladaptive avoidance: From animal models to clinical anxiety. *Neuropsychopharmacology*, *47*(5), 978–986. https://doi.org/10.1038/s41386-021-01263-4

Barnes-Holmes, D., Barnes-Holmes, Y., Luciano, C., & McEnteggart, C. (2017). From the IRAP and REC model to a multi-dimensional multi-level framework for analyzing the dynamics of arbitrarily applicable relational responding. *Journal of Contextual Behavioral Science*, *6*(4), 434–445. https://doi.org/10.1016/j.jcbs.2017.08.001

Beckers, T., Hermans, D., Lange, I., Luyten, L., Scheveneels, S., & Vervliet, B. (2023). Understanding clinical fear and anxiety through the lens of human fear conditioning. *Nature Reviews Psychology*, *2*(4), 233–245. https://doi.org/10.1038/s44159-023-00156-1

Belanich, J., & Fields, L. (1999). Tactual equivalence class formation and tactual-to-visual cross-modal transfer. *The Psychological Record*, *49*(1), 75–91. https://doi.org/10.1007/BF03395308

Belisle, J., Paliliunas, D., Catrone, R., Stickman, E., & Ramakrishnan, A. (2024). A comprehensive behavioral model of emotion rooted in Relational Frame Theory and contemporary extensions. *The Psychological Record*. https://doi.org/10.1007/s40732-024-00603-2

Bennett, M., Hermans, D., Dymond, S., Vervoort, E., & Baeyens, F. (2015a). From bad to worse: Symbolic equivalence and opposition in fear generalization. *Cognition and Emotion*, *29*(6), 1137–1145. https://doi.org/10.1080/02699931.2014.973833

Bennett, M., Meulders, A., Baeyens, F., & Vlaeyen, J. W. S. (2015b). Words putting pain in motion: The generalization of pain-related fear within an artificial stimulus category. *Frontiers in Psychology*, *6*(520), 1–12. https://www.frontiersin.org/articles/10.3389/fpsyg.2015.00520

Bennett, M., Roche, B., Dymond, S., Baeyens, F., Vervliet, B., & Hermans, D. (2020). Transitions from avoidance: Reinforcing competing behaviors reduces generalized avoidance in new contexts. *Quarterly Journal of Experimental Psychology*, *73*(12), 2119–2131. https://doi.org/10.1177/1747021820943148

Bennett, M., Vervoort, E., Boddez, Y., Hermans, D., & Baeyens, F. (2015c). Perceptual and conceptual similarities facilitate the generalization of instructed fear. *Journal of Behavior Therapy and Experimental Psychiatry*, *48*(2015), 149–155. https://doi.org/10.1016/j.jbtep.2015.03.011

Boldrin, L. S., & Debert, P. (2020). Direct and derived extinction of avoidance responses in equivalence classes. *Psychological Record*, *70*(3), 433–444. https://doi.org/10.1007/s40732-020-00419-w

Boldrin, L. S., Debert, P., & Dymond, S. (2024). Avoidance extinction in equivalence classes. *The Psychological Record*, *74*(1), 1–16. https://doi.org/10.1007/s40732-023-00580-y

Botella, C., Fernández-Álvarez, J., Guillén, V., García-Palacios, A., & Baños, R. (2017). Recent progress in virtual reality exposure therapy for phobias: A systematic review. *Current Psychiatry Reports*, *19*(7), 42. https://doi.org/10.1007/s11920-017-0788-4

Bradley, M. M., & Lang, P. J. (2007). *The International Affective Digitized Sounds (2nd Edition; IADS-2): Affective ratings of sounds and instruction manual*. (Tech. Rep. No. B-3). Gainesville, FL: University of Florida, NIMH Center for the Study of Emotion and Attention.

Brewer, A., Leon, Y., Kuhn, S.C., Kuhn, D., & Schlund, M.W. (2024). Fear conditioning, anxiety, and phobias: Considerations for operant-respondent interactions. In H.S. Roane, A.R. Craig, V. Saini, and J.E. Ringdahl (Eds.), *Behavior analysis: Translational perspectives and clinical practice* (pp. 170-190). Guilford Press.

Brockmeyer, T., Friederich, H.-C., Küppers, C., Chowdhury, S., Harms, L., Simmonds, J., Gordon, G., Potterton, R., & Schmidt, U. (2019). Approach bias modification training in bulimia nervosa and binge-eating disorder: A pilot randomized controlled trial. *International Journal of Eating Disorders*, *52*(5), 520–529. https://doi.org/10.1002/eat.23024

Carver, C. S., & White, T. L. (1994). Behavioral inhibition, behavioral activation, and affective responses to impending reward and punishment: The BIS/BAS scales. *Journal of Personality and Social Psychology*, *67*(2), 319–333. https://doi.org/10.1037/0022-3514.67.2.319

Cooper, S. E., van Dis, E. A. M., Hagenaars, M. A., Krypotos, A. M., Nemeroff, C. B., Lissek, S., Engelhard, I. M., & Dunsmoor, J. E. (2022). A meta-analysis of conditioned fear generalization in anxiety-related disorders. *Neuropsychopharmacology*, *47*(9), 1652–1661. https://doi.org/10.1038/s41386-022-01332-2

Craske, M. G., Rauch, S. L., Ursano, R., Prenoveau, J., Pine, D. S., & Zinbarg, R. E. (2011). What is an anxiety disorder? *FOCUS*, *9*(3), 369–388. https://doi.org/10.1176/foc.9.3.foc369

Crosbie, J. (1998). Negative reinforcement and punishment. In K. A. Lattal & M. Perone (Eds.), *Handbook of research methods in human operant behavior* (pp. 163–189). Springer US. https://doi.org/10.1007/978-1-4899-1947-2_6

Donati, M. R., Masuda, A., Schaefer, L. W., Cohen, L. L., Tone, E. B., & Parrott, D. J. (2019). Laboratory analogue investigation of defusion and reappraisal strategies in the context of symbolically generalized avoidance. *Journal of the Experimental Analysis of Behavior*, *112*(3), 225–241. https://doi.org/10.1002/jeab.550

Dougher, M. J., Augustson, E., Markham, M. R., Greenway, D. E., & Wulfert, E. (1994). The transfer of respondent eliciting and extinction functions through stimulus equivalence classes. *Journal of the Experimental Analysis of Behavior*, *62*(3), 331–351. https://doi.org/10.1901/jeab.1994.62-331

Dougher, M. J., Hamilton, D. A., Fink, B. C., & Harrington, J. (2007). Transformation of the discriminative and eliciting functions of generalized relational stimuli. *Journal of the Experimental Analysis of Behavior*, *88*(2), 179–197. https://doi.org/10.1901/jeab.2007.45-05

Dunsmoor, J. E., & LaBar, K. S. (2013). Effects of discrimination training on fear generalization gradients and perceptual classification in humans. *Behavioral Neuroscience*, *127*(3), 350–356. https://doi.org/10.1037/a0031933

Dunsmoor, J. E., & Murphy, G. L. (2015). Categories, concepts, and conditioning: How humans generalize fear. *Trends in Cognitive Sciences*, *19*(2), 73-77. https://doi.org/10.1016/j.tics.2014.12.003

Dunsmoor, J. E., & Paz, R. (2015). Fear generalization and anxiety: Behavioral and neural mechanisms. *Biological Psychiatry*, *78*(5), 336–343. https://doi.org/10.1016/j.biopsych.2015.04.010

Dymond, S. (2019). Overcoming avoidance in anxiety disorders: The contributions of Pavlovian and operant avoidance extinction methods. *Neuroscience & Biobehavioral Reviews*, *98*(2019), 61–70. https://doi.org/10.1016/J.NEUBIOREV.2019.01.007

Dymond, S., Bennett, M., Boyle, S., Roche, B., & Schlund, M. (2018). Related to anxiety: Arbitrarily applicable relational responding and experimental psychopathology research on fear and avoidance. *Perspectives on Behavior Science*, *41*(1), 189–213. https://doi.org/10.1007/s40614-017-0133-6

Dymond, S., Dunsmoor, J. E., Vervliet, B., Roche, B., & Hermans, D. (2015). Fear generalization in humans: Systematic review and implications for anxiety disorder research. *Behavior Therapy*, *46*(5), 561–582. https://doi.org/10.1016/j.beth.2014.10.001

Dymond, S., & Roche, B. (2009). A contemporary behavior analysis of anxiety and avoidance. *The Behavior Analyst*, *32*(1), 7–27. https://doi.org/10.1007/BF03392173

Dymond, S., Roche, B., Forsyth, J. P., Whelan, R., & Rhoden, J. (2008). Derived avoidance learning: Transformation of avoidance response functions in accordance with same and opposite relational frames. *The Psychological Record*, *58*(2), 269–286. https://doi.org/10.1007/BF03395615

Dymond, S., Roche, B., Forsyth, J., Whelan, R., & Rhoden, J. (2007). Transformation of avoidance response functions in accordance with same and opposite relational frames. *Journal of the Experimental Analysis of Behavior*, *88*(2), 249–262. https://doi.org/10.1901/jeab.2007.88-249

Dymond, S., Roche, B., & Rehfeldt, R. A. (2005). Relational frame theory and the transformation of stimulus function. *Revista Latinoamericana de Psicología*, *37*(2), 291–303.

Dymond, S., Schlund, M. W., Roche, B., Houwer, J. D., & Freegard, G. P. (2012). Safe from harm: Learned, instructed, and symbolic generalization pathways of human threat-avoidance. *PLOS ONE*, *7*(10), e47539. https://doi.org/10.1371/journal.pone.0047539

Dymond, S., Schlund, M. W., Roche, B., & Whelan, R. (2014). The spread of fear: Symbolic generalization mediates graded threat-avoidance in specific phobia. *Quarterly Journal of Experimental Psychology*, *67*(2), 247–259. https://doi.org/10.1080/17470218.2013.800124

Dymond, S., Schlund, M. W., Roche, B., Whelan, R., Richards, J., & Davies, C. (2011). Inferred threat and safety: Symbolic generalization of human avoidance learning. *Behaviour Research and Therapy*, *49*(10), 614–621. https://doi.org/10.1016/J.BRAT.2011.06.007

Dymond, S., & Rehfeldt, R. A. (2000). Understanding complex behavior: The transformation of stimulus functions. *The Behavior Analyst*, *23*(2), 239–254. https://doi.org/10.1007/BF03392013

Eberl, C., Wiers, R. W., Pawelczack, S., Rinck, M., Becker, E. S., & Lindenmeyer, J. (2013). Approach bias modification in alcohol dependence: Do clinical effects replicate and for whom does it work best? *Developmental Cognitive Neuroscience*, *4*, 38–51. https://doi.org/10.1016/j.dcn.2012.11.002

Eilertsen, J. M., & Arntzen, E. (2020). Tailoring of painful stimuli used for exploring transfer of function. *The Psychological Record*, *70*(2), 317–326. https://doi.org/10.1007/s40732-020-00381-7

Fraunfelter, L., Gerdes, A. B. M., & Alpers, G. W. (2022). Fear one, fear them all: A systematic review and meta-analysis of fear generalization in pathological anxiety. *Neuroscience & Biobehavioral Reviews*, *139*, 104707. https://doi.org/10.1016/j.neubiorev.2022.104707

Freitas, J. R. S., Velosa, V. H. S., Abreu, L. T. N., Jardim, R. L., Santos, J. A. V., Peres, B., & Campos, P. F. (2021). Virtual reality exposure treatment in phobias: A systematic review. *Psychiatric Quarterly*, *92*(4), 1685–1710. https://doi.org/10.1007/s11126-021-09935-6

Friman, P. C., & Dymond, S. (2020). The fear factor: A functional perspective on anxiety. In P. Sturmey (Ed.), *Functional Analysis in Clinical Treatment (Second Edition)*. https://doi.org/10.1016/B978-0-12-805469-7.00016-4

Gandarela, L., Boldrin, L. S., & Debert, P. (2020). Transfer of the avoidance function in equivalence classes using loss of points as the aversive stimulus. *The Psychological Record*, *70*(3), 471–479. https://doi.org/10.1007/S40732-019-00365-2

Gannon, S., Roche, B., Kanter, J. W., Forsyth, J. P., & Linehan, C. (2011). A derived relations analysis of approach-avoidance conflict: Implications for the behavioral analysis of human anxiety. *The Psychological Record*, *61*(2), 227–252. https://doi.org/10.1007/BF03395758

Garcia, Y., Grau-Gonzalez, I. A., & Cristiano-Botia, L. (2016). Flexibilidad relacional y estrés parental. *Universitas Psychologica*, *15*(4), 1-11. https://doi.org/10.11144/Javeriana.upsy15-4.frep

Garcia-Guerrero, S., Dickins, T. E., & Dickins, D. W. (2014). The gradual extinction of transferred avoidance stimulus functions. *The Psychological Record*, *64*(3), 581–599. https://doi.org/10.1007/s40732-014-0062-7

Glogan, E., Gatzounis, R., Bennett, M. P., Holthausen, K., & Meulders, A. (2023). Generalization of pain-related avoidance behavior based on de novo categorical knowledge. *PAIN*, *164*(4), 895-904. https://doi.org/10.1097/j.pain.0000000000002786

Gross, J. J. (1998). Antecedent- and response-focused emotion regulation: Divergent consequences for experience, expression, and physiology. *Journal of Personality and Social Psychology*, *74*(1), 224–237. https://doi.org/10.1037/0022-3514.74.1.224

Hayes, S. C., Barnes-Holmes, D., & Roche, B. T. (2001). *Relational Frame Theory: A Post-Skinnerian account of human language and cognition*. Plenum Press.

Higgins, S. T., & Morris, E. K. (1984). Generality of free-operant avoidance conditioning to human behavior. *Psychological Bulletin*, *96*(2), 247–272. https://doi.org/10.1037/0033-2909.96.2.247

Kazdin, A. E. (1982). *Single-case research designs: Methods for clinical and applied settings*. Oxford University Press.

Krypotos, A. M., Effting, M., Kindt, M., & Beckers, T. (2015). Avoidance learning: A review of theoretical models and recent developments. *Frontiers in Behavioral Neuroscience*, *9*(189), 1–16. https://doi.org/10.3389/fnbeh.2015.00189

Krypotos, A. M., Vervliet, B., & Engelhard, I. M. (2018). The validity of human avoidance paradigms. *Behaviour Research and Therapy*, *111*(2018), 99–105. https://doi.org/10.1016/j.brat.2018.10.011

Lattal, K. A., St. Peter, C., & Escobar, R. (2013). Operant extinction: Elimination and generation of behavior. In G. J. Madden, W. V. Dube, T. D. Hackenberg, G. P.

Hanley, & K. A. Lattal (Eds.), *APA handbook of behavior analysis, Vol. 2. Translating principles into practice* (pp. 77–107). American Psychological Association. https://doi.org/10.1037/13938-004

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (2008). *International Affective Picture System (IAPS): Affective ratings of pictures and instruction manual*. (Tech. Rep. No. A-8). Gainesville, FL: University of Florida, NIMH Center for the Study of Emotion and Attention.

LeDoux, J. E., & Pine, D. S. (2016). Using neuroscience to help understand fear and anxiety: A two-system framework. *American Journal of Psychiatry*, *173*(11), 1083–1093. https://doi.org/10.1176/appi.ajp.2016.16030353

Le Doux, J. E., & Daw, N. D. (2018). Surviving threats: Neural circuit and computational implications of a new taxonomy of defensive behaviour. *Nature Reviews Neuroscience*, *19*(5), 269–282. https://doi.org/10.1038/nrn.2018.22

Leech, A., & Barnes-Holmes, D. (2020). Training and testing for a transformation of fear and avoidance functions via combinatorial entailment using the Implicit Relational Assessment Procedure (IRAP): Further exploratory analyses. *Behavioural Processes*, *172*(2020), 104027. https://doi.org/10.1016/j.beproc.2019.104027

Leech, A., Bouyrden, J., Bruijsten, N., Barnes-Holmes, D., & McEnteggart, C. (2018). Training and testing for a transformation of fear and avoidance functions using the Implicit Relational Assessment Procedure: The first study. *Behavioural Processes*, *157*(2018), 24–35. https://doi.org/10.1016/j.beproc.2018.08.012

Lonsdorf, T. B., Menz, M. M., Andreatta, M., Fullana, M. A., Golkar, A., Haaker, J., Heitland, I., Hermann, A., Kuhn, M., Kruse, O., Meir Drexler, S., Meulders, A., Nees, F., Pittig, A., Richter, J., Römer, S., Shiban, Y., Schmitz, A., Straube, B., … Merz, C. J. (2017). Don't fear 'fear conditioning': Methodological considerations for the design and analysis of studies on human fear acquisition, extinction, and return of fear. *Neuroscience & Biobehavioral Reviews*, *77*(2017), 247–285. https://doi.org/10.1016/j.neubiorev.2017.02.026

Lonsdorf, T. B., Merz, C. J., & Fullana, M. A. (2019). Fear extinction retention: Is it what we think it is? *Biological Psychiatry*, *85*(12), 1074–1082. https://doi.org/10.1016/j.biopsych.2019.02.011

Luciano, C., Valdivia-Salas, S., Ruiz, F. J., Rodríguez-Valverde, M., Barnes-Holmes, D., Dougher, M. J., Cabello, F., Sánchez, V., Barnes-Holmes, Y., & Gutierrez, O. (2013). Extinction of aversive eliciting functions as an analog of exposure to conditioned fear: Does it alter avoidance responding? *Journal of Contextual Behavioral Science*, *2*(3–4), 120–134. https://doi.org/10.1016/j.jcbs.2013.05.001

Luciano, C., Valdivia-Salas, S., Ruiz, F. J., Rodríguez-Valverde, M., Barnes-Holmes, D., Dougher, M. J., López-López, J. C., Barnes-Holmes, Y., & Gutierrez-Martínez, O. (2014). Effects of an acceptance/defusion intervention on experimentally induced generalized avoidance: A laboratory demonstration. *Journal of the Experimental Analysis of Behavior*, *101*(1), 94–111. https://doi.org/10.1002/jeab.68

Markham, M. R., Dougher, M. J., & Augustson, E. M. (2002). Transfer of operant discrimination and respondent elicitation via emergent relations of compound stimuli. *The Psychological Record*, *52*(3), 325–350. https://doi.org/10.1007/BF03395434

Masuda, A., Hayes, S. C., Sackett, C. F., & Twohig, M. P. (2004). Cognitive defusion and self-relevant negative thoughts: Examining the impact of a ninety year old technique. *Behaviour Research and Therapy*, *42*(4), 477–485. https://doi.org/10.1016/j.brat.2003.10.008

Montoya-Rodríguez, M. M., & Molina-Cobos, F. J. (2017). Manipulation and generalization of aversive functions in children: Implications for treatment. *Psychology, Society & Education*, *9*(2), 163–179. https://doi.org/10.25115/psye.v9i2.654

Öhman, A. (2008). Fear and anxiety: Overlaps and dissociations. In M. Lewis, J. M. Haviland-Jones, & L. F. Barrett (Eds.), *Handbook Of Emotions* (pp. 709–728). The Guilford Press.

Osgood, C. E., Suci, G. I., & Tannenbaum, P. H. (1957). *The measurement of meaning*. University of Illinois Press.

O'Toole, C., Barnes-Holmes, D., & Smyth, S. (2007). A derived transfer of functions and the Implicit Association Test. *Journal of the Experimental Analysis of Behavior*, *88*(2), 263–283. https://doi.org/10.1901/jeab.2007.76-06

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *International Journal of Surgery*, *88*(2021), 105906. https://doi.org/10.1016/j.ijsu.2021.105906

Perez, W. F., Almeida, J. H. de, Soares, L. C. C. S., Wang, T. F. L., Morais, T. E. D. G. de, Mascarenhas, A. V., & Rose, J. C. de. (2020). Fearful faces and the derived transfer of aversive functions. *Psychological Record*, *70*(3), 387–396. https://doi.org/10.1007/s40732-020-00390-6

Perez, W. F., de Almeida, J. H., de Rose, J. C., Dorigon, A. H., de Vasconcellos, E. L., da Silva, M. A., Lima, N. D. P., de Almeida, R. B. M., Montan, R. N. M., & Barnes-Holmes, D. (2019). Implicit and explicit measures of transformation of function from facial expressions of fear and of happiness via equivalence relations. *The Psychological Record*, *69*(1), 13–24. https://doi.org/10.1007/s40732-018-0304-1

Perez, W. F., de Azevedo, S. P., Gomes, C. T., & Vichi, C. (2021). Equivalence relations and the contextual control of multiple derived stimulus functions. *Journal of the Experimental Analysis of Behavior*, *115*(1), 405–420. https://doi.org/10.1002/jeab.649

Perez, W. F., Kovac, R., Nico, Y. C., Caro, D. M., Fidalgo, A. P., Linares, I., de Almeida, J. H., & de Rose, J. C. (2017). The transfer of Crel contextual control (same, opposite, less than, more than) through equivalence relations. *Journal of the Experimental Analysis of Behavior*, *108*(3), 318–334. https://doi.org/10.1002/jeab.284

Perez, W. F., dos Santos, Z. T., Dorigon, A. H., de Vasconcellos, E. L., da Silva, M. A., Lima, N. D. P., de Almeida, R. B. M., Montan, R. N. M., de Almeida, J. H., & de Rose, J. C. (2023). The transfer of meaning via contextually controlled equivalence relations. *The Psychological Record*, *73*(4), 587–592. https://doi.org/10.1007/s40732-023-00568-8

Pittig, A., Treanor, M., LeBeau, R. T., & Craske, M. G. (2018). The role of associative fear and avoidance learning in anxiety disorders: Gaps and directions for future research. *Neuroscience & Biobehavioral Reviews*, *88*(2018), 117–140. https://doi.org/10.1016/j.neubiorev.2018.03.015

Roche, B. T., Kanter, J. W., Brown, K. R., Dymond, S., & Fogarty, C. C. (2008). A comparison of "direct" versus "derived" extinction of avoidance responding. *The Psychological Record*, *58*(3), 443–464. https://doi.org/10.1007/BF03395628

de Rose, J. C., McIlvane, W. J., Dube, W. V., Galpin, V. C., & Stoddard, L. T. (1988). Emergent simple discrimination established by indirect relation to differential consequences. *Journal of the Experimental Analysis of Behavior*, *50*(1), 1–20. https://doi.org/10.1901/jeab.1988.50-1

Sandoz, E. K., Bordieri, M. J., Tyndall, I., & Auzenne, J. (2021). A preliminary examination of derived relational responding in the context of body image. *The Psychological Record*, *71*(2), 291–306. https://doi.org/10.1007/s40732-020-00439-6

Schlund, M. W., Carter, H., Cudd, G., Murphy, K., Ahmed, N., Dymond, S., & Tone, E. B. (2021). Human social defeat and approach-avoidance: Escalating social-evaluative threat and threat of aggression increases social avoidance. *Journal of the Experimental Analysis of Behavior*, *115*(1), 157–184. https://doi.org/10.1002/jeab.654

Sidman, M. (1971). Reading and auditory-visual equivalences. *Journal of Speech and Hearing Research*, *14*(1), 5–13. https://doi.org/10.1044/jshr.1401.05

Sidman, M. (1994). *Equivalence relations and behavior: A research story*. Authors Cooperative.

Smyth, S., Barnes-Holmes, D., & Forsyth, J. P. (2006). A Derived transfer of simple discrimination and self-reported arousal functions in spider fearful and non-spider-fearful participants. *Journal of the Experimental Analysis of Behavior*, *85*(2), 223–246. https://doi.org/10.1901/jeab.2006.02-05

Sterne, J. A. C., Hernán, M. A., Reeves, B. C., Savović, J., Berkman, N. D., Viswanathan, M., Henry, D., Altman, D. G., Ansari, M. T., Boutron, I., Carpenter, J. R., Chan, A. W., Churchill, R., Deeks, J. J., Hróbjartsson, A., Kirkham, J., Jüni, P., Loke, Y. K., Pigott, T. D., … Higgins, J. P. (2016). ROBINS-I: A tool for assessing risk of bias in non-randomised studies of interventions. *BMJ*, *355*, i4919. https://doi.org/10.1136/bmj.i4919

Sterne, J. A. C., Savović, J., Page, M. J., Elbers, R. G., Blencowe, N. S., Boutron, I., Cates, C. J., Cheng, H.-Y., Corbett, M. S., Eldridge, S. M., Emberson, J. R., Hernán, M. A., Hopewell, S., Hróbjartsson, A., Junqueira, D. R., Jüni, P., Kirkham, J. J., Lasserson, T., Li, T., … Higgins, J. P. T. (2019). RoB 2: A revised tool for assessing risk of bias in randomised trials. *BMJ*, *366*, l4898. https://doi.org/10.1136/bmj.l4898

Tierney, K.J., De Largy, P., & Bracken, M. (1995). Formation of an equivalence class incorporating haptic stimuli. *Psychological Record, 45*, 431–437. https://doi.org/10.1007/BF03395152

Valdivia-Salas, S., Lombas, A. S., López-Crespo, G., & Zaldivar, P. J. L. (2022). Derived generalization of attentional bias for laboratory-induced threat: Yes but. *Frontiers in Psychology*, *13*(2022), 1-11. https://www.frontiersin.org/articles/10.3389/fpsyg.2022.1004157

Valverde, M. R., Luciano, C., & Barnes-Holmes, D. (2009). Transfer of aversive respondent elicitation in accordance with equivalence relations. *Journal of the Experimental Analysis of Behavior*, *92*(1), 85–111. https://doi.org/10.1901/jeab.2009.92-85

Valverde, M. R., Luciano, C., Barnes-Holmes, D., & Hernández-López, M. (2021). Transfer of conditioned fear and avoidance: Concurrent measurement of arousal and operant responding. *Journal of the Experimental Analysis of Behavior*, *115*(1), 204–223. https://doi.org/10.1002/jeab.646

Vansteenwegen, D., Dirikx, T., Hermans, D., Vervliet, B., & Eelen, P. (2006). Renewal and reinstatement of fear: Evidence from human conditioning research. In M. G. Craske, D. Hermans, & D. Vansteenwegen (Eds.), *Fear and learning: From basic processes to clinical implications* (pp. 197–215). American Psychological Association. https://doi.org/10.1037/11474-000

Vervliet, B., & Raes, F. (2013). Criteria of validity in experimental psychopathology: Application to models of anxiety and depression. *Psychological Medicine*, *43*(11), 2241–2244. https://doi.org/10.1017/S0033291712002267

Vervoort, E., Vervliet, B., Bennett, M., & Baeyens, F. (2014). Generalization of human fear acquisition and extinction within a novel arbitrary stimulus category. *PLOS ONE*, *9*(5), e96569. https://doi.org/10.1371/JOURNAL.PONE.0096569

Waters, A. M., & Pine, D. S. (2016). Evaluating differences in Pavlovian fear acquisition and extinction as predictors of outcome from cognitive behavioural therapy for anxious children. *Journal of Child Psychology and Psychiatry*, *57*(7), 869–876. https://doi.org/10.1111/jcpp.12522

Weil, R., Feist, A., Moritz, S., & Wittekind, C. E. (2017). Approaching contamination-related stimuli with an implicit approach-avoidance task: Can it reduce OCD symptoms? An online pilot study. *Journal of Behavior Therapy and Experimental Psychiatry*, *57*, 180–188. https://doi.org/10.1016/j.jbtep.2017.05.007

What Works Clearinghouse (2020). *What Works Clearinghouse standards handbook, Version 4.1*. U.S. Department of Education, Institute of Education Sciences, National Center for Education Evaluation & Regional Assistance. https://ies.ed.gov/ncee/wwc/handbooks

Wong, A. H. K., Wirth, F. M., & Pittig, A. (2022). Avoidance of learnt fear: Models, potential mechanisms, and future directions. *Behaviour Research and Therapy*, *151*(2022), 104056. https://doi.org/10.1016/j.brat.2022.104056

Figure 1

PRISMA Diagram of the Search and Screening Process

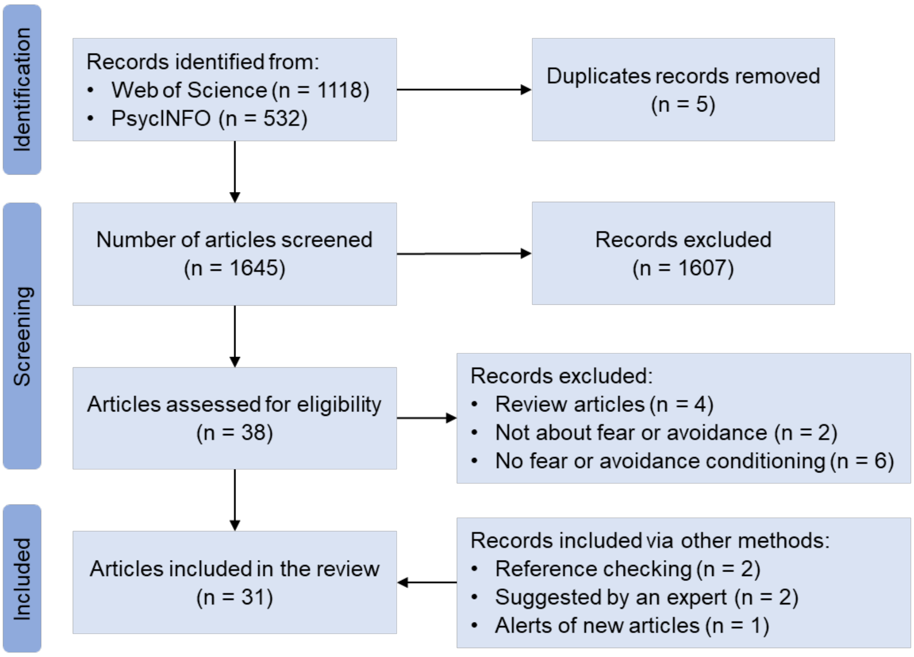
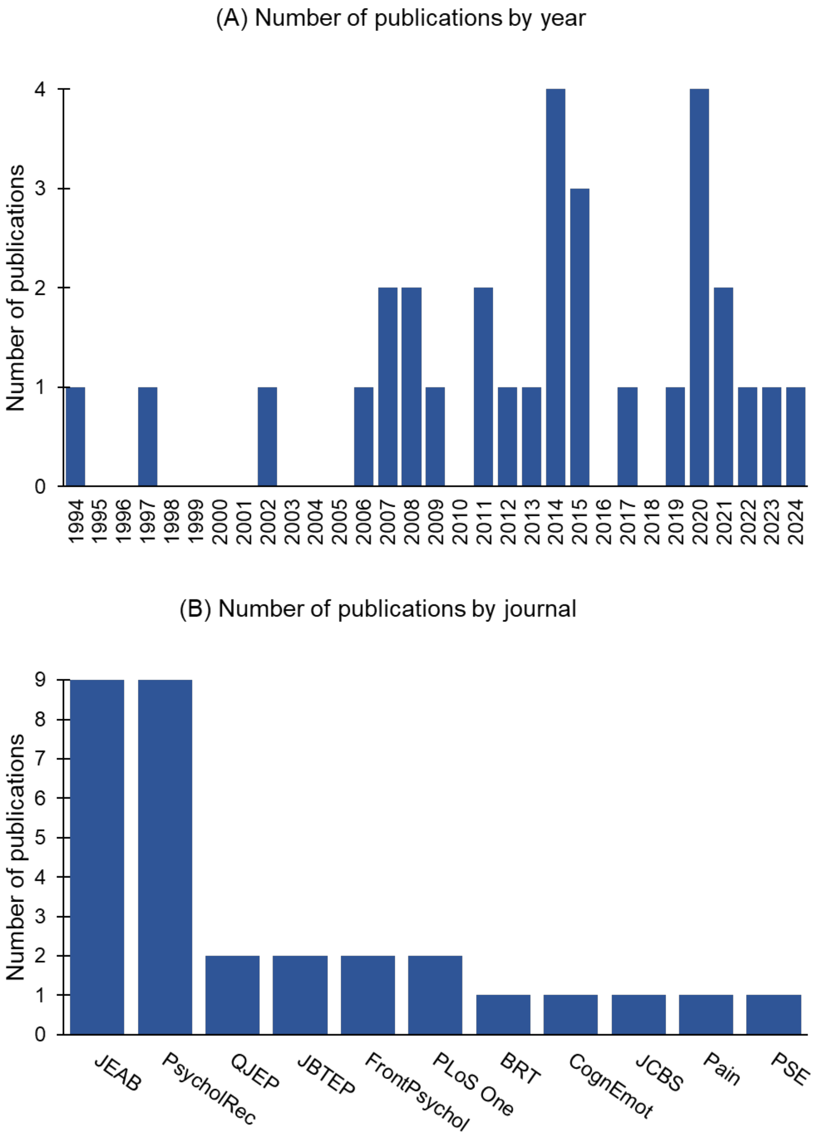


Figure 2

Number of Publications by Year (A) and Journal (B)



Note. JEAB: *Journal of the Experimental Analysis of Behavior*; PsycholRec: *The Psychological Record*; QJEP: *Quarterly Journal of Experimental Psychology*; JBTEP: *Journal of Behavior Therapy and Experimental Psychiatry*; FrontPsychol: *Frontiers in Psychology*; PLoS One: *PLoS One*; BRT: *Behaviour Research and Therapy*; CognEmot: *Cognition and Emotion*; JCBS: *Journal of Contextual Behavioral Science*; Pain: *Pain*; PSE: *Psychology Society and Education*.

Figure 3

Violin Plot of the Sample Size in the Studies Included in the Review

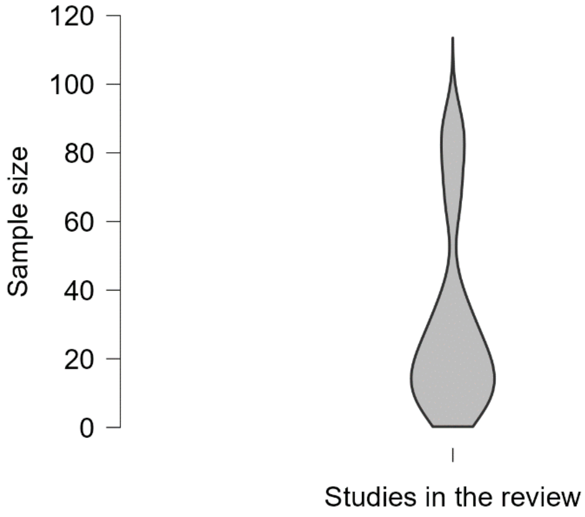


Table 1

General Characteristics of the Studies Included in the Present Review

Study	Fear/Avoidance		Participants, Gender & Age	Design	CS	US	Measures	Relations
Dougher et al. (1994)	Fear and fear extinction	Exp. 1	8 undergraduates: 8F	One-group posttest only	Abstract figures	Electric shock	Skin conductance	Two 4-member equivalence classes
		Exp. 2	8 undergraduates: 4F, 4M	Between-subjects (experimental and control)				
Augustson and Dougher (1997)	Avoidance		8 undergraduates: 1F, 7M	One-group posttest only	Abstract figures	Electric shock	Key pressing	Two 4-member equivalence classes
Markham et al. (2002)	Fear		5 undergraduates: 3F, 2M	One-group posttest only	Abstract figures	Electric shock	Skin conductance	Three 3-member equivalence classes
Smyth et al. (2006)	Fear		16 undergraduates: 15F, 1M	Between-subjects (spider-fearful and non-spider-fearful)	Nonsense words	Spider-attack videos	Ratings (fear, disgust, control, and intensity)	Two 3-member equivalence classes
Dougher et al. (2007)	Fear		21 undergraduates: 12F, 9M Aged 19–27	Between-subjects (experimental and control)	Abstract figures	Electric shock	Skin conductance	More than/less than relations
Dymond et al. (2007)	Avoidance		12 undergraduates: Aged 21-38	Between-subjects (experimental and control)	Nonsense words	Aversive and nonaversive images (IAPS), aversive sounds (female scream from IADS), message "Picture canceled"	Key pressing	Same and Opposite relations
Dymond et al. (2008)	Avoidance	Exp. 1	13 undergraduates: Aged 22-44	One-group posttest only	Nonsense words	Aversive and nonaversive images (IAPS), aversive	Key pressing	

		Exp. 2	3 undergraduates: Aged 21-38			sounds (female scream from IADS), message "Picture canceled"		Same and Opposite relations
Roche et al. (2008)	Avoidance extinction		20 undergraduates: 10F, 10M	Between-subjects (direct and derived extinction)	Nonsense words	Aversive and nonaversive images (IAPS), message "Picture canceled"	Key pressing	Same and Opposite relations
Valverde et al. (2009)	Fear	Exp. 1	17 undergraduates: 10F, 7M Aged 18-25	One-group reversal	Abstract figures	Electric shock	Skin conductance	Two 4-member equivalence classes
		Exp. 2	30 undergraduates: 14F, 16M Aged 18-29					Two 5-member equivalence classes
Dymond et al. (2011)	Fear and avoidance		21 undergraduates	One-group posttest only	Nonsense words	Aversive and nonaversive images (IAPS), aversive sounds (female scream from IADS), message "Picture canceled"	Key pressing, ratings (US expectancy)	Two 3-member equivalence classes
Gannon et al. (2011)	Approach and avoidance	Exp. 1	10 not specified: 10M Aged 20-29, M=26	One-group posttest only	Nonsense words	Aversive and nonaversive images (IAPS)	Key pressing	Two 4-member equivalence classes
		Exp. 2	8 not specified: 8M Aged 20-24, M=22				Key pressing, response latency	
Dymond et al. (2012)	Fear and avoidance		90 undergraduates: 68F, 22M M=25.06 (SD=10.05)	Between-subjects (conditioned, derived, and instructed)	Nonsense words, colored circles	Electric shock	Key pressing, ratings (US expectancy)	Two 3-member equivalence classes
Luciano et al. (2013)	Fear and avoidance extinction	Exp. 1	18 undergraduates: 13F, 5M Aged 19-25	One-group posttest only	Abstract figures, nonsense words	Electric shock, earning of points	Key pressing, skin conductance	Two 6-member

								equivalence classes
		Exp. 2	25 undergraduates: 13F, 12M Aged 18-26					
Luciano et al. (2014)	Fear and avoidance extinction		23 undergraduates: 17F, 6M Aged 18-27	Between-subjects (motivational, defusion, and control)	Abstract figures, nonsense words	Electric shock, earning of points	Key pressing, skin conductance	Two 6-member equivalence classes
Vervoort et al. (2014)	Fear extinction		35 undergraduates: 27F, 8M	Between-subjects (CS and GS extinction)	Abstract figures	Electric shock	Skin conductance, ratings (US expectancy)	Two 4-member equivalence classes
Garcia-Guerrero et al. (2014)	Fear and avoidance extinction		15 not specified: Aged 26-47, M=31 (SD=5.16)	Between-subjects (A and B)	Cyrillic and Arabic letters	Aversive sound (91 dB, 12000 Hz, 5-second)	Key pressing, ratings (US expectancy)	Three 4-member equivalence classes
Dymond et al. (2014)	Fear and avoidance		64 undergraduates: 50F, 14M Aged 18-30	Between-subjects (high-spider-fearful and Low-spider-fearful)	Nonsense words	Spider images (IAPS and Google), message "Picture canceled"	Key pressing, ratings (US expectancy)	Two 3-member equivalence classes
Bennett et al. (2015a)	Fear and avoidance		72 undergraduates: 58F, 14M M=18.4 (SD=1.1)	One-group posttest only	Nonsense words	Aversive images (IAPS), aversive sounds (female scream from IADS)	Key pressing, ratings (US expectancy, unpleasantness)	Same and Opposite relations
Bennett et al. (2015b)	Fear		80 not specified: 52F, 28M Aged 18–49, M=23.04 (SD=6.8)	Between-subjects (pain-US and instructed-US)	Nonsense words, abstract figures, joystick arm movements	Electric shock, threatening, and safety terms	Response latency, ratings (Pain-US expectancy, fear of pain, unpleasantness)	Two 3-member equivalence classes
Bennett et al. (2015c)	Fear and avoidance		30 undergraduates: 23F, 7M M=21 (SD=1.41)	One-group posttest only	Nonsense words, 3D animal-like objects	Aversive images (IAPS), aversive sounds (80 dB and 90dB, 5-second; female scream and white noise from IADS), threatening and safety terms	Key pressing, ratings (US expectancy, valence, unpleasantness)	Two 3-member equivalence classes

Montoya-Rodriguez and Molina-Cobos (2017)	Fear and avoidance		17 typically children: 12F, 5M Aged 10-11	One-group posttest only	Vowels, colored cards, geometric shapes	Evaluated videos (aversive, nonaversive, and neutral), earning of points	Ratings (discomfort, preference), selection of a video to watch	Three 3-member equivalence classes
Donati et al. (2019)	Fear and avoidance extinction		88 undergraduates: 80F, 8M Aged 18-25	Between-subjects (defusion, reappraisal, and control)	Nonsense words	Aversive and nonaversive images (IAPS), aversive sounds (female scream from IADS), message "Consequence canceled"	Mouse clicking, ratings (BIS and BAS scales)	Two 3-member equivalence classes
Boldrin and Debert (2020)	Avoidance extinction		43 undergraduates: Aged 18-26	Between-subjects (direct and derived extinction)	Abstract figures	Aversive sound (90 dB, 8400 Hz, 5-second)	Mouse clicking	Two 4-member equivalence classes
Perez et al. (2020)	Fear and avoidance		32 not specified: Aged 18-45	Between-subjects (experimental and control)	Abstract figures	Facial expressions of fear and happiness, aversive and neutral images (IAPS), aversive sound (metal scraping), message "Image/Sound canceled"	Key pressing, ratings (US expectancy, semantic differential, valence)	Two 4-member equivalence classes
Gandarela et al. (2020)	Avoidance		11 undergraduates: 8F, 3M Aged 18-24	One-group posttest only	Abstract figures	Point loss	Mouse clicking	Two 4-member equivalence classes
Bennett et al. (2020)	Approach and avoidance	Exp. 1	35 undergraduates: 30F, 5M M=21.54 (SD=4.88)	Between-subjects (extended and limited training)	Abstract figures, background colors	Aversive images (IAPS), aversive sounds (female scream from IADS), smiling or frowning emoticons, earning of points, message "Correct" or "Incorrect"	Key pressing	Two 3-member equivalence classes
		Exp. 2	79 undergraduates: 66F, 13M M=20.17 (SD=4.94)	Between-subjects (extended, limited, and no training)				
Valverde et al. (2021)	Fear and avoidance		24 undergraduates: 17F, 7M Aged 18-30	One-group reversal	Abstract figures	Electric shock	Key pressing, skin conductance, heart rate	Two 5-member equivalence classes

Perez et al. (2021)	Avoidance	Exp. 1	4 not specified: 1F, 3M Aged 24-32 M=26.75 (SD=7.39)	One-group posttest only	Abstract figures, background colors	Aversive and nonaversive sounds (dissonant and consonant notes)	Key pressing, mouse clicking	Two 5-member equivalence classes
		Exp. 2	3 not specified: 2F, 1M Aged 24-28, M=26 (SD=2)					Three 4-member equivalence classes
Valdivia-Salas et al. (2022)	Fear		86 undergraduates: 75F, 11M M=19.03 (SD=3.4)	One-group posttest only	Nonsense words, colored shapes	Aversive sound (100 dB, 150 ms)	Attentional bias, ratings (US expectancy, arousal, threat and valence)	Two 3-member equivalence classes
Glogan et al. (2023)	Fear and avoidance		65 undergraduates: 48F, 17M Aged 18-65, M=25.82 (SD=8.12)	Between-subjects (response-congruent and response-incongruent)	Robotic arm movements	Electric shock	Robotic arm movements, ratings (pain-US expectancy, fear of pain)	Symmetry relations
Boldrin et al. (2024)	Avoidance extinction	Exp. 1	16 undergraduates: Aged 18-29	Between-subjects (direct and derived extinction)	Abstract figures	Point loss	Mouse clicking	Two 4-member equivalence classes
		Exp. 2	16 undergraduates: Aged 18-35					

Table 2

Experimental Procedures and Parameters (Number of Stimuli Presentations, % CS-US Contingency, Response Requirements, and Learning/Mastery Criteria) Employed by the Studies Included in the Present Review

Study		Fear conditioning	Avoidance and Approach-Avoidance conditioning	Extinction and Interventions	Tests
Dougher et al. (1994)	Exp. 1	Differential conditioning 6 CS+ (100%) and 6 CS- Larger SCRs/SCLs to CS+ than to CS-	–	–	Steady-state generalization testing 2 CS+ (50%) and 1 CS-/GSs Larger SCRs/SCLs to GSs related to CS+ than to GSs related to CS-
	Exp. 2	Differential conditioning 4 CS+ (75%) and 3 CS- Larger SCRs/SCLs to CS+ than to CS- Differential reconditioning 6 CS+ (100%) and 6 CS- Not specified	–	US-withheld 6 CS+ and 6 CS- Not specified	US-withheld 1 CSs/GSs Smaller SCLs/SCRs to GSs in the test than in the fear conditioning Steady-state generalization testing 2 CS+ (50%) and 1 CS-/GSs Larger SCRs/SCLs to GSs related to CS+ than to GSs related to CS-
Augustson and Dougher (1997)		Differential conditioning 6 CS+ (100%) and 6 CS- Not specified	US-avoidance + CS-escape 6 CS+ (100%) and 6 CS- FR 20 Not specified	–	US-withheld 4 CSs/GSs Not specified
Markham et al. (2002)		Differential conditioning 8 CS+ (75%) and 8 CS- Larger SCRs to CS+ than to CS-	–	–	US-withheld 2 GSs Larger SCRs to GSs related to CS+ than to GSs related to CS-

Smyth et al. (2006)		Differential conditioning 2 CS+ (100%) and 2 CS- Not specified	–	–	US-withheld + ratings 1 CSs/GSs Not specified US-withheld + matching task 1 CSs/GSs Not specified
Dougher et al. (2007)		Single-cue conditioning 6 CS+ (100%) Not specified	–	–	Steady-state generalization testing 1 CS+ (100%) and 1 CS- Not specified
Dymond et al. (2007)		–	US-avoidance + CS-escape + feedback CS+ (75%) and CS- (75%) FR 1 Minimum and maximum number of trials with responses to CS+ and CS-	–	Steady-state generalization testing 6 GSs (75%) Minimum and maximum number of trials with responses to GSs related to CS+ or CS-
Dymond et al. (2008)	Exp. 1	–	US-avoidance + CS-escape + feedback CS+ (75%) and CS- (75%) FR 1 Minimum and maximum number of trials with responses to CS+ and CS-	–	US-withheld 6 GSs Minimum and maximum number of trials with responses to GSs related to CS+ or CS-
	Exp. 2	–	US-avoidance + CS-escape + feedback CS+ (75%) and CS- (75%) FR 1 Minimum and maximum number of trials with responses to CS+ and CS-	–	US-withheld 6 GSs Minimum and maximum number of trials with responses to GSs related to CS+ or CS-
Roche et al. (2008)		–	US-avoidance + CS-escape + feedback CS+ (75%) and CS- (75%) FR 1 Minimum and maximum number of trials with responses to CS+ and CS-	US-withheld 8 CSs or GSs Not specified	US-withheld 6 GSs Minimum and maximum number of trials with responses to GSs related to CS+ or CS-

Valverde et al. (2009)	Exp. 1	Differential conditioning 6 CS+ (100%) and 6 CS- Larger SCRs to CS+ than to CS- in more than half of the trials plus difference between average measures	–	–	Steady-state generalization testing 1 CS+ (100%) and 1 CSs/GSs Larger SCRs to GSs related to CS+ than to GSs related to CS-
	Exp. 2	Differential conditioning 3 CS+ (100%) and 3 CS- Larger SCRs to CS+ than to CS- in more than half of the trials plus difference between average measures	–	–	Steady-state generalization testing 3 GSs (100%) Larger SCRs to GSs related to CS+ than to GSs related to CS-
Dymond et al. (2011)		–	US-avoidance + CS-escape + feedback CS+ (75%) FR 1 Minimum and maximum number of trials with responses to CS+ and CS-	–	Steady-state generalization testing 2 CS+ (100%) and 5 GSs Not specified
Gannon et al. (2011)		Differential conditioning 5 CS+ (100%) and 4 CS- (100%) Not specified	US-approach-avoidance CS+ (100%) and CS- (100%) FR 1 Minimum number of trials with avoidance/approach responses to CS+/CS-	–	US-withheld 4 GSs after conditioning and 5 GSs after conditioning reversal Minimum and maximum number of trials with responses to GSs related to CS+ or CS-
Dymond et al. (2012)		Differential conditioning 6 CS+ (100%) and 6 CS- Not specified	US-avoidance + CS-escape CS+ (100%) FR 1 Minimum and maximum number of trials with responses to CS+ and CS-	US-withheld 3 CS+ and 3 CS- Not specified	US-withheld 6 CSs and 6 GSs Not specified

Luciano et al. (2013)	Differential context conditioning 2 CS+ (100%) and 2 CS- (100%) Larger SCRs to CS+ than to CS- in more than half of the trials plus difference between average measures	Differential context conditioning + US-approach-avoidance CS+ (100%) and CS- (100%) FR 1 Minimum number of trials with avoidance/approach responses to CS+/CS- plus absence of avoidance to CS+ and approach to CS-	US-withheld 6 CS+ and 6 CS- Difference between average measures to CS+ and CS-	Steady-state generalization testing 2 GSs (100%) Larger SCRs to GSs related to CS+ than to GSs related to CS-; Minimum and maximum number of trials with responses to GSs related to CS+ or CS- US-withheld 2 CSs and 1 GSs Not specified
Luciano et al. (2014)	Differential context conditioning 2 CS+ (100%) and 2 CS- (100%) Larger SCRs to CS+ than to CS- in more than half of the trials plus difference between average measures	Differential context conditioning + US-approach-avoidance CS+ (100%) and CS- (100%) FR 1 Minimum number of trials with avoidance/approach responses to CS+/CS- plus absence of avoidance to CS+ and approach to CS-	Motivational, Defusion or Control protocol Not specified	Steady-state generalization testing 2 GSs (100%) Larger SCRs to GSs related to CS+ than to GSs related to CS-; Minimum and maximum number of trials with responses to GSs related to CS+ or CS- Steady-state generalization testing 2 CS+ (100%) and 1 CS-/GSs Not specified
Vervoort et al. (2014)	Differential conditioning 10 CS+ (80%) and 10 CS- Not specified	–	US-withheld 15 CSs or GSs Not specified	US-withheld 1 CSs/GSs Not specified

Garcia-Guerrero et al. (2014)	Differential conditioning 4 CS+ (100%) and 4 CS- Not specified	US-avoidance CS+ (100%) FR 8 Minimum and maximum number of trials with responses to CS+ and CS-	–	Steady-state generalization testing 2 CS+ (100%) and 2 CS-/GSs Not specified US-withheld + UScheck 2 CSs/GSs Not specified
Dymond et al. (2014)	Differential conditioning 3 CS+ (100%) and 3 CS- Not specified	US-avoidance + CS-escape + feedback CS+ (100%) FR 1 Minimum and maximum number of trials with responses to CS+ and CS-	–	US-withheld 6 GSs Not specified
Bennett et al. (2015a)	Differential conditioning 5 CS+ (80%) and 5 CS- Not specified	US-avoidance + CS-escape CS+ (100%) FR 1 Minimum and maximum number of trials with responses to CS+ and CS-	–	US-withheld 4 CSs/GSs Not specified
Bennett et al. (2015b)	Differential conditioning 5 CS+ (80%) and 5 CS- Not specified	–	–	US-withheld 4 GSs Not specified
Bennett et al. (2015c)	Differential conditioning 5 CS+ (100%) and 5 CS- Not specified	–	–	US-withheld + instructions 4 GSs Not specified
Montoya-Rodriguez and Molina-Cobos (2017)	Differential conditioning 1 CS+ (100%) and 1 CS- (100%) Not specified	–	Alteration of function by establishing new relations and exercises focused on values	US-withheld 1 CSs/GSs Not specified

Donati et al. (2019)	Differential conditioning CS+ (75%) Not specified	US-avoidance + CS-escape + feedback CS+ (100%) and CS- (100%) FR 1 Minimum and maximum number of trials with responses to CS+ and CS-	Control, Defusion or Appraisal exercise Not specified	Steady-state generalization testing 1 CS+/CS- (100%) and 3 GSs Minimum and maximum number of trials with responses to GSs related to CS+ or CS- Steady-state generalization testing 1 CS+/CS (100%) and 3 GSs Not specified
Boldrin and Debert (2020)	Differential conditioning 4 CS+ (100%) and 4 CS- Not specified	US-avoidance CS+ (100%) FR 8 Minimum and maximum number of trials with responses to CS+ and CS-	US-withheld CS+ and CS- or GSs Absence of avoidance to CS+ and CS- or to GSs	US-withheld (before extinction) 4 CSs/GSs Minimum and maximum number of trials with responses to GSs related to CS+ or CS- US-withheld (after extinction) 4 CSs/GSs Not specified
Perez et al. (2020)	Differential conditioning 4 CS+ (75%) and 4 CS- Not specified	US-avoidance + feedback CS+ (75%) FR 1 Minimum and maximum number of trials with responses to CS+ and CS-	–	Steady-state generalization testing 16 CS+ (75%), 16 CS- and 5 GSs Not specified
Gandarela et al. (2020)	Differential conditioning 4 CS+ (100%) and 4 CS- Not specified	US-avoidance CS+ (100%) FR 8 Minimum and maximum number of trials with responses to CS+ and CS-	–	US-withheld 4 CSs/GSs Minimum and maximum number of trials with responses to GSs related to CS+ or CS-

Bennett et al. (2020)		Differential context conditioning 6 CS+ (80%) and 6 CS- (80%) Not specified	Differential context conditioning + US-approach-avoidance CS+ (100%) and CS- (100%) FR 1 Minimum number of trials with avoidance/approach responses to CS+/CS- plus more avoidance to CS+ and approach to CS-	–	US-withheld 4 GSs Not specified
Valverde et al. (2021)		Differential conditioning 4 CS+ (100%) and 4 CS- Larger SCRs/HR to CS+ than to CS- in the last trial	US-avoidance CS (100%) FR 5 Minimum and maximum number of trials with responses to CS+ and CS-	–	Steady-state generalization testing GSs (100%) Larger SCRs/HR to GSs related to CS+ than to GSs related to CS-; Minimum and maximum number of trials with responses to GSs related to CS+ or CS-
Perez et al. (2021)	Exp. 1	–	Differential context conditioning + US-approach-avoidance CS+ (100%) and CS- (100%) FR 1 Minimum number of trials with avoidance/approach responses to CS+/CS-	–	US-withheld 4 GSs Minimum and maximum number of trials with responses to GSs related to CS+ or CS- US-withheld 4 GSs Not specified

	Exp. 2	–	Differential context conditioning + US-approach-avoidance CS+ (100%) and CS- (100%) FR 1 Minimum number of trials with avoidance/approach responses to CS+/CS-	–	US-withheld 6 GSs Minimum and maximum number of trials with responses to GSs related to CS+ or CS- US-withheld 6 GSs Not specified
Valdivia-Salas et al. (2022)		Differential conditioning CS+ (100%) Larger US expectancy and ICI to CS+ than to CS- Differential conditioning 72 CS+ (50%) and 72 CS- Larger US expectancy and ICI to CS+ than to CS-	–	–	US-withheld 36 GSs Not specified Steady-state generalization testing 6 CS+ (50%), 6 CS- and 36 GSs Larger US expectancy and ICI to GSs related to CS+ than to GSs related to CS-
Glogan et al. (2023)		–	US-avoidance CS+ (80%, 40%, 100%) FR 1 Not specified	–	US-withheld 24 GSs Not specified
Boldrin et al. (2024)	Exp. 1	–	US-avoidance CS+ (100%) FR 8 Minimum and maximum number of trials with responses to CS+ and CS-	US-noneliminable CS+ and CS- or GSs Absence of avoidance to CS+ and CS- or to GSs	US-withheld (before extinction) 4 CSs/GSs Minimum and maximum number of trials with responses to GSs related to CS+ or CS- US-withheld (after extinction) 4 CSs/GSs Not specified

Exp. 2	–	US-avoidance CS+ (100%) FR 8 Minimum and maximum number of trials with responses to CS+ and CS-	US-withheld CS+ and CS- or GSs Absence of avoidance to CS+ and CS- or to GSs	US-withheld (before extinction) 4 CSs/GSs Minimum and maximum number of trials with responses to GSs related to CS+ or CS- US-withheld (after extinction) 4 CSs/GSs Not specified

Note. CS: Conditioned/Antecedent Stimulus; US: Unconditioned/Consequence Stimulus; GS: Generalized Stimulus; SCR: Skin Conductance Response; SCL: Skin Conductance Level; HR: Heart Rate; FR: Fixed Ratio Schedule; Dash symbol (–): Procedure not applied.