Behaviour Research and Therapy 107 (2018) 64–75

Contents lists available at ScienceDirect

Behaviour Research and Therapy

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

Pavlovian extinction of fear with the original conditional stimulus, a generalization stimulus, or multiple generalization stimuli

Tomislav D. Zbozinek*, Michelle G. Craske

University of California, Los Angeles, Department of Psychology, 1285 Franz Hall, Los Angeles, CA 90025, United States

ARTICLE INFO

Keywords:
Extinction
Exposure therapy
Generalization
Learning
Fear conditioning
Anxiety disorders

ABSTRACT

Exposure therapy for anxiety disorders is derived from Pavlovian extinction learning. With the aim of optimizing exposure therapy, the present study evaluated the effects of multiple extinction stimuli on inhibitory learning. In a differential fear conditioning procedure, participants were randomized to one of three extinction conditions: Extinction_CS+ received nine presentations of the original conditional stimulus (CS+); Extinction_Singular received nine presentations of a generalization stimulus (GS; stimulus similar to the CS+); and Extinction_Variety received one presentation each of nine GSs. One week later, participants returned for extinction test to the CS+, CS-, a GS from Extinction_Variety (Variable_GS), the GS from Extinction_Singular (Single_GS), and a novel GS (Novel_GS). Results showed that Extinction_CS+ exhibited less fear of the CS+ than Extinction_Singular (two dependent measures) and Extinction_Variety (three dependent measures). Additionally, Extinction_Singular had more fear of the Variable_GS than Extinction_Variety (two dependent measures) and Extinction_CS+ (one dependent measure). The results suggest that conducting extinction to the CS+ lessens conditional fear of the CS + more than extinction with GSs. Additionally, extinction with a variety of GSs lessens fear of those GSs more than repeated extinction with one GS. Results are discussed with relevance to exposure therapy for anxiety disorders.

1. Introduction

Exposure is well-established as an effective therapeutic strategy for anxiety disorders (Hofmann & Smits, 2008; In-Albon & Schneider, 2007), and processes of extinction learning are considered to be key mechanisms (Hermans, Craske, Mineka, & Lovibond, 2006). Advances in the science of extinction have greatly informed methods for optimizing exposure therapy (e.g., Craske, Hermans, & Vervliet, 2018). The purpose of the present study is to evaluate the effects of extinction with the original conditional stimulus, a single generalization stimulus, or multiple generalization stimuli upon extinction learning and extinction generalization with relevance for optimizing exposure therapy.

Generalization of fear and extinction learning is an area of growing clinical interest. Generalization of fear is observed as greater conditional fear to stimuli that are more similar to the CS+ (i.e., the conditional stimulus (CS) that has been paired with the aversive unconditional stimulus; US) compared to less similar stimuli (Guttman & Kalish, 1956; Hanson, 1959; Spence, 1936; Vervliet, Vansteenwegen, Baeyens, Hermans, & Eelen, 2005; Vervliet, Vansteenwegen, & Eelen, 2004). Degree of fear generalization is operationalized by the steepness of the excitatory gradient, with a flat slope indicating greater generalization. In the clinical context, an individual who is bitten (US) by a specific German shepherd dog (CS+) may generalize fear to generalization stimuli (GSs), such as other German shepherds, dogs of different breeds (e.g., Labradors), or other animals (e.g., cats).

The Rescorla-Wagner model (Rescorla & Wagner, 1972) predicts generalization of associative learning from a CS+ to a GS (Blough, 1975; Miller, Barnet, & Grahame, 1995; Rescorla, 1976) as a function of the degree of shared elements between the CS and GS. Take, for example, a CS+ that is comprised of element sets A and B (i.e., CS_{AB}). A GS could include overlapping elements (A) as well as unique elements (C) (i.e., CS_{AC}). While aversive fear learning to CS_{AB} (the CS+) may result in maximal learning to element sets A and B, this learning is transferred partially to CS_{AC} (the GS) – specifically only to element set A – resulting in a decrement in responding to CS_{AC} relative to CS_{AB}.

With acquisition to CS_{AB} (the CS+) and extinction to CS_{AC} (the GS), the Rescorla-Wagner model predicts that element set A reduces excitatory value and element set C acquires inhibitory value, whereas the excitatory value of element set B does not change because it is not present during extinction. Thus, at extinction test, fear responding is greater to the CS+ if extinction occurred with a GS than with the CS+ due to the unextinguished element set B. Furthermore, when presented

* Corresponding author.
E-mail address: tzbozinek@ucla.edu (T.D. Zbozinek).

https://doi.org/10.1016/j.brat.2018.05.009
Received 7 February 2018; Received in revised form 5 April 2018; Accepted 23 May 2018
Available online 24 May 2018
0005-7967/

with a novel GS with element sets A and D (i.e., CS_{AD}) at extinction test, the Rescorla-Wagner model predicts little-to-no responding to element set D because it has not undergone prior training and has no associative value. Thus, CS_{AD} will elicit responding to the degree that element set A has remaining excitatory value after extinction.

Using a clinical example, a German shepherd who bites a child is comprised of many elements. Element set A could include features that are common to most dogs, such as four legs and fur. Element set B could be unique features relative to other dogs, such as fur color and the sound of its bark. A golden retriever would share element set A (four legs and fur), but would not share element set B with the German shepherd; instead, it would contain element set C (e.g., different fur color, different bark sound). A third dog, such as a beagle, would share element set A with both other dogs but would additionally have its own element set D (e.g., different fur color, different bark sound). According to the Rescorla-Wagner model, following a German shepherd (CS+) attack (US), extinction to a golden retriever (GS) will lead to less fear reduction to the German shepherd than extinction to the German shepherd because the golden retriever only has some elements in common with the German shepherd. Extinction with a German shepherd would extinguish both element sets A and B (which comprise the German shepherd), whereas extinction with the golden retriever would extinguish element sets A and C (which comprise the golden retriever). The latter approach would leave element set B unextinguished.

Furthermore, studies have shown differential effects on fear of conducting extinction with the CS+ versus a GS. Vervliet et al. (2005) found that extinction with a GS reduced fear to that GS but not to the CS+, which is only partly consistent with the elemental approach from the Rescorla-Wagner model from which some fear reduction to the CS+ is predicted since the extinguished GS's elements partly overlap with the CS+ elements. Conversely, extinction to a CS+ reduced fear to the CS+ and a GS (Vervliet et al., 2004), presumably because extinction to the CS+ extinguished all elements that underwent fear conditioning. This is fully consistent with the Rescorla-Wagner model.

Together, these findings suggest that exposure therapy with the CS+ will reduce fear to the CS+ as well as GSs, whereas exposure to a GS will reduce fear to the GS but less so to the CS+. Hence, exposure to the CS+ offers greater overall benefit than exposure to a GS. Yet, it is often logistically difficult and sometimes unsafe to conduct exposure to the original CS+ (e.g., the German shepherd CS+ may be inaccessible or objectively dangerous), such that most exposures are conducted using GSs. This makes optimizing exposure therapy with GSs and optimizing generalization of extinction learning essential targets. For example, an exposure therapy study conducted with spider phobia found similar results to the ones mentioned in the previous paragraph (Preusser, Margraf, & Zlomuzica, 2017). Participants either engaged in two sessions of exposure therapy to spiders or no treatment. All participants were later tested with spiders and with cockroaches. Results showed that individuals in the spider exposure condition had less fear of both spiders and cockroaches than the no-treatment condition using behavioral, self-report, and physiological measures. This suggests that extinction learning generalized from spiders to cockroaches. From a Rescorla-Wagner perspective, the spider used during exposure and test – which was the same spider – is a GS of the original CS+ that presumably caused spider fear. Exposure was to the spider GS and then tested with the same spider GS. From the Rescorla-Wagner model, fear reduction during extinction should fully transfer to the same spider GS at test. The cockroach was a different GS that partially overlapped with the spider GS (e.g., spider was GS_{AC}, whereas cockroach was GS_{AD}). The degree of fear reduction to the cockroach would depend on the degree of elemental overlap between the spider and the cockroach and the degree of extinction to those elements (i.e., the degree of extinction to element set A). The Rescorla-Wagner model attributes fear reduction to the cockroach to extinction of element set A. This study highlights the importance of understanding the effects of extinction with generalization stimuli on generalization of extinction learning.

One method of enhancing generalization of extinction learning may be increasing variability during learning. From an associative learning theory perspective, increased GS variability during extinction may enhance generalization by increasing the number of elements that acquire inhibitory value during extinction. Studies with fearful samples have evaluated variability during exposure therapy, but with somewhat mixed results. On the one hand, variability in timing between exposures (Rowe & Craske, 1998; Tsao & Craske, 2000) and variability of stimuli during exposures (Lang & Craske, 2000; Rowe & Craske, 1998) improved outcomes for specific phobias. On the other hand, a study of contaminant anxiety showed only trends towards improved outcomes with stimulus variability during exposure therapy (Kircanski et al., 2012). While these studies are strong in clinical application, laboratory fear conditioning studies may offer greater experimental control. We are unaware of any fear conditioning studies investigating the effects of variability versus uniformity of extinction stimuli on extinction learning.

In the present study, all participants underwent acquisition with a CS+ and CS-; they were then randomized to conditions in which extinction was conducted with nine trials of the CS+ (i.e., Extinction_CS+), nine trials of a GS (i.e., Extinction_Singular), or one trial each of nine different GSs (i.e., Extinction_Variety). Our hypotheses of extinction test were based on predictions from the Rescorla-Wagner model. First, we hypothesized that Extinction_CS+ would show less conditional fear to the CS+ at test than the other two conditions. Second, we hypothesized that Extinction_Variety and Extinction_CS+ would show less conditional fear than Extinction_Singular to a GS that was extinguished in Extinction_Variety (Variable_GS). Third, we hypothesized that Extinction_Singular and Extinction_CS+ would show less conditional fear than Extinction_Variety to the GS that was extinguished repeatedly in Extinction_Singular (Single_GS). Fourth, we hypothesized that Extinction_Variety and Extinction_CS+ would show less conditional fear than Extinction_Singular to a novel GS that was never included in extinction training (Novel_GS).

2. Methods

2.1. Participants

Participants (N = 131) were students from the University of California, Los Angeles, who participated for course credit. Six participants dropped out, leaving 125 participants who completed the study. Participants were 66.7% female, 33.3% male; mean age 21.95 years (SD = 3.51); and 4.4% African-American, 0.8% American-Indian or Alaska Native, 37.0% Asian or Asian-American, 24.4% Hispanic/Latino, 0.8% Native Hawaiian or Other Pacific Islander, 3.7% Middle Eastern, 25.9% White, and 3.0% Multiracial. This study was approved by the University of California, Los Angeles Institutional Review Board, and all participants provided informed consent prior to commencing the study.

2.2. Design

Participants underwent habituation, acquisition, and extinction on Day 1. One week later (i.e., Day 8), participants conducted a test phase. CS Type (CS+, CS-, Variable_GS, Single_GS, Novel_GS), Linear Slope (Trial 1, 2, etc.), and Quadratic Slope (Trial 1, 2, etc.) were within-subject factors. Extinction Condition (Extinction_CS+, Extinction_Singular, Extinction_Variety) was the between-subjects factor.

2.3. Materials and apparatus

2.3.1. CS and US

The Pavlovian conditioning procedure was programmed using E-Prime 2 Professional Version 2.0.10.353. The CSs and GSs were chosen from two validated semantic categories that were qualitatively different