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## Developmental differences in aversive conditioning, extinction, and reinstatement: A study with children, adolescents, and adults



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### ABSTRACT

This study investigated developmental differences in aversive conditioning, extinction, and reinstatement (i.e., the recovery of conditioned aversive associations following reexposure to the unconditioned stimulus [US] post-extinction). This study examined these mechanisms in children ( $M_{\text{age}} = 8.8$  years), adolescents ( $M_{\text{age}} = 16.1$  years), and adults ( $M_{\text{age}} = 32.3$  years) using differential aversive conditioning with a geometric shape conditional stimulus (CS+) paired with an aversive sound US and another shape (CS-) presented alone. Following an extinction phase in which both CSs were presented alone, half of the participants in each age group received three US exposures (reinstatement condition) and the other half did not (control condition), followed by all participants completing an extinction retest phase on the same day. Findings indicated (a) significant differences in generalizing aversive expectancies to safe stimuli during conditioning and extinction that persisted during retest in children relative to adults and adolescents, (b) significantly less positive CS reevaluations during extinction that persisted during retest in adolescents relative to adults and children, and (c) reinstatement of US expectancies to the CS+ relative to the CS- in all age groups. Results suggest important differences in stimulus safety learning in children and stimulus valence reevaluation in adolescents relative to adults.

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## Introduction

Aversive conditioning is the process whereby a neutral stimulus acquires the capacity to elicit an anxiety response after it has been paired with an aversive event. Extinction refers to the process whereby a stimulus previously associated with an aversive event is presented in the absence of that event until the stimulus is considered safe and anxiety responses decline. Aversive conditioning is central to learning theories of anxiety disorders (see [Mineka & Oehlberg, 2008](#), for a review), and the principles of extinction provide a major theoretical basis for exposure-based treatments for anxiety disorders (see [Vervliet, Craske, & Hermans, 2013](#), for a review). Much of this research has been conducted with adults. Yet, childhood and adolescence are high-risk periods for the development of anxiety disorders ([Costello, Egger, & Angold, 2005](#); [Kessler et al., 2005](#); [Merikangas et al., 2011](#)) and their persistence into adulthood ([Kim-Cohen et al., 2003](#); [Pollack et al., 1996](#)). Adolescence has also been identified as a critical developmental period of heightened vulnerability for emotional disorders ([Casey, 2015](#)). To date, few studies have directly compared aversive conditioning and extinction in children, adolescents, and adults to determine whether there are critical developmental periods in which there is a vulnerability to acquiring and/or impairments in extinguishing conditioned responses.

### *Developmental differences in aversive conditioning and extinction*

The handful of studies that have examined developmental differences have employed Pavlovian differential conditioning and extinction paradigms. Conditioning involves repeated pairing of a neutral conditional stimulus (CS+) with an aversive unconditional stimulus (US) while another neutral conditional stimulus (CS-) is presented alone during the conditioning phase. Physiological (e.g., skin conductance responses [SCR], startle reflexes [SR]) and subjective indices of anxious responding (e.g., US expectancies, CS evaluations, subjective anxiety ratings) are observed to be larger to the CS+ than the CS- indexing the acquisition of differential conditioned aversive responding. During extinction, both CSs are repeatedly presented without the US and conditioned responses to the CS+ gradually decline.

Several studies of children have found that the magnitude of differential aversive conditioning increases with age. For example, children younger than 10 years fail to discriminate between the CS+ and CS-, whereas children older than 10 years show differential conditioning in both SCR and SR measures ([Glenn et al., 2011](#); [Jovanovic et al., 2014](#)). Both of these studies found no age-related differences in within-session extinction learning (neither included an extinction retest phase). However, numerous other studies of children have either not reported or not found age-related differences in differential aversive conditioning and extinction across this age range ([Craske et al., 2008](#); [Liberman, Lipp, Spence, & March, 2006](#); [Neumann, Waters, Westbury, & Henry, 2008b](#); [Waters, Henry, & Neumann, 2009](#)).

Only a few studies have compared aversive conditioning and extinction in adolescents and adults. One study found that adolescents exhibited a markedly smaller difference in trial-by-trial fear ratings of the CS+ compared with the CS- relative to adults (extinction effects were not reported) ([Lau et al., 2011](#)). A second study found comparable differential conditioning and within-session extinction effects across SCR, SR, and fear ratings among adolescents and adults (extinction retest was not assessed) ([Britton et al., 2013](#)). Finally, a third study found differential conditioning in adolescents and adults across self-report and SR measures but not SCR measures, and it also found significant within-session extinction effects on all measures in both age groups (extinction retest was not assessed) ([Shechner et al., 2015](#)).

To date, only one study has examined differential conditioning and extinction in children, adolescents, and adults. [Pattwell et al. \(2012\)](#) found significant differential conditioning (defined differently in this study relative to previous studies as SCR magnitudes only on the last three CS+ and CS- trials during acquisition) that did not differ between age groups. [Pattwell et al.](#) assessed extinction 24 h later by comparing SCR magnitudes with the first and last extinction trials and found that adolescents exhibited less SCR reduction to the CS+ than both children and adults. Given the paucity of research

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