

Associations Between Community Violence Exposure and Neurological and Behavioral Indices of Extinction Recall in Preadolescent Latina Youth

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ABSTRACT

Community violence exposure increases risk for fear-based disorders, such as anxiety, potentially due to disrupted recall of extinguished fear, whereby stimuli previously associated with threat continue to produce a fear response long after they have been deemed safe. However, this emerging work lacks adequate representation of youth from historically marginalized groups, despite their disproportionate exposure to community violence. As such, this study investigates whether such exposure is associated with neurological and behavioral indices of extinction recall in a sample of preadolescent Latina girls.

Thirty-five predominantly Mexican-heritage Latina girls ($M_{Age} = 10.04$, $SD = 1.23$, range = 8-12 years) underwent functional magnetic resonance imaging (fMRI) while completing an extinction recall task, assessing their ability to retrieve related but competing memories of previously conditioned and extinguished threats. Following the fMRI scan, participants self-reported their community violence exposure using the *Things I've Seen and Heard* scale. Relative to youth with low community violence, youth exposed to higher levels of community violence demonstrated significantly less ventromedial prefrontal cortex (vmPFC) engagement in response to increasingly ambiguous conditioned stimuli and were also marginally more likely to misattribute threat to conditioned stimuli that were least likely to predict threat.

These preliminary results suggest community violence exposure may contribute to disruptions in extinction recall and elucidate a potential mechanism by which these experiences could elevate anxiety, particularly among an understudied group during a sensitive developmental period of heightened anxiety risk.

KEYWORDS: community violence, extinction recall, anxiety, ventromedial prefrontal cortex, functional magnetic resonance imaging, fear conditioning

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INTRODUCTION

Community violence exposure, or instances of violence children encounter outside of the home, is common (> 60%) and has been linked to a range of fear-based disorders, such as anxiety, in adolescence and beyond (Fowler et al., 2009; Green et al., 2010). A growing body of research proposes disrupted recall of previously extinguished fear as one possible explanatory mechanism (Graham & Milad, 2011; Marusak et al., 2021). However, much of this work has yet to include youth from historically marginalized groups, despite their often disproportionate exposure to community violence (Chen et al., 2020). Latinx youth, in particular, witness higher rates of community violence relative to white youth, but remain severely underrepresented in emerging research, and Latina girls, who already exhibit heightened levels of untreated anxiety, may be at heightened risk (Crouch et al., 2000; McLaughlin et al., 2007). As such, the current study explores whether community violence exposure is associated with neurological and behavioral indices of extinction recall in a sample of preadolescent Latina girls residing in the Inland empire, a region in California ranking higher than state average in rates of violent crime (Federal Bureau of Investigation, 2019).

Fear Conditioning and Extinction

Fear conditioning, a form of associative learning, is a widely used experimental paradigm for investigating the neurological and behavioral underpinnings of fear-based disorders, like anxiety (Shechner et al., 2014). During fear conditioning, a neutral conditioned stimulus (CS) is repeatedly paired with an aversive unconditioned stimulus (US), resulting in a CS-US association, whereby the previously neutral stimulus now produces a learned or “conditioned” fear response (CR). Some paradigms also probe safety learning processes (Mullins et al., 2021, 2024) via two CS’s, one paired with the US (CS+) and another unpaired (CS-). When the CS+, but not the CS-, elicits a CR, this reflects an enhanced ability to respond adaptively to future aversive events while recognizing situations that remain safe. Importantly, conditioned fear responses may be extinguished after the CS+ is presented repeatedly in the absence of the US, in a process called extinction (Hobin et al., 2003). Finally, extinction recall occurs when the CS-

and extinguished CS+, along with a set of blended morphs that fall along a continuum of increasing similarity to the extinguished CS+, are presented again at a later time with the general consensus that low levels of fear responding reflect successful extinction recall and high levels of fear responding reflect poor extinction recall (Michalska et al., 2019).

Extinction Recall in Anxiety Disorders

Anxious individuals often show deficits in extinction recall, as evidenced by heightened fear responding to previously extinguished threats (Garfinkel et al., 2014; Milad et al., 2009). Evidence suggests these deficits are due, in part, to structural and functional alterations in key neural regulatory regions necessary for extinction recall. One such region is the ventromedial prefrontal cortex (vmPFC), which is thought to inhibit the expression of fear and aid in safety learning (Quirk & Beer, 2006). This regulatory role is important as experiences of community violence are instances of learning that condition how future social interactions are encountered. If community violence exposure disrupts activation of the vmPFC, this can maintain or exacerbate anxiety. During extinction recall, anxious adult patients consistently exhibit lower vmPFC activation relative to healthy controls (Britton et al., 2013; Milad et al., 2005, 2007). Further, a study of extinction recall during adolescence found that anxious youth were less able to differentiate between the CS+ and its most similar morph variations relative to nonanxious youth, as evidenced by representationally similar vmPFC activation patterns (Glenn et al., 2020). In a related study, anxious adolescents exhibited a U-shaped pattern of vmPFC activation, showing heightened responding to the CS+ and CS- and reduced responding to their blended, more ambiguous, morphs (Britton et al., 2013). Together, these studies demonstrate that anxious youth have difficulty differentiating between threatening and non-threatening stimuli and regulating their response to increasingly ambiguous stimuli. Importantly, this work rarely considers how social influences, like community violence exposure may shape these neural and behavioral responses.

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Study Overview

Despite the well-documented detrimental impact of community violence exposure on fear-based disorders (Fowler et al., 2009; Green et al., 2010), research specifically addressing how these experiences confer heightened risk for anxiety remains limited. The current study aimed to address this gap by testing whether community violence exposure is associated with neurological and behavioral indices of disrupted extinction recall in a sample of preadolescent Latina youth. First, we tested the hypothesis that community violence exposure would be associated with deviations in vmPFC activation when viewing increasingly ambiguous conditioned stimuli morphs, such that high community violence exposed youth would exhibit reduced vmPFC responding relative to low community violence exposed youth. Second, we tested the hypothesis that community violence exposure would predict disrupted recall of previously extinguished fear, whereby high community violence exposed youth would be more likely to incorrectly label an ambiguous stimulus as one they had previously experienced as aversive. Characterizing the effect of community violence exposure on this fear-related brain region and behavior may elucidate possible mechanisms through which adverse community-level experiences in childhood confer risk for anxiety later in development.

METHODS

Participants and Procedure

Participants included 35 predominantly Mexican-heritage preadolescent Latina girls ($M_{Age} = 10.04$, $SD = 1.23$, range = 8-12 years) residing in the Inland Empire. Participants were recruited via fliers in outpatient mental health clinics local hospitals, and the University of California, Riverside (UCR) Psychology Department shared database of child participants. We received IRB approval for the current study prior to data collection. Participant eligibility was determined by phone screening with a parent. Children were eligible for participation if they were conversant in English, age 8-13 years, self-identified as Latina, were pre-menstrual, and had no contraindications for neuroimaging. While undergoing a functional magnetic resonance imaging (fMRI) scan at the UCR Center for Advanced Neuroimaging, participants completed an extinction recall task assessing their ability

to retrieve related but competing memories of previously extinguished threat. Following the scan, participants completed a series of questionnaires assessing demographics and community violence exposure.

Measures

Brain Imaging and Data Processing

Whole-brain neuroimaging data were collected using a 3T Siemens Prisma scanner and 32-channel head coil. During 3 runs of 10 minutes 26 seconds each, 272 functional image volumes with 47 contiguous interleaved axial slices (in-plane resolution 2.5 mm, 3 mm slice thickness) were obtained with a T2*-weighted echo-planar sequence (TR = 2300 ms; TE = 25 ms; flip angle = 50; field of view [FOV] = 240 mm; matrix = 96 x 96). All functional data were anatomically localized and co-registered to a high-resolution T1-weighted volumetric scan of the whole brain, using a magnetization prepared gradient echo sequence (MPRAGE; TE = min full; TI = 425 ms; flip angle = 7, FOV = 256 mm; matrix = 256 x 256; in plane resolution 1.0 mm). Individual echo-planar images were preprocessed and analyzed for each participant using Analysis of Functional NeuroImages (AFNI; Cox, 1996). Preprocessing included despiking, slicetime correction, motion correction, and smoothing with a 4 mm full-width at half maximum (FWHM) kernel. All data were transformed to Montreal Neurological Institute (MNI) space. Blood oxygen level dependent (BOLD) data was scaled at the voxel-wise time series by their temporal means so effect estimates can be interpreted as percent signal change. Using the AFNI 3dDeconvolve function, a linear model was generated to estimate mean task-related vmPFC activation for each presented CS+, CS-, and blended morph.

Extinction Recall

To assess extinction recall, participants first completed a differential fear conditioning and extinction paradigm (Figure 1) consisting of three phases (Britton et al., 2013; Glenn et al., 2021). During the pre-acquisition phase, participants were shown a series of pictures of two women, the CS's, without the US. During the acquisition phase, one woman (CS+) predicted an image of a fearful face paired with a loud, aversive scream (US) while the other woman (CS-) did not. During the extinction phase, the CS+ and CS- were presented repeatedly without the US. Approximately two

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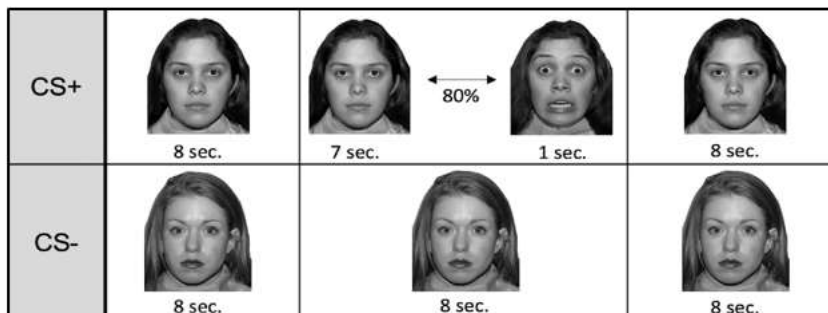


Figure 1. Fear Conditioning and Extinction Paradigm

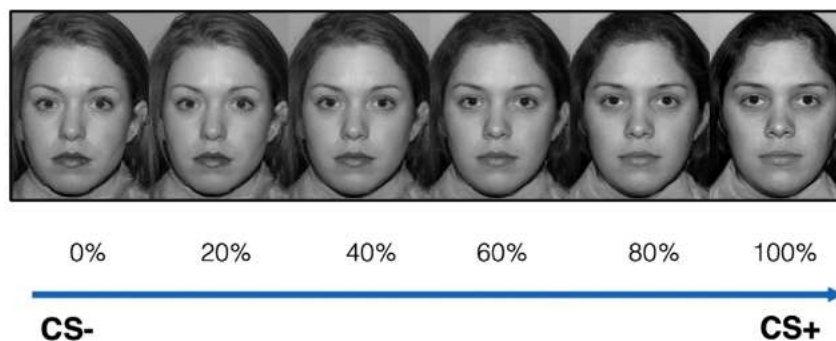


Figure 2. Extinction Recall Paradigm

weeks later, participants completed an extinction recall paradigm (Figure 2) during which they were shown a series of generated morphs blending the faces of the two women from the initial fear conditioning and extinction paradigm at 0%, 20%, 40%, 60%, 80%, and 100% (i.e., 0% = CS-, 100% = CS+). Participants were asked to use a 7-point Likert scale (0 = *not at all* to 6 = *extremely*) to judge the likelihood that the face was previously accompanied by a scream.

Community Violence Exposure

Participants self-reported their community violence exposure via the *Things I've Seen and Heard* scale (TISH; Richters & Martinez, 1993). For each of the 18 items (e.g., “heard gunshots outside your window”, “seen somebody arrested”, etc.), children reported on a 5-point Likert scale (0 = *never* to 4 = *more than three times*) the extent to which each was true for them. Item-level responses were averaged for each participant such that higher values indexed higher levels of community violence exposure. The TISH demonstrated

moderately strong internal consistency in the current sample with a Cronbach's α of 0.64.

DATA ANALYSIS

To assess hemodynamic responding during extinction recall, we averaged vmPFC activation in response to each stimulus to index responsivity to low (CS-/0% and 20%), mid (40% and 60%), and high (80% and CS+/100%) similarity morphs. To assess behavioral responding during extinction recall, we averaged scream likelihood ratings (i.e., “how likely was the face to scream?”) for each presented stimulus to index recall of low (CS-/0% and 20%), mid (40% and 60%), and high (80% and CS+/100%) similarity morphs. Whereas the low similarity morphs are most reflective of the CS- (high safety) and the high similarity morphs are most reflective of the CS+ (high threat), the mid similarity morphs represent a blend of the CS- and CS+ and are therefore the most ambiguous. To assess low vs. high levels of community

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violence exposure, TISH scores were mean split (0 = low, 1 = high). Finally, to account for developmental differences in extinction recall, child age was included as a covariate in all models.

Using SPSS (Version 29), a 2 (low *vs.* high community violence exposure) x 3 (low *vs.* mid *vs.* high morph similarity) repeated-measures analysis of covariance (ANCOVA) examined differences in vmPFC responsivity across the morph similarity spectrum between the low *vs.* high community violence exposed youth. A second 2 (low *vs.* high community violence exposure) x 3 (low *vs.* mid *vs.* high morph similarity) repeated-measures ANCOVA then examined differences in scream likelihood ratings across the morph similarity spectrum between the low *vs.* high community violence exposed youth. Finally, to probe any interactions resulting from each ANCOVA, we conducted post-hoc *t*-tests for the low *vs.* high community violence exposed youth within each level of morph similarity.

RESULTS

Descriptive statistics and bivariate correlations for variables of interest are reported in Table 1. Of note, child age was inversely associated with vmPFC activation in response to the low similarity morphs $r = -0.33, p = 0.050$. Additionally, community violence exposure was positively associated with scream likelihood ratings when viewing the low similarity morphs, $r = 0.34, p = 0.048$.

Neural Index of Extinction Recall

The first 2 (low *vs.* high community violence exposure) x 3 (low *vs.* mid *vs.* high morph similarity) repeated-measures ANCOVA examined vmPFC activation as a neural index of extinction recall, controlling for child age (Figure 3). Morph similarity and community violence exposure interactively predicted vmPFC activation, $F(2,64) = 3.68, p = 0.031$. Post-hoc *t*-tests revealed that high community violence exposed youth ($M = -0.08, SD = 0.23$) exhibited reduced vmPFC activation in response to the mid-similarity ambiguous morphs relative to low community violence exposed youth ($M = 0.13, SD = 0.31$), $t(33) = 2.31, p = 0.014$. No group differences in vmPFC activation were observed in response to the low or high similarity morphs, all p 's > 0.201 .

Behavioral Index of Extinction Recall

The second 2 (low *vs.* high community violence exposure) x 3 (low *vs.* mid *vs.* high morph similarity) repeated-measures ANCOVA examined scream likelihood ratings as a behavioral index of extinction recall, controlling for child age (Figure 4). Morph similarity and community violence exposure neither independently nor interactively predicted scream ratings, all p 's > 0.712 . However, given our *a priori* hypotheses, we conducted post-hoc exploratory *t*-tests, which revealed trend-level differences in scream ratings, such that high community violence exposed youth had marginally higher scream likelihood ratings for the low $t(33) = -1.60, p = 0.059$ and mid $t(33) = -1.51, p = 0.070$ similarity morphs relative to low community violence exposed youth.

CONCLUSION

A long-standing body of research has documented consistent and detrimental effects of community violence exposure on anxiety (Fowler et al., 2009; Green et al., 2010) and more recently emerging work has begun to explore disrupted extinction recall as a potential explanatory mechanism (Graham & Milad, 2011; Marusak et al., 2021). These investigations, while informative, have lacked adequate representation of youth from historically marginalized groups, who frequently face disproportionate levels of community violence (Chen et al., 2020). The current study addressed this gap by testing whether community violence exposure is linked to neurological and behavioral indices of extinction recall in a sample of preadolescent Latina girls, a group exhibiting heightened levels of untreated anxiety (McLaughlin et al., 2007) that has been underrepresented in neuroscientific research on anxiety development (La Scala et al., 2023).

We first tested whether community violence exposure predicted reduced vmPFC responsivity, whereby we expected high community violence exposed youth to exhibit lower vmPFC activation relative to low community violence exposed youth in response to ambiguous blends between threatening and safe stimuli. This hypothesis was fully supported. Youth exposed to higher levels of community violence demonstrated significantly less vmPFC engagement in response to the mid similarity morphs, but not to the

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Variable	<i>N</i>	<i>M</i>	<i>SD</i>	1	2	3	4	5	6	7	8
1. Child Age	35	10.04	1.23								
2. Community Violence Exposure	35	0.76	0.44	0.08							
3. vmPFC Activation - Low	35	0.00	0.34	-0.33*	0.12						
4. vmPFC Activation - Mid	35	0.03	0.29	-0.07	-0.28	0.43*					
5. vmPFC Activation - High	35	-0.08	0.25	0.01	0.09	0.30	-0.08				
6. Scream Rating - Low	35	1.25	1.35	-0.30	0.34*	0.39*	0.08	0.09			
7. Scream Rating - Mid	35	1.55	1.17	-0.28	0.12	0.27	0.11	0.13	0.82**		
8. Scream Rating - High	35	2.08	1.50	-0.20	-0.04	0.18	0.09	0.14	0.46**	0.83**	

Table 1. Descriptive Statistics and Bivariate Correlations. * $p < 0.05$, ** $p < 0.01$.

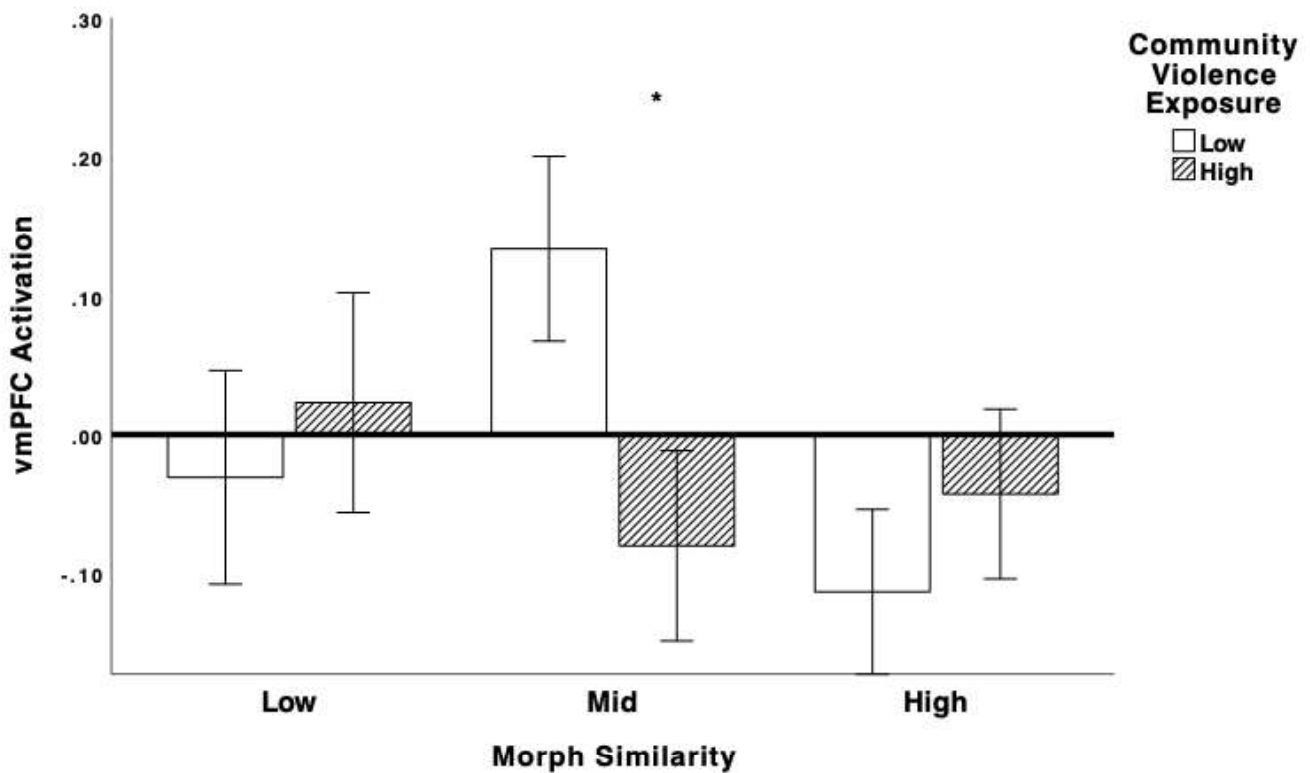


Figure 3. Hemodynamic Response to generalization morphs. vmPFC = ventromedial prefrontal cortex.

Note: Error bars represent standard errors. * $p < 0.050$.

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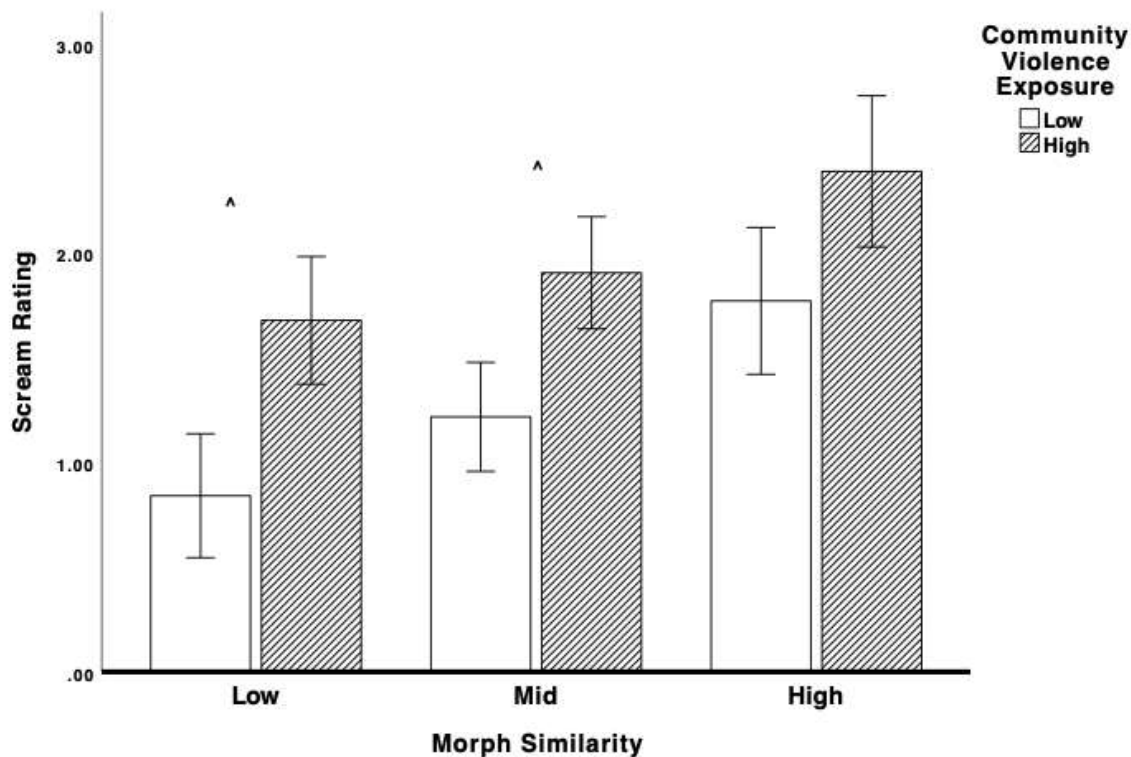


Figure 4. Behavioral Responding

Note: Error bars represent standard errors. $^{\wedge}p < 0.070$.

low or high similarity morphs. This suggests a decreasing ability to engage regulatory brain regions as stimuli become increasingly ambiguous and suggests that community violence exposure may confer higher anxiety risk, in part, by disrupting regulatory processes when youth are tasked with recalling previously extinguished threats. Thus, community violence exposure may fundamentally alter how youth process fear and ambiguity, which can potentiate how future social interactions are experienced.

Next, we tested whether community violence exposure predicted disrupted recall of previously extinguished threat, where we expected high community violence exposed youth would incorrectly recollect that ambiguous stimuli had previously been threatening. This hypothesis was only partially supported. While we did not observe an effect of community violence on this behavioral index of extinction

recall, we did observe marginal group differences for the low and mid similarity morphs in exploratory analyses. Specifically, youth exposed to higher levels of community violence tended to endorse higher scream ratings for the morphs that were least likely to be paired with the unconditioned event relative to youth exposed to lower levels of community violence. This suggests that experiences of community violence may disrupt children's recall of the likelihood of aversive events specifically for stimuli that are similar, but not identical, to previously extinguished threats.

The current findings should be considered in the context of several limitations. First, our sample size was modest, potentially reducing statistical power. Future work in larger samples would be informative. Second, this was a cross-sectional design that did not explicitly examine anxiety symptoms. Longitudinal studies testing whether community

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violence may elevate anxiety through alterations in extinction recall processes would provide complementary insight into causal mechanisms. Acknowledging these limitations, we view our preliminary results as elucidating a potential mechanism by which community violence can adversely impact anxiety, particularly among an understudied group during an especially sensitive developmental period of heightened anxiety risk. Our hope is that this work may guide future research that will shape the development of culturally informed treatment programs aimed at reducing the burden of systemic and environmental stressors on mental health disparities among historically marginalized youth.

ACKNOWLEDGMENTS

We would like to thank all the participants who generously contributed their time and insights to this study. Without your contributions, this study would not have been possible. Your participation enriched our understanding, adding depth to our findings. Thank you for your trust and collaboration.

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