Neighborhood crime risk and racial/ethnic differences in children's neural reactivity to emotional stimuli

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Abstract

Research has shown that exposure to higher rates of neighborhood disadvantage and contextual threat increases risk for the development of psychopathology in youth, with some evidence that these effects may differ across racial/ethnic groups. Although studies have shown that direct exposure to stress impacts neural responses to threat-relevant stimuli, less is known about how neighborhood characteristics more generally (e.g., living in neighborhood characterized by high crime risk, whether or not the individual directly experiences any crime) may impact children's neural responses to threat. To address this question, we examined links between census-derived indices of neighborhood crime and neural reactivity to emotional stimuli in a sample of 100 children (Mage = 9.64, 54% girls, 65% non-Hispanic White) and whether these relations differ for children from minority backgrounds compared to non-Hispanic White children. Focusing on the late positive potential (LPP) event-related potential (ERP) component, we examined neural reactivity to threat-relevant stimuli (fearful faces) as well as non-threat relevant negative (sad faces) and positive (happy faces) stimuli across low, medium, and high intensities (morph levels). We found that levels of neighborhood crime were associated with LPP response to high intensity fearful, but not happy or sad, faces, but only among children from racial/ethnic minority backgrounds. This suggests that levels of crime within one's neighborhood may be a more salient stressor for children from minority racial-ethnic groups than for non-Hispanic White children.

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Abstract

Research has shown that exposure to higher rates of neighborhood disadvantage and contextual threat increases risk for the development of psychopathology in youth, with some evidence that these effects may differ across racial/ethnic groups. Although studies have shown that direct exposure to stress impacts neural responses to threat-relevant stimuli, less is known about how neighborhood characteristics more generally (e.g., living in neighborhood characterized by high crime risk, whether or not the individual directly experiences any crime) may impact children's neural responses to threat. To address this question, we examined links between census-derived indices of neighborhood crime and neural reactivity to emotional stimuli in a sample of 100 children ($M_{age} = 9.64$, 54% girls, 65% non-Hispanic White) and whether these relations differ for children from minority backgrounds compared to non-Hispanic White children. Focusing on the late positive potential (LPP) event-related potential (ERP) component, we examined neural reactivity to threat-relevant stimuli (fearful faces) as well as non-threat relevant negative (sad faces) and positive (happy faces) stimuli across low, medium, and high intensities (morph levels). We found that levels of neighborhood crime were associated with LPP response to high intensity fearful, but not happy or sad, faces, but only among children from racial/ethnic minority backgrounds. This suggests that levels of crime within one's neighborhood may be a more salient stressor for children from minority racial-ethnic groups than for non-Hispanic White children.

Keywords : Neighborhood stress, Threat, Late positive potential (LPP)

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Neighborhood context during childhood and adolescence contributes to the development of self and perceptions of the world that are maintained into adulthood (Dupéré et al., 2012). Children from lower income neighborhoods have been shown to be exposed to more psychosocial stressors than their peers, including greater exposure to community violence (Evans and English, 2002). In turn, children and adolescents from lower income neighborhoods experiencing greater levels of crime are more likely to experience chronic stress and are at increased risk for psychopathology (Dupéré et. al., 2012; Jorgensen et. al., 2023;King et. al., 2022; Lowe et. al., 2016; Ramey and Harrington, 2019). Although the precise mechanisms by which this risk is conveyed are not clear, a promising candidate is heightened reactivity to threatening stimuli.

Childhood exposure to threat, whether that be negative life events, childhood abuse, or experiences of corporal punishment, have been associated with increased neural reactivity to threat-relevant stimuli (Cuartas et. al., 2021; Gollier-Bryant et. al., 2016; Puetz et. al., 2020; White et. al., 2019). Further, adolescents who had experienced or witnessed violence (e.g. gun/knife violence and physical altercations) exhibited heightened amygdala responses to angry emotional facial stimuli (White et. al., 2019). Each of these studies focused on direct experiences and less is known about how contextual markers such as simply living in an area with higher crime rates may impact neural reactivity to threat. This type of investigation is important because many children live in high crime areas, even if they are not personally the victim of crime themselves.

The primary goal of this study, therefore, was to examine links between neighborhood indices of crime risk and children's neural reactivity to threat-relevant stimuli. In doing so, we focused on the late positive potential (LPP), which is an event-related potential (ERP) component commonly used to study neural reactivity to emotional stimuli, with larger LPPs observed for emotional or personally salient stimuli than for neutral stimuli (REFs). To determine whether the findings were specific threat-relevant stimuli (fearful faces), we also included non-threat-relevant negative stimuli (sad faces) and positive stimuli (happy faces). We predicted that children from areas with higher levels of neighborhood crime would exhibit larger LPP responses specifically to threat-relevant stimuli. Given evidence that threat exposure may also increase children's sensitivity to milder or ambiguous displays of threat (e.g., neutral stimuli), we examined three levels of emotional stimuli – low, medium, and high – though we did not make specific hypotheses regarding the different intensity levels.

A secondary aim was to determine whether links between neighborhood crime risk and children's neural reactivity to emotional stimuli may differ for children from minority racial/ethnic backgrounds compared to non-Hispanic White children. There is evidence for greater neural reactivity to threat relevant stimuli in

Black compared to White individuals, particularly among those exposed to higher levels of stress (Fani et. al., 2021; Harnett et. al., 2019) There is also evidence from one study that higher levels of parent-reported levels of neighborhood disadvantage are associated with greater neural reactivity to threat in children and adolescents from racial/ethnic minority backgrounds but not among White youth (Jorgensen et al., 2023). Given this, we predicted that the link between neighborhood crime risk and LPP reactivity to threat-relevant stimuli would be stronger among racial/ethnic minorities, compared to Non-Hispanic White children.

Method

Participants

Participants in the study were 100 children and their parents recruited from the community. Because our goal was to recruit a representative community sample with minimal inclusion/exclusion criteria, the only inclusion criterion was that the child be between 7 and 11 years old and the only exclusion criteria was the presence of a learning or developmental disorder, per mother report, that would make it difficult for them to complete the study. The average age was 9.64 ($SD = 1.47$) and 54% of the children were girls. In terms of the race/ethnicity, 65% were non-Hispanic White and 35% were racial/ethnic minorities (African American (12%), Asian (2%), Biracial (11%), Hispanic (16%)). The median annual family income based on parent reports was $50,000-$55,000.

Measures

Morphed faces task

Participants completed a morphed faces task (Burkhouse et al., 2014) in which they viewed grayscale faces from a standardized stimulus set of child actors (Egger et al., 2011) displaying a variety of emotions (fear, happy, sad, or neutral). Each face was 26.5 cm tall (16 visual angle) and 16.5 cm wide (10 visual angle). The stimuli consisted of emotional and neutral photographs from each actor morphed to form a continuum of 10% increments between the two photographs. Each emotion was represented by 4 continua (2 male and 2 female actors) for a total of 12 continua. A total of 11 morphed images were used from each continuum, representing 10% increments of the two emotions ranging from 100% neutral to 100% target emotion (e.g., 100% neutral, 0% fear; 90% neutral, 10% fear; 80% neutral, 20% fear). The pictures were presented one at a time in the middle of the screen for 3 s, after which they disappeared and participants were asked to indicate which emotion was being presented using the following four response options for each image: fear, happy, sad, or calm/relaxed. The inter-trial interval varied randomly between 500 and 750 ms. The stimuli were presented in semi-random order with the condition that no two images from the same actor were presented consecutively. Each of the 132 images was presented twice for a total of 264 trials, with a rest after every 55 trials. Consistent with previous research (Burkhouse et al., 2014; Burkhouse et al., 2016; Jenness et al., 2015), and to provide an adequate number of trials within each morph level, images were binned into three separate morph conditions for analyses: low (10%, 20%, and 30%), medium (40%, 50%, 60%, and 70%), and high (80%, 90%, and 100%). During the morphed faces task, continuous electroencephalography (EEG) was recorded using a custom cap and the BioSemi ActiveTwoBio system (Amsterdam, Netherlands). The EEG was digitized at 24-bit resolution with a sampling rate of 512 Hz. Recordings were taken from 34 scalp electrodes based on the 10/20 system. Offline analysis was performed using the MATLAB extension EEGLAB (Delorme & Makeig, 2004) and the EEGLAB plug-in ERPLAB (Lopez-Calderon & Luck, 2014). All data were re-referenced to the average of the left and right mastoid electrodes and bandpass-filtered with cutoffs of 0.1 and 30 Hz. EEG data were processed using both artifact rejection and correction. Large and stereotypical ocular components were identified and removed using independent component analysis (ICA) scalp maps (Jung et al., 2001). Artifact detection and rejection was then conducted on epoched uncorrected data to identify and remove trials containing blinks and large eye movements at the time of stimulus presentation. Epochs with large artifacts (>100 lV) were excluded from analysis. Consistent with previous studies measuring LPP responses in children (Dennis & Hajcak, 2009; Kujawa, Klein, & Hajcak, 2012) the LPP was calculated as the mean activity 400 to 1000 ms following face onset averaged across occipital (O1, O2, and Oz) and parietal (P3, P4, PO3, PO4, and Pz) electrode sites separately for each emotion and morph level.

Neighborhood crime exposure

Neighborhood crime exposure indices were obtained from CrimeRisk (Applied Geographic Solutions, 2015), which is a database containing geocoded information about crime risk indices for multiple types of crime including property (i.e., burglary, larceny, motor vehicle theft) and personal (i.e., murder, rape, robbery, assault) crime rates for each zip code within the target county. Crime risk indices, reflecting the relative risk of a crime occurring in an area compared to the national average, were calculated from a thorough analysis of crime reports in the target county across a 7-year period. A score of "100" reflects the national average for each crime statistic.

Symptoms of anxiety and depression

Children's symptoms of anxiety and depression were assessed with the Multidimensional Anxiety Scale for Children (MASC; March, Parker, Sullivan, Stallings, & Conners, 1997) and the Children's Depression Inventory (CDI; Kovacs, 1981), respectively. Both measures have demonstrated excellent psychometric properties in previous research (Kovacs, 1981; March et al., 1997). In the current sample both the MASC and the CDI exhibited excellent internal consistency (αs = .87 and .74, respectively).

Procedure

Participants were recruited from the community through various forms of advertisements (e.g., television, bus ads, flyers, and newspapers). Upon arrival to the laboratory, parents provided consent and children provided assent. Following this, children completed the morphed face task and parents completed questionnaires including a report of their current address. All study procedures were approved by the university's Institutional Review Board.

Results

Preliminary analyses revealed that children from racial/ethnic minority groups lived in areas with greater crime risk ($M = 93.54$, $SD = 28.62$) than their non-Hispanic White peers ($M = 68.64$, $SD = 34.75$), t (91) = 3.57, $p < .01$, Cohen's d = .79. This said, there was a clear range of crime risk for minority children (58-143) and non-Hispanic White children (13-143). To test our hypotheses regarding the link between neighborhood crime and children's LPP responses to emotional stimuli, and how this may be moderated by children's race/ethnicity, we used a repeated measures general linear model with level of neighborhood crime and racial-ethnic group (non-Hispanic White vs. racial-ethnic minority) as between subjects factors and emotion (fearful, sad, happy) and morph level (low, medium, high) as within subjects factors. In this analysis, there were significant crime × emotion × morph, F (4, 384) = 5.03, $p < .001$, $\eta_\pi{}^2 = .05$, and racial/ethnic group × emotion × morph, F (4, 384) = 4.66, $p = .001$, $\eta_\pi{}^2 = .05$, interactions. Importantly, the crime × racial/ethnic group × emotion × morph interaction was also significant, F (4, 384) = 3.70, $p = .006$, $\eta_\pi{}^2 = .04$.

To determine the form of this interaction, we examined the crime × emotion × morph interaction separately in minority and non-Hispanic White children. In these analyses, the crime × emotion × morph interaction was significant for racial/ethnic minority children, F (4, 132) = 4.89, $p = .001$, $\eta_\pi{}^2 = .13$, but not for non-Hispanic White children, F (4, 252) = 1.36, $p = .25$, $\eta_\pi{}^2 = .02$. Examining this further in children from racial/ethnic minority groups, the crime × emotion interaction was significant for fearful faces, F (2, 66) = 6.99, $p = .002$, $\eta_\pi{}^2 = .18$, but not for happy, F (2, 66) = 2.66, $p = .08$, $\eta_\pi{}^2 = .08$, or sad, F(2, 66) = 0.73, $p = .48$, $\eta_\pi{}^2 = .02$, faces. As a final step, we examined the correlation between neighborhood crime and LPP amplitude to fearful faces at each morph level in racial/ethnic minority children. Higher levels of neighborhood crime were associated with greater LPP amplitude for fearful faces at high, $r = .36$, $p = .03$, but not medium, $r = -.14$, $p = .42$, or low, $r = -.26$, $p = .13$, morph levels. Although all analyses were based on continuous levels of neighborhood crime risk, we used a median split to provide a visual depiction of these results (see Figure 1).

To evaluate the robustness of these results, we conducted follow-up partial correlation analyses to determine whether the relation between higher levels of neighborhood crime risk and greater LPP responses to fearful faces among racial/ethnic minority children was maintained after statistically controlling for the influence of children's family income and their current symptoms of anxiety and depression. In call cases, the significant relation was maintained (all p s $< .05$).

Conclusions

The goal of this study was to examine the link between census-derived indices of neighborhood crime risk and children's neural reactivity to threat-relevant stimuli, and whether this link may be stronger among children from racial/ethnic minority backgrounds. We found that levels of higher neighborhood crime risk were associated with larger LPP amplitudes to threat-relevant images, but only among racial/ethnic minority children and not among non-Hispanic White children. This finding was specific to full intensity threat images and was not observed at lower intensities. It was also specific to threat-relevant images (fearful faces) and was not observed for non-threat negative images (sad face) or positive images (happy faces). Therefore, in addition to living in areas characterized by higher crime risk, children from racial/ethnic minority groups were also more reactive to the presence of higher crime risk in terms of their neural reactivity. This suggests that levels of neighborhood crime risk may be more salient in racial/ethnic minority children than for non-Hispanic White children. Importantly, the relation between neighborhood crime risk and children's LPP reactivity to threat-relevant images was also maintained when we statistically controlled for the influence of children's family income and current symptoms of depression and anxiety, suggesting that the relation is at least partially independent of these other factors.

The current results build upon previous research showing that direct experiences with crime and violence are associated with greater neural reactivity to threat-relevant stimuli, which suggests that similar patterns are observed as a function of simply living in an area characterized by higher risk of crime (King et. al., 2022). For example, previous research has shown that living in an area with higher crime rates, regardless of whether the individual is a victim of crime themselves, is associated with higher levels of externalizing problems and anxiety symptoms (Hessel et. al., 2019; Jacobs et. al., 2019; Lowe et. al., 2016; Ramey and Harrington, 2019). Research has also shown that this risk differs across racial/ethnic groups such that racial/ethnic minorities that resided in areas experiencing higher crime rates are at particularly high risk for developing psychopathology (Andrews et. al., 2019). The current results suggest that increased neural reactivity to threat may be one mechanism by which living in an area characterized by higher risk of crime increases risk for psychopathology among racial/ethnic minority children. However, longitudinal studies are needed to more formally test this mediational hypothesis.

Despite the strengths of this study, there were limitations as well, which highlight important areas for future research. First, the current study was cross sectional and longitudinal studies are needed to determine if neighborhood characteristics contribute to increased neural reactivity to threat-relevant stimuli over time. These longitudinal studies should also examine the impact of moving into versus out of higher-crime areas on children's neural reactivity to threat, including potential sensitive periods, given evidence from previous research that moving out of high crime areas is associated with reductions in anxiety and depression (King et. al., 2022). A second limitation is that representation for individuals of different racial/ethnic minority groups was limited, so we could not examine whether the link between neighborhood crime risk and neural reactivity to threat is stronger for some minority groups than others. Finally, additional research is needed to understand the mechanisms underlying the link between neighborhood crime risk and neural reactivity to threat among racial/ethnic minority children. Although, on average, racial/ethnic minority families in this sample tended to live in areas with higher crime rates than the non-Hispanic White families, level of neighborhood crime risk also appear to be more salient to children from minority backgrounds. Although the specific mechanisms for this are not clear, it is possible that children from racial/ethnic minority backgrounds have a greater fear of being a victim themselves or may be more reactive to the correlates of living in a higher crime area (e.g., increased police presence). Future research is needed to explore these possibilities.

In summary, this study supports the link between neighborhood crime risk and children's increased neural reactivity to threat-relevant stimuli, but only among racial/ethnic minority children and not non-Hispanic White children. This increased neural reactivity to threat may be one mechanism of risk for later psychopathology in these children. Future research is needed to identify potential sensitivity periods for the impact of neighborhood characteristics as well as the impact of moving out of higher crime areas. Research is also needed to better understand mediators and moderators of the link between neighborhood crime risk and minority children's neural reactivity to threat, which may highlight additional targets of intervention to reduce risk for later psychopathology in these children.

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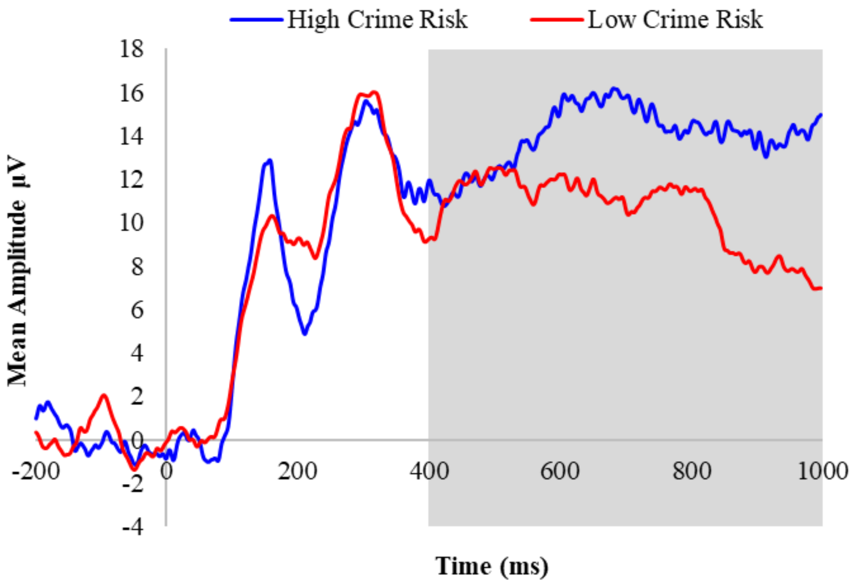
High Crime Risk
Low Crime Risk
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18
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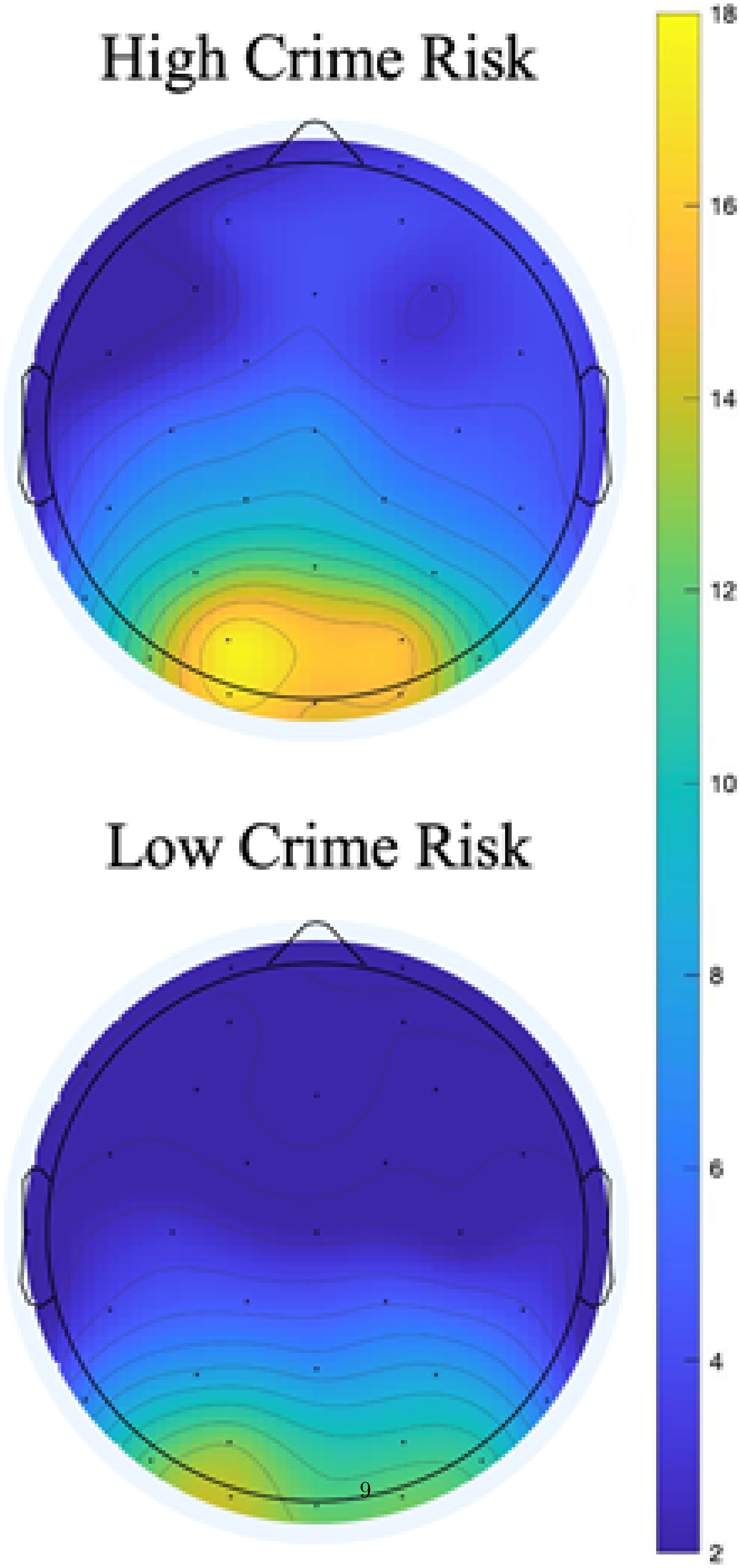
Time (ms)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Low Crime Risk
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Fig 1. Waveforms and scalp topographies depicting the LPP 400-1000 ms following onset of high-morph afraid faces in racial/ethnic minority children from high and low crime risk neighborhoods.

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