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Adolescent Externalizing Problems: Contributions of Community Crime Exposure and Neural Function During Emotion Introspection in Mexican-Origin Youth

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Models of the etiology of adolescent antisocial behavior suggest that externalizing problems may reflect a susceptibility to crime exposure and a diminished capacity for emotion introspection. In this study, adolescents of Mexican origin completed a neuroimaging task that involved rating their subjective feelings of sadness in response to emotional facial expressions or a nonemotional aspect of each face. At lower levels of neural activity during sadness introspection in posterior cingulate and left temporoparietal junction, and in left amygdala, brain regions involved in mentalizing and emotion, respectively, a stronger positive association between community crime exposure and externalizing problems was found. The specification of emotion introspection as a psychological process showing neural variation may help inform targeted interventions to positively affect adolescent behavior.

Evidence demonstrates that neurobiological mechanisms underlie many of the effects of early social-contextual adversity on child and adolescent development, warranting greater focus on their interrelations within groups facing disadvantage (Boyce, Skolowski, & Robinson, 2012). Latino adolescents generally face more disadvantage than their White counterparts, including greater financial hardship, more experiences of racial and ethnic discrimination, and greater exposure to neighborhood crime and violence (Conger et al., 2012; Crouch, Hanson, Saunders, Kilpatrick, & Resnick, 2000; Slopen et al., 2016). Higher rates of crime exposure place low-income Latino adolescents at increased risk for developing externalizing problems (Fowler, Tompsett, Braciszewski, Jacques-Tiura, & Baltes, 2009; Schofield et al., 2012). Despite the increased risk exposure, Latino participants are underrepresented in psychological research (Case & Smith, 2000; Mak, Law, Alvidrez, & Perez-Stable, 2007). Within a sample of mostly low-income Latino adolescents, all of Mexican origin, we investigated neurobiological mechanisms influencing the relation between community crime exposure and later externalizing problems.

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Community Crime and Adolescent Externalizing Problems

Community crime exposure is associated with more externalizing behavior problems in adolescence (Fowler et al., 2009; Schofield et al., 2012; Schwartz & Proctor, 2000). In one study, children who reported witnessing more community violence were nominated by their peers as being more aggressive (Schwartz & Proctor, 2000). One hypothesis about this link is that repeated exposure to community violence may desensitize adolescents to victims' distress signals (Mrug, Madan, & Windle, 2016). Hypoactivation of a "violence inhibition mechanism," an emotional response promoting withdrawal in response to others' distress, has been shown to be an important contributor to the development of antisocial behavior more broadly (Blair, 1995, 1999). In particular, among adolescents with diminished empathic arousal elicited by others' emotions, it is plausible that crime exposure facilitates negative behaviors derived from harmful or aggressive impulses (Hastings et al., 2009; Wu & Pyrooz, 2016).

Role of Emotion Introspection in the Neurobiology of Adolescent Externalizing Problems

This study focused on the role of brain function during emotion introspection in externalizing prob-

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lems. Emotion introspection is one type of mentalizing, or representation of one's own mental states and the mental states of others. Mentalizing about thoughts is considered to be an aspect of cognitive theory of mind, while mentalizing about emotions is an aspect of emotional theory of mind (Blair, Veroude, & Buitelaar, 2016; Corradi-Dell'Acqua, Hofstetter, & Vuilleumier, 2014). As a form of emotional theory of mind, introspection about how someone else's emotions make one feel requires an understanding of the others' emotions and reflecting on them internally, paralleling cognitive empathy (Hastings, Miller, Kahle, & Zahn-Waxler, 2014) or emotional perspective-taking (Eisenberg & Sulik, 2012). Although cognitive theory of mind seems to be relatively intact in adolescents with antisocial behavior, deficits in emotional theory of mind, or representation of others' emotions, are well documented in aggressive youth, as is reduced neurobiological arousal to others' emotions (Blair et al., 2016); thus, introspection about emotional responsiveness may play an important role in regulating aggressive behavior. For example, older children with more aggressive behavior problems have been found to have reduced awareness of their own emotions in emotionally arousing situations (Bohnert, Crnic, & Lim, 2003).

A network of brain regions, including the medial prefrontal cortex (mPFC), posterior cingulate cortex (PCC), and temporoparietal junction (TPJ) is associated with mentalizing, whether one is representing one's own thoughts and emotions or the thoughts and emotions of others (Blakemore, 2008; Lombardo et al., 2010). Some studies find no differences in activation in these regions during cognitive or emotional theory of mind tasks among youth with antisocial behavior (Blair et al., 2016; Sebastian et al., 2012). However, two studies found TPJ activation to be reduced in adolescents with antisocial behavior when evaluating the fairness of a social interaction, a task that involves representing the intent of the social partner (G. J. Klapwijk et al., 2016; Van den Bos et al., 2014). All of these studies utilized tasks that investigated theory of mind by probing representation of the mental states of others, but not introspection into one's own thoughts or emotions pertaining to others.

In one study that did investigate the relation between conduct disorder and neural activity during emotion introspection, adolescents with conduct disorder were found to have reduced amygdala activation during emotion introspection versus processing a nonemotional aspect of a face, compared with typically developing adolescents (E. T. Klapwijk et al., 2015). Processing of emotions tends to recruit the amygdala (Fusar-Poli et al., 2009; Phan, Wager, Taylor, & Liberzon, 2002), and multiple other studies have demonstrated reduced amygdala activity in response to negative emotional faces in youth with antisocial behavior (Hyde et al., 2016; Jones, Laurens, Herba, Barker, & Viding, 2009; Marsh et al., 2008). Amygdala response to emotional faces has not been found to differ significantly when adolescents are instructed to focus on their own emotions versus when attending to nonemotional aspects of the face (Monk et al., 2003), suggesting that amygdala activity may not play a stronger role in emotion introspection relative to emotion processing more generally. Nonetheless, this does not preclude amygdala activation specifically during emotion introspection playing a role in youth externalizing problems (E. T. Klapwijk et al., 2015), and it remains important to track amygdala response, given its engagement more generally in facial emotion processing (Fusar-Poli et al., 2009).

Adolescent Neurobiological Sensitivity to Social Context

Adolescents may be vulnerable to the effects of community crime exposure because their stage of social, physical, and brain development makes them especially sensitive to extrafamilial influences. Increased autonomy and unsupervised time afford adolescents greater exposure to influences in their community (Dishion & McMahon, 1998; Dishion & Patterson, 1997). Concurrently, puberty-related increases in gonadal hormones heighten amygdala reactivity to social stimuli, guiding the connections among motivational pathways that influence later social behavior (Nelson, Jarcho, & Guyer, 2016). The adolescent-specific timing of structural and functional changes in brain regions associated with representing the thoughts of one's self and others, such as the mPFC, TPJ, and PCC, may create a sensitive developmental window for shaping the circuitry of the social brain (Blakemore & Mills, 2014). Individual differences in social cognition and emotion processing more generally emerging in adolescence may contribute to the extent to which they are vulnerable or resilient to the influence of crime in their communities on their own behavior.

Increasingly, developmental psychopathology research considers how aspects of neurobiological regulation may enhance or buffer the effects of various environments and experiences on emotional and behavioral problems (Ellis, Boyce, Belsky, Bakermans-Kranenburg, & Van Ijzendoorn, 2011; Schriber & Guyer, 2016). Dual risk or diathesis stress models propose that certain biological characteristics may predispose individuals to negative outcomes in the presence of environmental risk factors (Hankin & Abela, 2005). For example, young men who were maltreated as children have been found to be more likely to develop antisocial behavior in adulthood if they have a genotype conferring lower activity of the enzyme monoamine oxidase (Caspi et al., 2002). Given recent calls for including direct measures of brain function in such models (Schriber & Guyer, 2016), it is important to test whether similar processes are at play using markers of brain function. As such, exposure to community crime may be especially likely to lead to later externalizing problems among adolescents with a diminished capacity for the neural representation of their own emotional states in response to others' emotions.

The Current Study

This study sought to expand our understanding of the neural processes contributing to adolescent externalizing problems by examining whether those processes amplify or mitigate the influence of community crime exposure, an important environmental risk factor, on externalizing problems. Through this approach, we aim to better characterize how neurocognitive and environmental factors interact in the etiology of adolescent externalizing problems.

First, we sought to test whether parent and adolescent report of community crime exposure was in fact a risk factor for later externalizing problems. We hypothesized that more community crime would be associated with more externalizing problems.

Second, we sought to investigate whether reflecting on their own emotional state would engage neural circuitry that the neuroscience literature has previously associated with emotional reactivity and/or mentalizing, processes with relevance for vulnerability to externalizing problems. Specifically, neural responses during sadness introspection were assessed when participants viewed emotional facial expressions while rating their own affective reaction to the face. Those neural responses were contrasted against neural responses to the same emotional faces when participants rated a nonemotional aspect of the faces. Analyses focused on the amygdala, activation of which is associated with emotional reactivity, and the mPFC, TPJ, and PCC, brain regions associated with mentalizing. We hypothesized that the sadness introspection task would engage brain regions involved in mentalizing, as it involves representation of one's own mental state.

Third, we sought to understand how neural activity related to mentalizing and emotional reactivity may confer risk or resilience to externalizing problems, either directly or through their interactions with community crime exposure. We hypothesized that greater amygdala activation during sadness introspection would be associated with fewer externalizing problems, as demonstrated previously (E. T. Klapwijk et al., 2015). Further, we hypothesized that greater activity in the amygdala during sadness introspection would buffer the positive relation between community crime and externalizing problems, indicating that emotional reactivity specifically when processing one's own emotions may decrease susceptibility to environmental risk for antisocial behavior. We also hypothesized that greater activation of mentalizing regions during sadness introspection would similarly buffer the positive relation between community crime and externalizing problems. This would suggest that greater engagement of neurocognitive processes involved in representing mental states might also play a role in decreasing susceptibility to environmental risk for antisocial behavior.

METHOD

Participants

Participants were 229 Mexican-origin adolescents (M_{Age} = 17.16 years, *SD* = .44, 110 females) enrolled in a neurobiology sub-study of the California Families Project (CFP), a 10-year, prospective, longitudinal study. Most youth (73.8%) were born in the United States (56.3% first-generation; 17.5% second-generation), and 26.2% were born in Mexico. CFP participants included 674 Mexican-origin families with a fifth-grade child (M_{Age} = 10.4, *SD* = .61, 49.8% females) drawn at random from school rosters during the 2006–2007 and 2007–2008 school years. The sub-study was designed to examine neurobiological mechanisms in the etiology of depression. Therefore, youth with elevated depressive symptoms were oversampled from the CFP, using counts of adolescents' self-reported symptoms in ninth grade (age 14) on the Diagnostic Interview Schedule for Children-IV (DISC; Shaffer, Fisher, Lucas, Dulcan, & Schwab-Stone, 2000) as well as indicators of elevated severity from the Anhedonic Depression and General Distress subscales of the Mood and Anxiety Symptom Questionnaire (Watson & Clark, 1991). The sample consisted of adolescents whose symptom scores ranged above the median on all three measures of depression (N = 43), on two measures (N = 64), on one measure (N = 68), and adolescents who were at or below the median on all three measures (N = 54), ensuring variability in symptoms. This recruitment criterion, operationalized as the number of depression measures on which adolescents scored above the median, was used as a control variable in all analyses due to this study's focus on externalizing problems.

Procedures

All procedures were approved by the Institutional Review Board of the researchers' university. Participants and their parents completed yearly home interviews. At age 16–17 years, adolescents and a parent visited a medical research facility, where procedures included obtaining their informed consent and assent, training on functional magnetic resonance imaging (fMRI) tasks in a mock scanner, questionnaire completion, and completion of a structural and three task-based fMRI scans (about 1.5 hr), the third being the emotion introspection task. Each adolescent and their parent were compensated monetarily for their participation.

Measures

Community crime. When adolescents were in fifth (~10 years), seventh (~12 years), and ninth (~14 years) grades, adolescents and their mothers independently completed the Neighborhood Criminal Events Scale (Bowen & Bowen, 1999). Participants reported how frequently they observed various criminal activities (e.g., "How often were there shootings or stabbings in the past year?") in their neighborhood, defined as "the block on which you live and the blocks on either side of you." All 10 items were rated on a 4-point scale (1 = *almost never or never* to 4 = *almost always or always*). Higher scores indicated greater exposure to crime. Adolescents also completed an adapted measure to assess crimes seen at school. All assessments demonstrated good internal reliability ($\alpha \geq .78$). Within each time, youth-reported school and neighborhood crime were significantly correlated, as were youth- and mother-reported neighborhood crime (r = .32; r = −.54); relations were weaker between youth-reported school and mother-reported neighborhood crime (r = .00; r = −.15). All assessments at all time points were averaged to produce a single community crime score.

Externalizing problems. Parents completed the Child Behavior Checklist (CBCL; Achenbach & Edelbrock, 1981) to report on the frequency of their child's problem behaviors within the past 6 months. Each item was rated on a 3-point scale (0 = *not true*, 1 = *sometimes or somewhat true*, or 2 = *very true or often true*). The sums of responses to the Aggressive subscale (e.g., "argues a lot", 20 items, α = .85) and the Delinquent subscale (e.g., "doesn't seem to feel guilty after misbehaving", 13 items, α = .72) were combined to create an externalizing subscale (α = .88). Higher scores indicated more externalizing problems. This scale was missing for two participants.

Adolescents completed the Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997), a 25-item scale comprised of five subscales, with five items each. Participants rated their behaviors on a 3-point scale (0 = *not true*, 1 = *somewhat true*, 2 = *certainly true*), and an average score was generated per subscale. The conduct problems subscale (e.g., "I fight a lot"; α = .63) was used as an index of externalizing problems.

Parent- and adolescent-reported externalizing problems were positively correlated (r = .24, p < .01), and as a result these two scores were converted to z-scores and averaged to produce a single index of adolescent externalizing problems.

Income, gender, and IQ. Income-to-needs ratio, gender, and IQ were used as control variables. Mothers reported their annual income yearly when adolescents were 10–14 years old, to the nearest $5,000 increment (e.g., $30,001–35,000), with $95,001 or more as the highest reporting option. Each increment corresponded to a number between 1 = *less than $5,000* and 20 = *$95,001 or more*. Mothers also reported their household roster. Income values were then divided by the income value that corresponded to the poverty line for a family of that size as indicated by the U. S. Census Bureau (www.census.gov/hhes/www/poverty/data/threshld/). For example, in 2010, the poverty threshold for a family of three was $17,552, corresponding to income value 4 = *$15,001–$20,000*. A family of three reporting an income between $15,001 and 20,000 would have an income-to-needs ratio for that year of 1. A family of three reporting an income of $20,001–25,000 would have an income-to-needs ratio of 1.25. Each family's mother-reported annual income-to-needs ratios were averaged over the first 5 years of reporting when adolescents were 10–14 years old. Participants completed the Woodcock–Johnson III IQ test (Woodcock, Mather, & McGrew, 2001) when they were in fifth grade.

Emotion introspection fMRI task. Adapted from past fMRI work (e.g., Guyer et al., 2008), the emotional faces task (Guyer, Choate, Grimm, Pine, & Keanan, 2011; Vilgis et al., in press) examined neural response to facial expressions of emotion while attention was focused on sadness introspection or a nonemotional feature of the faces. Participants viewed 12 sad, 12 angry, 12 happy, and 12 neutral faces portrayed by 48 unique actors. While viewing each picture, participants responded using their fingers on one hand to one of two questions: "How sad does this face make you feel?" or "How wide is the nose?" (1 = *not at all* to 5 = *very much so*). Due to time constraints, 192 of 229 participants completed this task (95 females, M_{Age} = 17.16 years, SD = 0.41). Trials in which participants did not respond were excluded. Two adolescents who responded to fewer than 75% of the trials were excluded.

FMRI data acquisition and preprocessing. The scan was conducted on a Siemens 3T TIM Trio MRI scanner with a 32-channel head coil. Images were T2 weighted and volume acquisition parameters were set to voxel size = 3.5 × 3.5 × 3.5 mm, slices = 35, slice thickness = 3.5 mm, repetition time = 2,000 ms, echo time = 27 ms, flip angle = 80 degrees, interleaved slice geometry, field of view = 224 mm. The first three volumes were discarded to ensure magnet stabilization. Preprocessing was conducted using the FMRIB Software Library (FSL; Smith et al., 2004) and Analysis of Functional NeuroImaging (AFNI; Version AFNI_16.2.09) software (Cox, 1996). Each participant's functional data were co-registered with their brain-extracted structural images and normalized to Montreal Neurological Institute stereotaxic space using FSL's two-stage registration method via FLIRT. Alignment was visually confirmed for all participants. One participant was excluded from further analysis due to incomplete acquisition resulting in no coverage of dorsal cortical regions. Normalized data then underwent preprocessing and first-level analysis using afni_proc.py in AFNI. Preprocessing consisted of slice timing correction, rigid body motion correction with six degrees of freedom, spatial smoothing with a 6 mm half-maximum Gaussian kernel, nuisance regression of the 6 rigid body motion parameters, and censoring of volumes with head motion >1 mm from the previous volume. Eight participants missing >20% of total volumes following motion censoring were excluded from further analysis. After excluding these eight for motion, two for nonresponses during the task, and two for missing parent-reported externalizing problems, the final analysis sample was 180.

Data Analysis

First-level processing. Blood-oxygen-level dependent response to each of the nine trial types (4 emotions × 2 attention states, 1 fixation) was modeled as a gamma variant function using AFNI's *3dDeconvolve* for each participant. Betas of responses to each of the four emotions were then averaged per attention condition to obtain an estimate of neural response during introspective and nonintrospective processing of emotional faces.

ROI-based analyses. Neurosynth-automated meta-analysis (www.neurosynth.org; Yarkoni, Poldrack, Nichols, Van Essen, & Wager, 2011) was used to identify regions of interest (ROIs) encompassing voxels that appear in independent peer-reviewed published work and significantly predict the presence of the terms *mentalizing* (124 studies) or *emotion* (790 studies) in that paper (i.e., reverse inference), because mentalizing and emotion are key components of sadness introspection. This lexical automated meta-analytic approach has been found to produce maps consistent with those in published meta-analyses for several terms and concepts (Yarkoni et al., 2011). Restricting ROIs to only voxels in which the reverse inference prediction exceeded a z-score of 6 or higher resulted in seven areas: rostral mPFC (331 voxels, Center of Mass MNI x, y, z coordinates [CM] = 2, 55, 24), ventral mPFC (154 voxels, CM = −2, 47, −16), posterior cingulate (PCC; 217 voxels, CM = 2, −55, 38), and right (143 voxels, CM = 56, −54, 24) and left (219 voxels, CM = −50, −57, 19) TPJ were identified in relation to mentalizing, and right (548 voxels, CM = −22, −4, −18) and left (608 voxels, CM = 24, −4, −18) amygdala were identified in relation to emotion (see Figure 1).

Group-level analyses were conducted using an a priori ROI approach (Poldrack, 2007) In contrast to a voxel-based approach, we obtained a single mean response across voxels for each ROI to reduce risk of making Type I errors. Betas of the response to emotional faces within each of the task's two

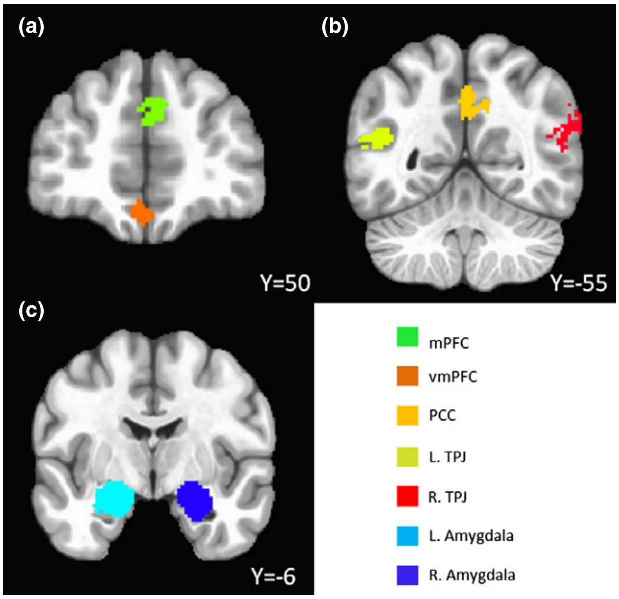

FIGURE 1 A priori regions of interest derived from automated meta-analysis of the terms *mentalizing* (A and B) and *emotion* (C). mPFC, (rostral) medial prefrontal cortex; vmPFC, ventromedial prefrontal cortex; PCC, posterior cingulate cortex; L.TPJ, left temporoparietal junction; R.TPJ, right temporoparietal junction; L.Amy, left amygdala; R.Amy, right amygdala.

attention conditions were averaged across all the voxels in each of the a priori ROIs and extracted for each participant. The sadness introspection–specific response was calculated by subtracting the average response to emotional faces when rating nose width from the average response to emotional faces when rating sadness (i.e., "How sad…" – "How wide…"). These ROIs are consistent with many of the activations elicited by this same task and contrast, and differentially related to emotion regulation and depression, in an independent sample (Vilgis et al., in press).

Community crime and ROI betas were mean-centered. Then, seven multiple regression analyses, one for each ROI, were then conducted examining the linear relation of community crime, sadness introspection ROI response, and their interaction with externalizing problems, controlling for the effects of sex, IQ, income-to-needs ratio, and depression recruitment status. Simple slopes analyses (Aiken & West, 1991) were used to examine significant interactions, modeling the linear relationship between community crime and externalizing problems when ROI activation to sadness introspection was estimated at low (1 standard deviation below the mean) versus high (1 standard deviation above the mean) levels.

RESULTS

Descriptive Analyses

Family income-to-needs ratio was low (M_{Inc} = 1.09, SD = 0.72), indicating the average participant's family was at the poverty line. Income-to-needs ratio was negatively associated with community crime exposure ($r = -.29$, $p < .01$), but not to externalizing problems (see Table 1). IQ was slightly below average in the sample (M_{IQ} = 93.70, SD = 10.52), but was not significantly related to any variable of interest.

Regression Analyses

Mean activation during sadness introspection within each ROI and correlations with crime and externalizing problems are summarized in Table 2. All five mentalizing regions demonstrated significantly greater activation in response to faces in the "How sad…" condition than the "How wide…"

TABLE 1
Descriptive Statistics and Intercorrelations of Study Variables

	N	*M*	*Range*	*SD*	1	2	3	4	5	6	7	8
1. Gender (1 = female)	182	0.49	0 to 1	0.50	–							
2. IQ	180	0.94	0.60 to 1.15	0.11	.09	–						
3. Income-to-needs ratio	180	1.10	0.12 to 4.00	0.72	−.08	.07	–					
4. Depression recruitment status	182	1.42	1.04 to 2.43	0.27	.25*	−.10	−.09	–				
5. Externalizing problems	180	0.79	−0.97 to 2.77	0.79	−.07	−.10	−.02	.20*	–			
6. Crime exposure	182	2.00	1.00 to 4.00	0.62	−.02	−.02	−.28*	.22*	.28*	–		
7. Mean response to "How Sad…"	182	1.64	1.00 to 3.23	0.48	.06	−.14	.02	.15*	.07	−.11	–	
8. Mean response to "How wide…"	182	2.26	1.41 to 3.83	0.33	.15*	.11	.02	.02	−.12	−.21*	.32*	–

Note. All pairwise, Pearson correlations. M = Mean, SD = Standard Deviation; IQ scores were divided by 100 so as to be on a similar scale as the other variables.
*$p < .05$.

TABLE 2
Descriptive Statistics and Correlations for Regions of Interest (ROIs)

ROI	*CM (x, y, z)*	*Meta-analysis term*	*Difference between mean response betas: (How Sad – How Wide)*	*Correlation with mean sadness rating*	*Correlation with crime exposure*	*Correlation with externalizing problems*
mPFC	2, 55, 24	Mentalizing	.19*	−.10	−.17*	−.14*
vmPFC	−2, 47, −16	Mentalizing	.11*	.07	−.08	−.09
PCC	2, −55, 38	Mentalizing	.05*	−.08	−.08	−.25*
L.TPJ	−50, −57, 19	Mentalizing	.15*	−.14	−.05	−.22*
R.TPJ	56, −54,24	Mentalizing	.12*	−.21*	−.09	−.24*
L.Amy	−22, −4, −18	Emotion	.01	−.01	−.11	−.16*
R.Amy	24, −4, −18	Emotion	.01	.01	−.10	−.20*

Note. CM, center of mass; mPFC, (rostral) medial prefrontal cortex; vmPFC, ventromedial prefrontal cortex; PCC, posterior cingulate cortex; L.TPJ, left temporoparietal junction; R.TPJ, right temporoparietal junction; L.Amy, left amygdala; R.Amy, right amygdala.
**p* < .05.

TABLE 3
Multiple Regression Analyses of the Interaction of Community Crime Exposure and ROI Activation to Sadness Introspection in Relation to Externalizing Problems

	mPFC			*vmPFC*			*PCC*			*L.TPJ*			*R.TPJ*		
	B	*SE*	*p*	*B*	*SE*	*p*	*B*	*SE*	*p*	*B*	*SE*	*p*	*B*	*SE*	*p*
Intercept	.37	.53	.49	.44	.53	.41	.27	.51	.59	.55	.52	.29	.32	.53	.54
Gender	−.12	.12	.31	−.15	.12	.22	−.10	.12	.38	−.13	.12	.26	−.13	.12	.29
Income	.07	.08	.39	.07	.08	.41	.10	.08	.21	.08	.08	.33	.07	.08	.36
Dep	.11	.06	.06	.13	.06	.03	.08	.05	.13	.08	.06	.15	.09	.06	.12
IQ	−.59	.55	.28	−.67	.55	.23	−.48	.55	.36	−.72	.55	.18	−.50	.55	.37
Crime exposure	.79	.24	.00	.70	.24	.00	.97	.23	.00	.87	.23	.00	.77	.24	.00
ROI	−.26	.19	.18	−.08	.10	.42	−.99	.24	.00	−1.13	.30	.00	−.64	.24	.01
Crime × ROI	−1.39	.78	.08	−.69	.46	.13	−3.34	.96	.00	−2.64	1.12	.02	−.62	.92	.50
Model summary	R^2 = .14, p < .01			R^2 = .13, p < .01			R^2 = .22, p < .01			R^2 = .19, p < .01			R^2 = .15, p < .01		

Note. mPFC, (rostral) medial prefrontal cortex; vmPFC, ventromedial prefrontal cortex; PCC, posterior cingulate cortex; L.TPJ, left temporoparietal junction; R.TPJ, right temporoparietal junction; Dep, depression; ROI, region of interest.

condition. Amygdala activation did not differ between the two conditions. Only right TPJ was significantly negatively correlated with sadness ratings. Only rostral mPFC activation during sadness introspection was significantly negatively correlated with community crime. All of the ROIs except ventral mPFC were significantly negatively correlated with externalizing problems.

Activation during sadness introspection was found to interact with community crime in relation to externalizing problems for three of the seven ROIs: left TPJ, PCC (Table 3), and left amygdala (Table 4). Thus, significant interactions were detected in 43% (3/7) of the models, far more than would be expected by chance. In each case, the interaction explained a small to moderate amount of additional variance (ΔR^2 = .03 for left TPJ, .06 for PCC, and .02 for left amygdala). For all three of these ROIs, the association between community crime and externalizing problems was more positive when neural activation in those same regions was lower during sadness introspection.

Based on the simple slopes analyses shown in Figure 2, for adolescents with low activation in the three ROIs—left TPJ, PCC, and left amygdala during sadness introspection—a significant positive linear relation between community crime and externalizing problems was found, but not for adolescents with high activation in each of the three ROIs during sadness introspection. To illustrate these associations, the linear relationship between community crime and externalizing problems was modeled at higher (1 standard deviation above the mean) and lower (1 standard deviation below the mean) levels of PCC, left TPJ, and left amygdala activation. For adolescents with lower PCC activation during sadness introspection of emotional faces, externalizing problems during late

TABLE 4
Multiple Regression Analyses of the Interaction of Community Crime Exposure and Amygdala Activation to Sadness Introspection in Relation to Externalizing Problems

	L.Amy			*R.Amy*		
	B	*SE*	*p*	*B*	*SE*	*p*
Intercept	.29	053	.58	.28	0.53	.60
Gender	−.12	.12	.30	−.14	0.12	.23
Income	.08	.08	.31	.09	0.08	.29
Depression	.11	.06	.06	.11	0.06	.06
IQ	−.52	.55	.34	−.49	.55	.37
Crime exposure	.78	.23	.00	.75	.23	.00
ROI	−.54	.30	.07	−.69	.30	.02
Crime × ROI	−2.56	1.28	.04	−1.38	1.12	.22
Model summary	R^2 = .15, p < .01			R^2 = .15, p < .01		

Note. L. Amy, left amygdala; R.Amy, right amygdala; ROI, region of interest.

adolescence were increased for those exposed to more community crime earlier in adolescence (b = 1.75, p < .01). For adolescents with higher PCC activation during sadness introspection, there was not a significant association between externalizing problems and community crime (b = 0.18, ns). Similarly, for adolescents with lower left TPJ activation (b = 1.40, p < .01) and lower left amygdala activation (b = 1.29, p < .01) during sadness introspection of emotional faces, externalizing problems during late adolescence were increased, again for those exposed to more community crime earlier in adolescence (b = 1.40, p < .01). Neither association was significant at higher levels of activation (b = 0.32 and .27, respectively, both ns).

DISCUSSION

During adolescence, youth experience increasingly greater exposure to the happenings in their communities as well as marked neurodevelopment in social-emotional regions of the brain. This study investigated whether community crime exposure across early to middle adolescence was related to externalizing problems in late adolescence. Guided by models of differential biological susceptibility to context (Ellis et al., 2011; Schriber & Guyer, 2016), we tested whether earlier community crime exposure and later externalizing problems were differentially associated as a function of adolescents' levels of neural response during sadness introspection. We pursued these questions using a sample

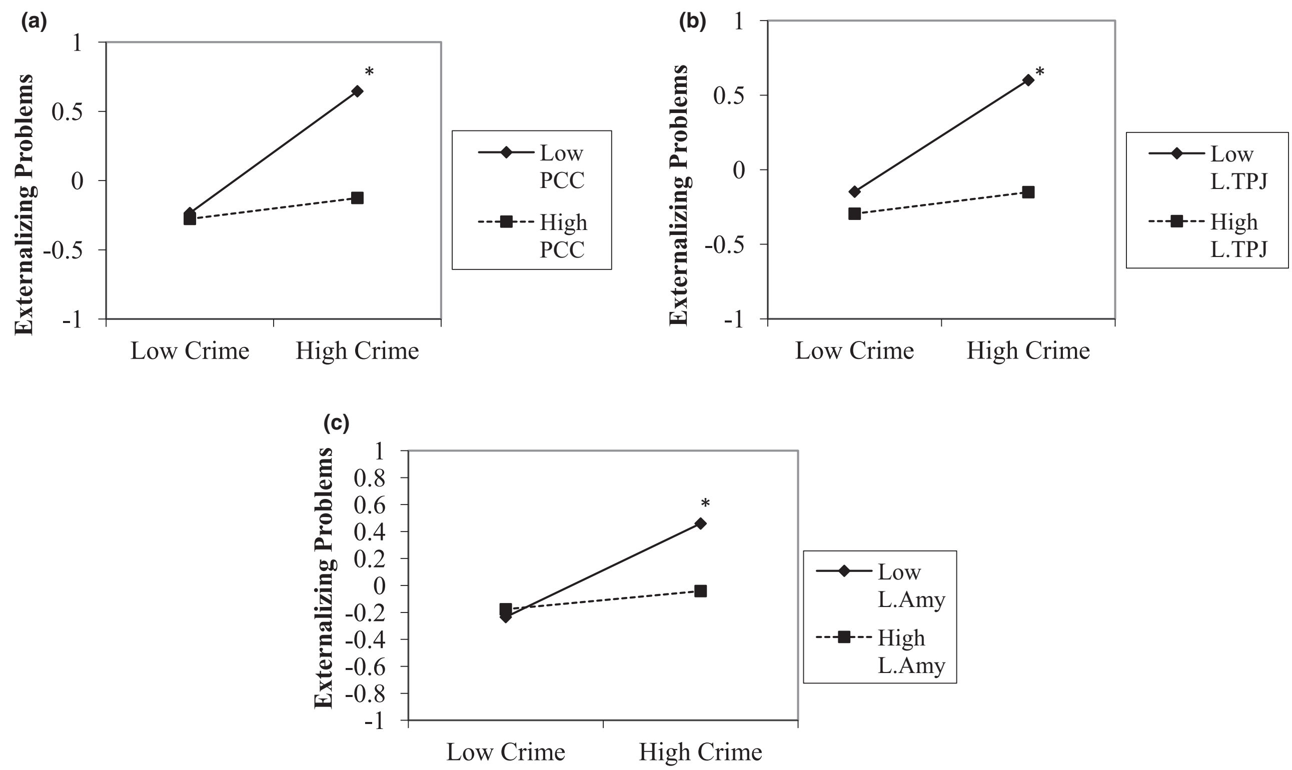

FIGURE 2 Interaction of community crime exposure and neural activation to sadness introspection in relation to externalizing problems. *Slope is significantly different from 0; (A) PCC, posterior cingulate cortex, (B) L.TPJ, left temporoparietal junction, (C) L.Amy, left amygdala.

of Mexican-origin youth because this growing, yet understudied, demographic is disproportionally likely to encounter high levels of community crime (Crouch et al., 2000; Slopen et al., 2016).

The positive association between community crime and externalizing problems was especially strong when adolescents exhibited reduced activity in the PCC, left TPJ, and left amygdala during sadness introspection. Reduced neurophysiological reactivity to typically emotion-eliciting stimuli has been theorized to contribute to externalizing problems in biosocial theories of antisocial behavior for decades (Blair, 1995; Brennan & Raine, 1997). Our findings add to this perspective that emotion introspection, a specific type of emotional theory of mind involving reflection on one's own emotions in response to others' expressions, may be a particularly important neurocognitive process, influencing the link between exposure to crime and externalizing problems during adolescence.

Participants in this study were asked to reflect on their own emotional state by responding to the question "how sad does this person make you feel?" This involves mentalizing, or representing the cognitive or affective state of one's self or others (Blair et al., 2016; Corradi-Dell'Acqua et al., 2014). PCC and left TPJ were selected as ROIs because they are consistently implicated in neuroimaging studies of mentalizing (e.g., Corradi-Dell'Acqua et al., 2014; Lombardo et al., 2010). Greater neural activity in regions associated with mentalizing may increase individuals' recognition and representation of others' emotional cues, thereby keeping violence inhibition mechanisms intact encouraging appropriate responding to others' needs (Blair, 1995, 1999), even in the presence of exposure to crime and violence.

Externalizing problems were also more strongly related to community crime among adolescents who demonstrated reduced left amygdala response when they thought about their feelings of sadness while viewing emotional faces. This is consistent with previous work finding reduced amygdala response to emotion in adolescents with conduct problems (Jones et al., 2009; Marsh et al., 2008). However, in our study, the reduced amygdala reactivity is specific to emotion introspection, suggesting that a mechanism contributing to adolescent externalizing problems may be reduced emotional arousal when thinking about one's own state resulting from the emotions of others (E. T. Klapwijk et al., 2015). In addition, reduced left amygdala activation acts as a moderator of the influence of community crime on externalizing problems, highlighting the important interaction between environmental context and brain function in the development of externalizing behaviors as suggested by diathesis stress models (Hankin & Abela, 2005) and neurobiological susceptibility models (Ellis et al., 2011; Schriber & Guyer, 2016).

Lower amygdala activation during sadness introspection suggests reduced emotional arousal and saliency attributed to and resulting from processing one's own emotions, whereas lower activation in the mentalizing network during sadness introspection suggests reduced mental representation of one's own emotions. Together, these patterns of neural function may represent reduced recognition of one's own emotional state in response to others' emotions and consequently in reduced responsivity to others' distress. Adolescents residing in high crime communities exhibiting these patterns of neural activity may therefore be more susceptible to and willing to take part in aggressive or harmful activities that they see taking place around them. Recognition and awareness of emotions in one's self and others may therefore be important targets for interventions aimed at reducing externalizing problems in youth in high crime communities.

The brain regions involved in mentalizing and emotion undergo functional change from childhood to adolescence, across adolescence, and into adulthood. Children and adolescents typically demonstrate greater activity in mPFC than adults during self-referential thinking, and involvement of TPJ increases across adolescence (Blakemore, 2008; Pfeifer et al., 2009). The apparent decreasing role of mPFC activity in mentalizing across adolescence may be one reason we did not observe its activity during late adolescence to be a significant moderator of crime exposure. Given the course of maturation of the extended mentalizing network, the social environment during the early adolescent period may be especially influential. This age may mark a time when youths' exposures to crime increase due to spending more unsupervised time in their neighborhoods, or they may begin to process occurrences of crime in their neighborhood and school more deeply. Indeed, adolescents are particularly sensitive to their social environments, and individual differences in their neurobiological sensitivity to social context may be an important moderator of the relation between adolescents' context and outcomes (Schriber & Guyer, 2016). The results of the present investigation are consistent with this view, with reduced neural activity in brain regions associated with mentalizing and emotion, in particular PCC, left TPJ, and left amygdala, representing a neural marker that may make adolescents more vulnerable to the effects of exposure to community crime.

While level of activity in brain regions associated with mentalizing and emotion moderated the influence of community crime on externalizing problems, for the most part these neural processes did not seem to be influenced directly by crime exposure, suggesting that these neural mechanisms acted as moderators, but not mediators, of the association between crime and externalizing. Adolescents exposed to higher levels of crime demonstrated reduced mPFC activation to sadness introspection, but no differences in activation in any of the other six ROIs. Determining whether this was a single spurious correlation or a valid indicator of specificity of environmental influences on neurodevelopment will require further investigation. In regression analyses, community crime remained a significant predictor of externalizing problems, whereas mPFC activation during sadness introspection did not, suggesting that reduced mPFC activation is likely not a primary mediator of the relation between community crime and externalizing behaviors.

Given the high level of crime exposure experienced by Latino adolescents relative to their European American counterparts (Crouch et al., 2000), the present findings contribute new information to biopsychosocial models of how individual differences in neurobiological function may influence the extent to and manner in which the environment affects behavior. Among Mexican-origin adolescents, social mechanisms such as stressful life events, parent–child conflict, and affiliation with deviant peers have been found to explain only half as much of the variance in externalizing problems as among White adolescents (Roosa et al., 2005). This study elucidates other mechanisms that may explain additional variance within this population, specifically the neural processes underlying emotional self-reflection and the processing of others' emotional cues. In particular, reduced neural sensitivity to and representation of emotional states may make Latino adolescents more vulnerable to externalizing behavior problems in the context of community crime exposure. However, the source of that reduced neural activity is unknown. Future work investigating how genetics and proximate processes in neighborhoods and families and distal effects of public policy and social acceptance interact to shape Latino adolescents' neural processing of emotion over time can further illuminate these mechanisms, allowing for a better understanding of the biological and environmental factors that may contribute to adolescents' neurobiological vulnerability to the effects of community crime.

Although this study used information from multiple reporters at multiple time points, it was nonetheless limited by externalizing problems and brain function being measured concurrently, making the direction of their relations less clear. This could be addressed in future work utilizing repeated assessments of neural function and of externalizing problems to test more complex longitudinal models, or through experimental manipulations including interventions. For example, a similar fMRI task could be used to evaluate the effects of an emotional awareness training intervention, such as mindfulness, on neural activation to sadness introspection among adolescents exposed to community crime, and whether neural changes relate to reductions in externalizing problems. This type of evidence would support training and scaffolding of emotion recognition and awareness as a powerful intervention tool among adolescents at risk for developing externalizing problems, including those in high crime communities. Another significant limitation of this study is the lack of a measure of callous and unemotional traits (Frick & White, 2008). Callous and unemotional traits are a well-documented differentiator in the neurobiological etiology of externalizing problems, particularly with regard to amygdala activation to affective cues (Blair et al., 2016). Future work investigating the relation between neural activation during emotional introspection and callous unemotional traits could be essential in synthesizing the present work with the well-established literature on the neurobiological bases of externalizing problems. Finally, we conducted this investigation within a sample of all Mexican-origin adolescents to take advantage of rich longitudinal data on an understudied population, for whom community crime is a relevant risk factor. However, we have little reason to believe that our findings would be unique to this population. This warrants further investigation of the interaction between community crime exposure and neural activity during emotion introspection in other ethnic groups or in samples reflecting the diversity of the U.S. population for whom low income and crime exposure are also common.

Neurodevelopmental processes, combined with increased autonomy and exposure to their neighborhood, may make adolescents especially vulnerable to the effects of community crime. Mexican-origin adolescents exposed to more community crime exhibit more externalizing problems. This relation is especially strong among adolescents who demonstrated neural activity consistent with reduced representations of their own and others' emotional states. These findings complement and contribute to the extant literature on environmental and neurocognitive factors conferring risk and resilience for externalizing problems in adolescence by demonstrating one way in which brain function and environment interact. With further replication and investigation, this information has the potential to help with early identification of adolescents at the highest risk of developing externalizing problems. In addition, this study highlights the importance of emotion introspection, or reflecting on one's own emotional state, as a relevant neurocognitive mechanism for understanding susceptibility to externalizing problems in adolescence. Combined with previous research on the etiology of antisocial behavior (e.g., Blair, 1999; Bohnert et al., 2003; Fowler et al., 2009), our results support the idea that interventions aimed at improving emotion recognition, awareness, and introspection may prove promising for preventing aggression and delinquency among adolescents in high crime communities.

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