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Original Paper

Neighborhood Poverty and Amygdala Response to Negative Face

Shervin Assari[1,2*]

[1] Department of Family Medicine, College of Medicine, Charles R. Drew University of Medicine and Science, Los Angeles, CA 90059, USA

[2] Department of Urban Public Health, Charles R. Drew University of Medicine and Science, Los Angeles, CA 90059, USA

[*] Shervin Assari, E-mail: assari@umich.edu; Phone: 1-734-232-0445; Fax: +734-615-8739

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Abstract

Introduction: *Considerable research has established a link between socioeconomic status (SES) and brain function. While studies have shown a link between poverty status and amygdala response to negative stimuli, a paucity of knowledge exists on whether neighborhood poverty is also independently associated with amygdala hyperactive response to negative stimuli.* ***Purpose:*** *Using functional brain imaging data, this study tested the association between neighborhood SES and the amygdala's response to negative stimuli. Considering race as a sociological rather than a biological construct, we also explored racial heterogeneity in this association between non-Hispanic Black and non-Hispanic White youth.* ***Methods:*** *We borrowed the functional Magnetic Resonance Imaging (fMRI) data of the Adolescent Brain Cognitive Development (ABCD) study. The sample was 2,490 nine to ten years old non-Hispanic Black and non-Hispanic White adolescents. The independent variable was neighborhood income which was treated as a continuous measure. The primary outcomes were the right and left amygdala response to negative face during an N-Back task. Age, sex, race, marital status, and family SES were the covariates. To analyze the data, we used linear regression models.* ***Results:*** *Low neighborhood income was independently associated with a higher level of amygdala response to negative face. Similar results were seen for the right and left amygdala. These effects were significant net of race, age, sex, marital status, and family SES. An association between low neighborhood SES and higher left but not right amygdala response to negative face could be observed for non-Hispanic Black youth. No association between neighborhood SES and left or right amygdala response to negative face could be observed for non-Hispanic White youth.* ***Conclusions:*** *For American youth, particularly non-Hispanic Black youth, living in a poor neighborhood predicts the left amygdala reaction to negative face. This result suggested that Black youth who live in poor neighborhoods are at a high risk of poor* *emotion regulation. This finding has implications for policy making to reduce inequalities in undesired behavioral and emotional outcomes. Policy solutions to health inequalities should address inequalities in neighborhood SES.*

Keywords

socioeconomic factors, amygdala, emotion regulation, brain development, fMRI

1. Introduction

Low socioeconomic status (SES) is a strong social determinant of youth brain development (Oshri et al., 2019). Youth from a low SES background experience a higher level of economic adversities as well as social stress (Javanbakht et al., 2015; Masten, Telzer, & Eisenberger, 2011; Wu et al., 2015). As a result of poor brain development, youth from low SES families become at risk for poor school performance (Sirin, 2005), depression (Mendelson, Kubzansky, Datta, & Buka, 2008), suicide (Eisenberg, Gollust, Golberstein, & Hefner, 2007; Yildiz, Demirhan, & Gurbuz, 2019), antisocial behaviors (Palma-Coca et al., 2011), aggression (Heshmat et al., 2016), as well as the use of tobacco (Barreto, de Figueiredo, & Giatti, 2013; Kaleta, Usidame, Dziankowska-Zaborszczyk, & Makowiec-Dabrowska, 2015), alcohol (Moore & Littlecott, 2015; Silveira et al., 2014), and drugs (Gerra et al., 2020). At least some of the undesired effects of low SES on these undesired emotional and behavioral outcomes are attributed to the effects of SES to brain function within (Oshri et al., 2019) and across (Javanbakht et al., 2015) regions.

Across various brain regions and structures that carry the effect of SES is the amygdala. The association between low SES and hyperactive response of the amygdala to negative stimuli is a common observation in neuroscience studies (Evans et al., 2016; Javanbakht et al., 2016; Javanbakht et al., 2015). This is important given that amygdala reactivity to negative stimuli has a central role in emotion regulation (Baczkowski et al., 2017; Barreiros, Almeida, Baia, & Castelo-Branco, 2019; Gaffrey, Barch, Luby, & Petersen, 2020). Dysregulation and hyperactivity of the amygdala is also shown to predict high risk behaviors such as aggression and use of alcohol, tobacco, and drugs (Dotterer, Hyde, Swartz, Hariri, & Williamson, 2017; Gard et al., 2018; Morawetz, Bode, Baudewig, & Heekeren, 2017; Szczepanik et al., 2016; Venta et al., 2018).

Although a well-established link has been documented between SES and youth brain function including amygdala reactivity, most of this research has focused on family rather than neighborhood SES. For example, poverty status, at a family level, is commonly shown as a salient determinant of youth brain function and development (Evans et al., 2016; Javanbakht et al., 2016; Javanbakht et al., 2015; Noble et al., 2015). Studies have documented the effect of poor family SES on amygdala over-reactivity to negative stimuli (Evans et al., 2016; Javanbakht et al., 2016; Javanbakht et al., 2015). However, the effect of low family SES on brain development is not limited to the amygdala (Silverman, Muennig, Liu, Rosen, & Goldstein, 2009; Yaple & Yu, 2019). In fact, low SES impacts a wide range of functions and structures across various brain regions that support language, reading, executive function, and spatial skills (Noble et al., 2015). However, as mentioned above, the most consistent brain imaging finding of youth who live in poverty is an increased activation of the amygdala toward negative stimuli (e.g., faces) (Evans et al., 2016; Javanbakht et al., 2016; Javanbakht et al., 2015). There is also a controversy whether this finding differs for right and left amygdala (Evans et al., 2016; Javanbakht et al., 2016; Javanbakht et al., 2015).

Accurate knowledge regarding the nature of the undesired effect of low SES on brain development and function will help us better understand why low SES youth report worse developmental outcomes (Spera, Wentzel, & Matto, 2009), school performance (Spera et al., 2009), mental health (Goodman, Slap, & Huang, 2003), emotion regulation (Morris, Silk, Steinberg, Myers, & Robinson, 2007; Park & Holloway, 2013), aggression (Pabayo, Molnar, & Kawachi, 2014), and substance use (Goodman et al., 2003; Wills, McNamara, & Vaccaro, 1995). Such an enhanced understanding of the role of SES as a determinant of youth brain function is essential for breaking the vicious cycle between low SES and poor developmental outcomes across multiple emotional and behavioral domains.

From a theoretical perspective, the scarcity hypothesis proposes an explanation for why SES deteriorates healthy youth brain development. According to this hypothesis, low SES is a proxy of lack of resources and early adversity that operate as risk factors for poor child development. In this view, stress and adversity combined with a low level of access to resources are the underlying mechanisms that can explain the link between SES and brain development (Yaple & Yu, 2019). Low family SES is a proxy of living in stressful environments, food insecurity, environmental toxins, as well as parental risk behaviors that can jeopardize a healthy brain development (Assari & Bazargan, 2019). As a result of unhealthy brain development, youth from low SES backgrounds manifest with increased risk of various types of psychopathologies (Chassin, Presson, Sherman, & Edwards, 1992; Kocaoglu et al., 2005; Padilla-Moledo, Ruiz, & Castro-Pinero, 2016). Low SES is also a mediator (an underlying mechanism) of racial and ethnic disparities that evolve in youth development (Assari, 2018).

Recent research, however, suggests that family SES may have different implications for brain development of youth across racial and ethnic groups. A study provided evidence suggesting that family income might be a more relevant determinant of brain function for the most disadvantaged compared to the least disadvantaged groups in society (Noble et al., 2015). For children under poverty, change in income was associated with a larger increase in the surface area of the brain. For high SES children, however, the same change in family SES was associated with smaller changes in the surface area of the brain (Noble et al., 2015). Our work has also shown that non-Hispanic Black and non-Hispanic White youth show different patterns of association between SES and health (Assari & Caldwell, 2019a; S. Assari, Thomas, Caldwell, & Mincy, 2018). Across multiple national and local studies, the strength of the SES effects on a wide range of developmental, emotional, cognitive, behavioral, and health outcomes have been shown to be weaker for non-Hispanic Blacks than non-Hispanic Whites (Assari, 2018; Assari, Lankarani, & Caldwell, 2018; Fuller-Rowell, Curtis, Doan, & Coe, 2015; Fuller-Rowell & Doan, 2010; Hudson, Bullard, et al., 2012; Hudson, Neighbors, Geronimus, & Jackson, 2012), a pattern called the Minorities' Diminished Returns (MDRs) (Assari, 2017). As a result of MDRs, high SES Black youth remain at risk for poor developmental and health outcomes (Assari, Caldwell, & Bazargan, 2019; Assari, Thomas, et al., 2018). For example, high SES Black youth remain at risk of anxiety (Assari, Caldwell, & Zimmerman, 2018), depression (Assari & Caldwell, 2018), poor health (Assari, 2018), poor school performance (Assari & Caldwell, 2019b), high risk behaviors (Assari et al., 2019), aggression (Assari et al., 2019) and tobacco use (Assari & Mistry, 2018).

1.1 Aims

To understand the social determinants of brain function of American youth, our first aim was to study the effect of neighborhood SES on the amygdala's response to negative faces. Using the ABCD data, we also compared non-Hispanic White and non-Hispanic Black youth for the effects of neighborhood SES on right and left amygdala's response to negative faces. We expected racial differences in the association between family SES and neighborhood SES on the amygdala's response to negative faces. This is in line with research on other phenotypes and behaviors (Assari, 2017; Assari et al., 2019).

2. Methods

2.1 Design and Settings

We conducted a secondary analysis of the ABCD study data (Alcohol Research: Current Reviews Editorial, 2018; Casey et al., 2018; Karcher, O'Brien, Kandala, & Barch, 2019; Lisdahl et al., 2018; Luciana et al., 2018). With a cross-sectional design, we applied data from wave 1 of the ABCD study. ABCD is a national, state-of-the-art brain imaging study of youth brain development (Alcohol Research: Current Reviews Editorial, 2018; Auchter et al., 2018).

2.2 Sample and Sampling

Participants in the ABCD study were selected across 21 sites across cities selected from various states. This ABCD sample was mostly drawn from schools, where school selection was based on sex, race, ethnicity, socioeconomic status of the children and urbanicity of the schools (Garavan et al., 2018). The analytical sample included 2490 non-Hispanic White and non-Hispanic Black youth who had complete data on all study variables listed below.

2.3 Study Constructs

The study constructs included demographic factors (age and sex), SES indicators (financial difficulty and neighborhood income), and brain function (right and left amygdala response to negative relative to neutral face), which was captured by functional MRI measures. A detailed explanation of the procedures and harmonization of the fMRIs are explained here (Casey et al., 2018).

2.3.1 Outcome

The outcomes were the right and left amygdala response to negative relative to neutral face. These outcomes were selected because the amygdala response to negative face is a brain consequence of exposure to poverty, trauma, and adversity (Barreiros et al., 2019; Papini et al., 2016; Stevens et al., 2013).

2.3.2 Moderator

Race / Ethnicity. Race was identified by the parents and was treated as a dichotomous variable: Blacks = 1, Whites = 0. Parents also reported if their family had any ties to Hispanic ethnicity. This variable was coded Hispanic = 1 and non-Hispanic = 0. Race/ethnicity was non-Hispanic White = 0 and non-Hispanic Black = 1.

Independent Variables

Neighborhood SES. Neighborhood median family income was derived from the ABCD residential history files of the neighborhood. This variable was derived from geocoding of the study variables in the census tract (Duran, Diez Roux, Latorre Mdo, & Jaime, 2013; D. Kim, Diez Roux, Kiefe, Kawachi, & Liu, 2010; Linetzky, Mejia, Ferrante, De Maio, & Diez Roux, 2012; Nordstrom, Diez Roux, Jackson, Gardin, & Cardiovascular Health, 2004).

2.3.3 Confounders

Age, sex, parental educational attainment, family income, and marital status were the confounders. Parents reported the age of the youth which was a continuous measure in years. Child sex was a dichotomous variable: 1 for males and 0 for females. Family structure was a dichotomous variable with 1 for married 0 for unmarried.

Parental Educational Attainment. Participants were asked, "What is the highest grade or level of school you have completed or the highest degree you have received?" Responses ranged from 0 to 21. This variable was an interval measure, with higher scores indicating higher levels of educational attainment.

Family income. Family income was an interval measure with a range from 1 to 10, where a higher score was indicative of higher income. The exact question was “What is your total combined family income for the past 12 months? This should include income (before taxes and deductions) from all sources, wages, rent from properties, social security, disability and/or veteran’s benefits, unemployment benefits, workman”. Responses included 1 = Less than $5; 2 = $5; 3 = $12; 4 = $16; 5 = $25; 6 = $35; 7 = $50; 8 = $75; 9 = $100; 10 = $200.

2.4 Data Analysis

*W*e used Statistical Package for the Social Sciences 22.0 (SPSS; IBM Corporation, Armonk, NY, USA) for data analysis. Frequency (%) and mean (standard deviation [SD]) were used to describe our sample overall and by race. We also used Chi square and t test to compare racial groups. To estimate bivariate analyses between the study variables, we used the Pearson correlation test both in the pooled sample and by race. We also used Chi-square and independent samples t-test to compare non-Hispanic Blacks and non-Hispanic White youth. To perform our multivariable analyses, we ran three multivariable linear regressions. The independent variable was neighborhood SES. Outcomes were the right and left amygdala response to negative face. All these models controlled for age, sex, family structure, and family SES indicators. *Model 1* was performed in the pooled sample. *Model 2* was performed in non-Hispanic Whites. *Model 3* was performed in non-Hispanic Blacks. Identical models were performed for right and left amygdala response to negative face. Standardized (beta) and regression coefficient, SE, confidence interval (95% CI), and p values were reported for each model.

2.5 Ethical Aspect

The ABCD study was approved by the Institutional Review Board (IRB) of the University of California, San Diego (UCSD) (Auchter et al., 2018). As we used de-identified data, our study was exempt from a full IRB review.

3. Results

3.1 Descriptive Statistics

As Table 1 shows, the current analysis was performed on 2,490 9-10-year old pre-adolescents who were either non-Hispanic White (*n* = 2002; 80.4%) or non-Hispanic Black (*n* = 488; 19.6%). Table 1 presents the descriptive statistics of the pooled sample, as well as by race/ethnicity. Non-Hispanic White and non-Hispanic Black youth differed in family SES and neighborhood SES. Compared to non-Hispanic White youth, non-Hispanic Black youth were less likely to be from married families and had lower family- and area- level SES. Based on an independent sample t-test, non-Hispanic White and non-Hispanic Black youth did not significantly differ in right and left amygdala response to negative face (Table 1).

Table 1. Descriptive Data Overall and by Race/Ethnicity (n=2,490)

	All (*n* = 2,490)		**non-Hispanic Whites (*n* = 2,002)**		**non-Hispanic Blacks (*n* = 488)**	
	n	**%**	***n***	**%**	***n***	**%**
Race*[a]						
Non-Hispanic White	2002	80.4	2002	100.0	-	-
Non-Hispanic Black	488	19.6	-	-	488	100.0
Sex*[a]						
Male	1185	47.6	936	46.8	249	51.0
Female	1305	52.4	1066	53.2	239	49.0
Family Struture *[a]						
Not-Married	621	24.9	299	14.9	322	66.0
Married	1869	75.1	1703	85.1	166	34.0
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
Age (Year) *[b]	9.51	0.51	9.52	0.50	9.48	0.51
Parental Education *[b]	17.24	2.20	17.63	1.90	15.62	2.57
Family Income *[b]	7.72	2.18	8.27	1.58	5.45	2.77

Neighborhood Median Income *[b]	82744.37	34189.89	89255.14	32062.44	56034.20	29348.32
Activation of the Left Amygdala in Response to Negative Face	0.45	0.59	0.44	0.55	0.52	0.72
Activation of the Right Amygdala in Response to Negative Face	0.41	0.54	0.39	0.52	0.48	0.60

* $p < 0.05$ for a comparison of non-Hispanic Whites and non-Hispanic Blacks

[a:] Chi-Square test,

[b:] independent samples t-test

3.2 Bivariate Correlations

Table 2 shows the results of bivariate correlations based on the Pearson test. Activation of the right and left amygdala in response to negative face were positively correlated. Race (non-Hispanic Black) was positively correlated with the activation of the right and left amygdala in response to negative face. The right amygdala showed more consistent correlations with family and neighborhood SES indicators. That means all family SES and neighborhood SES indicators were correlated with activation of the right amygdala in response to negative face. These correlations were inconsistent for the left amygdala. There were also heterogeneities in these correlations between the racial groups.

Table 2. Bivariate Correlations in the Pooled Sample and by Race

	1	2	3	4	5	6	7	8	9
All (n=2490)									
1 Race (Non-Hispanic Black)	1	-.03	-.03	-.47**	-.36**	-.51**	-.39**	.06**	.07**
2 Sex (Male)		1	.01	.04*	-.03	-.01	-.01	.05*	.06**
3 Age (Year)			1	.02	.01	.06**	.06**	-.02	-.05*
4 Marital Status (Married)				1	.35**	.59**	.31**	-.01	-.04*
5 Parental Educatioal Attainment					1	.59**	.42**	-.04*	-.06**
6 Family Income						1	.52**	-.03	-.07**
7 Neighborhood Median Income							1	-.05*	-.05**
8 Activation of the Right Amygdala in Response to Negative Face								1	.66**
9 Activation of the Left Amygdala in Response to Negative Face									1
Non-Hispanic Whites (n=2002)									
1 Race (Non-Hispanic Black)		-	-	-	-	-	-	-	-
2 Sex (Male)		1	-.00	.04	-.05*	-.03	-.03	.02	.05*
3 Age (Year)			1	-.01	-.02	.03	.05*	-.03	-.05*
4 Marital Status (Married)				1	.18**	.43**	.12**	-.01	-.02
5 Parental Educatioal Attainment					1	.46**	.31**	-.04	-.04

6 Family Income					1	.40**	-.01	-.04
7 Neighborhood Median Income						1	-.03	-.02
8 Activation of the Right Amygdala in Response to Negative Face							1	.67**
9 Activation of the Left Amygdala in Response to Negative Face								1
Non-Hispanic Blacks (n=488)								
1 Race (Non-Hispanic Black)	-	-	-	-	-	-	-	-
2 Sex (Male)	1	.06	.01	-.01	-.03	.00	.13**	.12*
3 Age (Year)		1	.05	.07	.07	.09*	.02	-.01
4 Marital Status (Married)			1	.33**	.53**	.28**	.07	-.01
5 Parental Educatioal Attainment				1	.60**	.41**	.00	-.01
6 Family Income					1	.48**	.01	-.04
7 Neighborhood Median Income						1	-.03	-.07
8 Activation of the Right Amygdala in Response to Negative Face							1	.64**
9 Activation of the Left Amygdala in Response to Negative Face								1

3.3 Pooled-Sample Associations

Table 3 reports the results of regression models in the pooled sample. Race was not associated with activation of the amygdala in response to negative face. Neighborhood SES was associated with activation of the amygdala in response to negative face. Neighborhood SES was not significantly associated with activation of both right and left amygdala in response to negative face.

Table 3. Linear Regressions in the Pooled Sample

	Left Amygdala					Right Amygdala				
	b	SE	95% CI		p	b	SE	95% CI		p
Race (Non-Hispanic Black)	0.03	0.01	-0.05	0.06	.841	0.03	0.00	-0.05	0.06	.887
Sex (Male)	0.02	0.03	-0.01	0.07	.098	0.02	0.02	-0.02	0.06	.249
Age	0.02	-0.01	-0.05	0.02	.535	0.02	-0.01	-0.04	0.03	.748
Married	0.03	0.05	0.00	0.11	.039	0.03	0.06	0.00	0.11	.036
Family Income	0.01	0.01	0.00	0.02	.186	0.01	0.01	-0.01	0.02	.404
Parental Education	0.01	0.00	-0.02	0.01	.396	0.01	-0.01	-0.02	0.01	.305
Neighborhood Median Income	0.00	0.00	0.00	0.00	.024	0.00	0.00	0.00	0.00	.031

3.4 Race-Specific Associations

Table 4 reports the results of two race-specific models for left and two race-specific models for right amygdala activation in response to negative face. *Model 2* was performed in non-Hispanic White youth and *Model 3* was performed in non-Hispanic Black youth. We found that neighborhood income was associated with a higher level of left amygdala activation in response to negative face in non-Hispanic Black but not non-Hispanic White youth.

Table 4. Linear Regressions by Race/Ethnicity

	Left Amygdala						Right Amygdala					
	Beta	SE	b	95% CI		p	Beta	SE	b	95% CI		p
Model 2 (Non-Hispanic Whites)												
Sex (Male)	0.02	0.03	0.02	-0.01	0.07	.096	0.02	0.03	0.02	-0.01	0.07	.151
Age	0.00	0.00	0.02	-0.04	0.03	.816	-0.01	-0.01	0.02	-0.05	0.03	.708
Married	0.03	0.05	0.03	0.00	0.11	.069	0.03	0.06	0.03	0.00	0.12	.066
Family Income	0.01	0.00	0.01	-0.01	0.02	.536	0.01	0.01	0.01	-0.01	0.02	.498
Parental Education	-0.01	0.00	0.01	-0.02	0.01	.460	-0.02	-0.01	0.01	-0.02	0.00	.155
Neighborhood Median Income	-0.02	0.00	0.00	0.00	0.00	.139	-0.03	0.00	0.00	0.00	0.00	.117
Model 3 (Non-Hispanic Blacks)												
Sex (Male)	0.01	0.02	0.05	-0.07	0.12	.655	0.00	-0.01	0.05	-0.11	0.10	.906
Age	-0.02	-0.04	0.05	-0.13	0.05	.427	0.00	0.00	0.05	-0.10	0.10	.971
Married	0.04	0.07	0.06	-0.05	0.18	.256	0.03	0.07	0.07	-0.06	0.20	.305
Family Income	0.05	0.02	0.01	-0.01	0.04	.208	0.02	0.01	0.01	-0.02	0.03	.673
Parental Education	-0.01	0.00	0.01	-0.03	0.02	.768	0.01	0.00	0.01	-0.02	0.03	.798
Neighborhood Median Income	-0.07	0.00	0.00	0.00	0.00	.047	-0.05	0.00	0.00	0.00	0.00	.101

4. Discussion

Four findings were observed. First, neighborhood not family SES showed an effect on activation of the amygdala activation in response to negative face. Second, race was not correlated with activation of the amygdala in response to negative face. That is, SES, not race per se, is linked to activation of the amygdala in response to negative relative to neutral faces. Third, neighborhood SES was associated with higher amygdala activation in response to negative face for non-Hispanic Black but not non-Hispanic White youth. Fourth, this pattern could be found for left but not right amygdala activation in response to negative face could be seen for wight and left amygdala.

In a series of fMRI studies, low family SES is shown to impact the amygdala response to negative face (Evans et al., 2016; Javanbakht et al., 2016; Javanbakht et al., 2015). These studies included 52 predominantly non-Hispanic White subjects from a longitudinal study. Participants underwent brain imaging during the Emotional Faces Assessment Task at 23-25 years of age. In their first study, they established a link between low family SES (childhood poverty) and higher amygdala response to a threatening face (Javanbakht et al., 2015). This effect was independent of adulthood family SES (income). They also shown a link between family SES (childhood poverty) and reduced functional connectivity between the left amygdala and the medial prefrontal cortex (Javanbakht et al., 2015). In their second study, Javanbakht et al. (2016) explored sex-specific effects of childhood family SES. They found that childhood poverty status may be correlated with amygdala reactivity to fearful faces in females but not males. In their third study led by Evans, social adversities showed cumulative (additive) effects on amygdala structure and function, including amygdala response to threatening faces (Evans et al., 2016).

An fMRI study by Brody et al. (2019), showed that each additional year spent in poverty may be associated with a lower level of connectivity in neural networks involved in emotion regulation. However, these effects may be more pronounced for youth who receive low levels of supportive parenting. Another study by Barch et al. (2016), showed that childhood poverty may be linked to reduced connectivity between the amygdala and hippocampus and some other regions, including the superior frontal cortex. The study showed that family SES predicts connectivity between 1) the right superior frontal cortex and left hippocampus and 2) the right amygdala and the right lingual gyrus, such brain connectivity mediates the effect of childhood poverty on youth depression. Yaple and Yu (2019) have shown us that the reward network becomes hyperactive and the executive network becomes hypoactive in low SES individuals. Thus, the effects of SES go beyond amygdala hyper-reactivity to negative stimuli and also impacts memory and cognition (Finn et al., 2017).

Our study findings suggested some Black-White differences in the effects of SES on brain function, with non-Hispanic Black youth being at a double jeopardy. The first risk is that they live in lower SES neighborhoods and families. The second risk is that their low SES may come with a higher impact on their emotion regulation. The more salient effects of low SES for non-Hispanic Black than non-Hispanic White youth may be due to other stressors that are unique in the life of racial minorities. For example, studies have shown that racial discrimination results in an increase in amygdala connections with various brain regions. In the presence of racial discrimination, the amygdala and the thalamus show weaker connections. Similarly, discriminatory experiences increase connections between the amygdala with the putamen, the caudate, anterior insula, anterior cingulate, and medial frontal gyrus (Clark, Miller, & Hegde, 2018).

Sociological and epidemiological studies, however, have reported opposite results. In fact, many studies have documented stronger influences of SES on various outcomes for non-Hispanic White than non-Hispanic Black youth (Assari, 2018). For example, family SES has shown larger effects on ADHD (Assari & Caldwell, 2019a), anxiety (Assari, Caldwell, & Zimmerman, 2018), aggression (Assari et al., 2019), tobacco dependence (Assari et al., 2019), school bonding (Assari, 2019), school performance (Assari & Caldwell, 2019b), and overall health (Assari, C. H. Caldwell, & R. B. Mincy, 2018b) for non-Hispanic White than non-Hispanic Black youth. Family SES has also shown a more salient role in shaping the impulsivity of non-Hispanic White than non-Hispanic Black youth (Assari, C. H. Caldwell, & R. Mincy, 2018a). As a result, worse than expected health and behaviors are observed in high SES non-Hispanic Black youth (Assari & Caldwell, 2019a; Assari, Thomas et al., 2018). These patterns are also called MDRs. These MDRs are robust as they hold valid across outcomes, resources, populations, cohorts, age groups, and settings (Assari, 2017). The findings observed in this analysis, however, did not support MDRs.

Differential effects of SES for non-Hispanic Black and non-Hispanic White families contributes to transgenerational transmission of inequalities (Assari et al., 2019; Assari, Caldwell, & Mincy, 2018b; Assari, Thomas et al., 2018). The differential effect of SES means that equal SES generates unequal outcomes for the next generation of youth, which means inequalities reproduce themselves from one to the next generation of non-Hispanic Black people. However, the existing literature on MDRs has mainly relied on self-reported outcomes. Thus, there is a need to extend the MDRs literature from self-reported outcomes to biological and brain imaging outcomes. As such, research should be done on the differential effects of family SES on youth brain function and structure of Blacks and Whites. The main contribution of the current paper is to extend the existing literature from self-reported data to brain function data measured by MRI.

We should emphasize that we see race as a social factor (a proxy of poverty and SES) on how the brain is affected by low or high SES (parental education). Across various brain structures, we focused on the amygdala response to a negative face. The amygdala has implications for emotion regulation, aggression, emotion expression, as well as impulsive, and high risk behaviors (Eden et al., 2015; Gaffrey et al., 2020; Venta et al., 2018). An alteration of the amygdala response is involved in a wide range of behavioral, emotional, cognitive, and health outcomes (Fowler, Miernicki, Rudolph, & Telzer, 2017; Morawetz et al., 2017; Sarkheil, Klasen, Schneider, Goebel, & Mathiak, 2019). To be more specific, we tested if neighborhood SES impacted the amygdala response to negative relative to neutral face- the brain functions were profoundly affected by race and SES (D'Angiulli, Lipina, & Olesinska, 2012; Javanbakht et al., 2016; Javanbakht et al., 2015; P. Kim et al., 2013; Silverman et al., 2009).

We should list some of the limitations of this study. First, a cross-sectional study did not allow causal associations and inference. Second, we only studied neighborhood income and many other structural and contextual factors (e.g., racial composition, similarity index, residential segregation, job segregation, crime rate, air pollution, and urbanity) were not included. Third, we only compared non-Hispanic Black and non-Hispanic White youth. There is a need for comparison of other racial and ethnic groups such as Asian Americans, Native Americans, Hispanics, and immigrants. Despite these limitations, an advantage of this study was a large sample size. Most previous studies have used a significantly smaller sample size. For example, the studies by Javanbakht et al., have included 52 youth (Evans et al., 2016; Javanbakht et al., 2016; Javanbakht et al., 2015). Another strength of this study was to include neighborhood SES. Most previous studies have studied family-level SES.

5. Conclusions

In summary, low neighborhood SES correlates with a higher amygdala response to negative face in a large national sample of American youth. This result provides additional evidence that SES impacts youth brain development and emotion regulation. As neighborhood SES affects brain activity, policy solutions to real equality demands addressing health inequalities at all SES levels. Given that non-Hispanic Black and non-Hispanic White youth may show different patterns of association between neighborhood SES and brain development, more research is needed on nuances and complexities of the associations of race, social environment, stress, family SES, neighborhood SES, and youth brain development.

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