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Parents' Perceived Neighborhood Safety and Children's Cognitive Performance: Complexities by Race, Ethnicity, and Cognitive Domain

Shervin Assari [1,2,*], Shanika Boyce [3], Ritesh Mistry [4], Alvin Thomas [5], Harvey L. Nicholson Jr. [6], Ryon J. Cobb [7], Adolfo G. Cuevas [8], Daniel B. Lee [9], Mohsen Bazargan [1,10], Cleopatra H. Caldwell [4,11], Tommy J. Curry [12] and Marc A. Zimmerman [4,13]

1 Department of Family Medicine, Charles R Drew University of Medicine and Science, Los Angeles, CA 90059, USA; Mohsenbazargan@cdrewu.edu
2 Department of Urban Public Health, Charles R Drew University of Medicine and Science, Los Angeles, CA 90059, USA
3 Department of Pediatrics, Charles R Drew University of Medicine and Science, Los Angeles, CA 90059, USA; shanikaboyce@cdrewu.edu
4 Department of Health Behavior and Health Education, University of Michigan, Ann Arbor, MI 48109-2029, USA; riteshm@umich.edu (R.M.); cleoc@umich.edu (C.H.C.); marcz@umich.edu (M.A.Z.)
5 Department of Human Development and Family Studies, University of Wisconsin, Madison, WI 53706, USA; athomas42@wisc.edu
6 Sociology and Criminology, Law & Society, University of Florida, Gainesville, FL 32611-7330, USA; hnicholson@ufl.edu
7 Department of Sociology, University of Georgia, Athens, GA 30602, USA; ryoncobb@gmail.com
8 Department of Community Health, Tufts University, Medford, MA 02155, USA; adolfo.cuevas@tufts.edu
9 Amherst H. Wilder Foundation, Wilder Research, Saint Paul, MN 55104, USA; leedanb@umich.edu
10 Department of Family Medicine, University of California, Los Angeles, CA 90095, USA
11 Center for Research on Ethnicity, Culture and Health, School of Public Health, University of Michigan, Ann Arbor, MI 48109-2029, USA
12 Department of Philosophy, University of Edinburgh, Edinburgh EH8 9JS, UK; t.j.curry@ed.ac.uk
13 Prevention Research Center, School of Public Health, University of Michigan, Ann Arbor, MI 48109-2029, USA
* Correspondence: assari@umich.edu; Tel.: +734-232-0445; Fax: +734-615-8739

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Abstract: *Background: Aim:* To examine racial/ethnic variations in the effect of parents' subjective neighborhood safety on children's cognitive performance. *Methods:* This cross-sectional study included 10,027 children from the Adolescent Brain Cognitive Development (ABCD) study. The exposure variable was parents' subjective neighborhood safety. The outcomes were three domains of children's cognitive performance: general cognitive performance, executive functioning, and learning/memory. We used mixed-effects regression models for data analysis. *Results:* Overall, parents' subjective neighborhood safety was positively associated with children's executive functioning, but not general cognitive performance or learning/memory. Higher parents' subjective neighborhood safety had a more positive influence on the executive functioning of non-Hispanic White than Asian American children. Higher parents' subjective neighborhood safety was associated with higher general cognitive performance and learning/memory for non-White children relative to non-Hispanic White children. *Conclusion:* The race/ethnicity of children moderates the association between neighborhood safety and cognitive performance. This becomes more complicated, as the patterns seem to differ across ethnicity and cognitive domains. It is unknown whether the observed racial/ethnic variations in the effect of neighborhood safety on cognitive performance are neighborhood characteristics such as residential segregation. Addressing neighborhood inequalities is needed if we wish to reduce racial/ethnic inequities in the cognitive development of children.

Keywords: race; ethnicity; population groups; children; cognition; cognitive performance

1. Introduction

There are significant racial/ethnic disparities in the cognitive performance of American children [1–3]. For example, non-Hispanic White children perform better on tests of cognitive functioning than non-Hispanic Black and Hispanic children [4]. Hispanic and Black children are at a higher risk of low academic achievement and school dropout than non-Hispanic White children [5]. Racial/ethnic disparities in cognitive functioning are likely attributable to the social and economic consequences of structural racism, social stratification, and segregation [6]. As childhood cognitive performance is the primary predictor of future educational and economic success during adulthood, there is an emerging interest to identify the complex interactions between various social factors that drive racial/ethnic disparities in childhood cognitive function [7–10]. Identifying such social factors is necessary to design effective interventions to eliminate racial/ethnic disparities in children's cognitive development and associated inequalities later in life [7–10].

Neighborhood conditions such as neighborhood safety [11–15] are a social determinant of children's cognitive development, independent of socioeconomic status (SES) [16–19]. Compared to non-Hispanic Whites, racial/ethnic minorities are more likely to reside in unsafe neighborhoods unconducive for proper brain development [20]. Such unequitable neighborhood conditions are the result of America's legacy of segregation, both de jure and de facto, which systematically denied racial/ethnic minorities the opportunities and resources needed to live in safe, resourced, and high-quality neighborhoods [21]. Children who reside in safer neighborhoods, for instance, show higher levels of cognitive outcomes [16–19]. As such, neighborhood safety may be an important mechanism that informs inequalities in children's cognitive, behavioral, developmental, and health outcomes across racial and ethnic groups [22–24]. Unsafe neighborhoods have fewer resources to engage in stimulating learning, constructive socialization, and supportive parenting, which have lasting impacts on child development [25–27]. Moreover, children who live in safer neighborhoods attend high-quality schools and have access to enriching environments that promote cognitive functioning [28–31]. In contrast, unsafe neighborhood and school environments can undermine children's outcomes [32–36] including cognitive development [37–41].

Although various environmental factors influence children's cognitive development, most previous research has focused on subjective and objective aspects of SES at the family level [42]. There are neighborhood characteristics, such as neighborhood safety, however, that also contribute to racial/ethnic inequalities in child development [16–19]. Some studies suggest that racial groups may be differently impacted by neighborhood safety [43]. For example, neighborhood safety may better predict Whites' than Blacks' life expectancy over a 25-year follow up [43].

Measures of family SES such as parental education, household income, and family wealth have been consistently associated with children's developmental outcomes such as cognitive performance [44]. The magnitude of these effects, however, differ across racial and ethnic groups [45]. Nevertheless, family SES reflects a partial aspect of children's lives. To have a comprehensive understanding of children's exposure to adversities, more research is needed on how contextual factors such as neighborhood safety influence different racial and ethnic groups. Subjective measures of neighborhood safety are a proxy of how much environmental stress families and children perceive on a daily basis. Chronic exposure to adversity such as living in unsafe neighborhoods may blunt child cognitive development. Thus, while objective measures are essential for understanding the family environment [46–48], subjective neighborhood measures are also essential to understanding child development [43].

Parents' subjective neighborhood safety is associated with health and developmental outcomes of the child [49–51], independent of objective measures such as SES [42,46–48,52,53]. For racially and ethnically marginalized populations, having fewer SES resources means economic distress, housing insecurity, and food scarcity, which may reduce parents' subjective neighborhood safety and increase baseline stress and fear of violence [54]. Recent

research suggests that diverse groups based on race, ethnicity, and gender are differently sensitive to negative effects of low family SES [45] and subjective neighborhood safety [55]. Thus, there is a need to extend this literature to decompose the effects of objective and subjective measures of SES and neighborhood safety [56–58]. We also need more studies that test whether racial and ethnic groups differ in their sensitivity to objective and subjective evaluation of environmental safety [59].

While cognitive function is a multi-dimensional construct that reflects general cognitive functioning, executive functioning, and learning and memory, we know less about the relevance of SES, subjective neighborhood safety, and marginalization-related diminished returns (MDRs) to each cognitive domain. Very few studies have disaggregated cognitive functioning, and most of the existing knowledge on SES and cognitive function is not nuanced and granular enough at the level of cognitive domains.

Aims

To extend the existing knowledge on racial/ethnic variation in social determinants of children's cognitive outcomes in the US, we applied the MDRs theory [55], defined as weaker effects of social and economic resources on outcomes for racially and ethnically marginalized than non-Hispanic White children, to assess racial and ethnic variations in the association between parents' subjective neighborhood safety (as a social resource) and children's cognitive function, in a large national dataset. We hypothesized positive associations between parents' subjective neighborhood safety and children's cognitive function [35,60,61]. However, we expected weaker associations for non-White compared to non-Hispanic White children.

2. Methods

2.1. Design

This study is a secondary analysis of wave 1 data (2016–2018) of the Adolescent Brain Cognitive Development (ABCD) study [62–66], a landmark children's brain development study in the United States. More nuanced data on the details of the ABCD study are available elsewhere [62,67].

2.2. Sampling

In the ABCD study, participants were limited to 9–10-year-old children who were recruited from multiple cities across several states in the US. In total, 21 ABCD centers were involved in the recruitment of the children. The main recruitment strategy was through the school systems [68]. The current analysis's eligibility criteria were: having valid data on race/ethnicity, demographic factors, neighborhood safety, and cognitive performance (n = 10,027).

2.3. Study Variables

2.3.1. Demographic and Socioeconomic Confounds

Age, sex, parental education, household income, and parental marital status were the confounders. Parents were asked to report the age of their children. Child age was a continuous variable, measured in months. Child sex was a dichotomous variable with 1 for males and 0 for females. Household income was a three-level categorical variable: less than 50 K, 50–100 K, and 100 K+, as reported by the parent. Parental marital status was equal to 1 for married and equal to 0 for unmarried. Parental education was a categorical variable: less than high school, high school completed, some college, Bachelor's degree, and postgraduate studies.

2.3.2. Primary Outcome

Cognitive performance. The ABCD study used multiple neurocognitive measures [66] to define three aspects of cognitive function: (1) general cognitive performance, (2) executive function, and (3) learning and memory. In all of these domains, the variable is treated as

a continuous measure, and a higher score indicated higher cognitive performance. For a full description of how these domains of cognitions are generated, please see the paper by Thompson et al. [69].

2.3.3. Independent Variable

Neighborhood safety. Parents answered questions about their sense of neighborhood safety. The items were developed by Diez Roux and colleagues [70] and included: "I feel safe walking in my neighborhood, day or night", "violence is not a problem in my neighborhood", and "my neighborhood is safe from crime". Responses were 1 = Strongly Disagree; 2 = Disagree; 3 = Neutral (neither agree nor disagree)/Neutral; 4 = Agree; 5 = Strongly Agree. We calculated the mean of the three items [70]. This variable was treated as a continuous variable [70]. A higher score was higher neighborhood safety.

2.3.4. Moderator

Race. Race/ethnicity, a sociological, rather than a biological factor, was self-identified by the parents. Race/ethnicity was a categorical variable non-Hispanic White, non-Hispanic Black, Hispanic, Asian, and other race/ethnicity. Other-race included racial minority youths who are not White, Hispanic, Asian, or Black.

2.4. Data Analysis

We used the Data Analysis and Exploration Portal (DEAP) for data analysis. DEAP is specifically designed for analysis of ABCD data. Mean, standard deviation (SD), frequency, and relative frequency were reported. We performed an analysis of variance (ANOVA) and Chi-square test to test group differences in the association between race/ethnicity and our study variables. We also ruled out multi-collinearity between our study variables. Using kurtosis and skewness measures, outcomes showed normal distribution. Error terms also showed near to normal distribution. For our multivariable models, we applied mixed-effects linear regression models (Appendix A). All of our models were performed on the study sample. Our mixed-effects models adjusted for the nested nature of the data in the families. We used the propensity score to generate results that are representative of the US. As such, our results were weighted. Our *Model 1* did not have any interaction terms. Our *Model 2*, however, included interaction terms between race/ethnicity and parents' subjective neighborhood safety. Separate models were performed for each cognitive domain: (1) general cognitive performance, (2) executive function, and (3) learning and memory. Thus, we performed a total of six regression models. From our models, we reported b, SE, and p values, with p less than 0.05 considered statistically significant.

3. Results

3.1. Descriptives

Table 1 shows that 10,027 9–10-year-old children were included in the current analysis. Of this number, 5494 (weighted percentage = 55.2%) were non-Hispanic White, followed by 1911 who were Hispanic (weighted percentage = 22.5%), 1371 who were non-Hispanic Black (weighted percentage = 12.3%), and 1046 who were Other race/ethnicity (weighted 6.6%). Only 205 children were Asian (weighted percentage = 3.5%).

Table 2 presents the fit of mixed-effects regression models in the overall sample. The inclusion of the interaction term of race/ethnicity by parents' subjective neighborhood safety (Models 2) helped explain a larger variance of the outcomes compared to Model 1, which did not include any interaction terms.

Table 1. Descriptive data overall and by race/ethnicity.

Level	Overall		Non-Hispanic White		Non-Hispanic Black		Hispanic		Asian		Other		*p*	
		Weighted		Weighted		Weighted		Weighted		Weighted		Weighted		Weighted
n	**10,027**		**5494**		**1371**		**1911**		**205**		**1046**			
	Mean (SD)	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**		
Age (Month)	118.93 (7.47)	119.20 (7.48)	119.11 (7.51)	119.39 (7.50)	118.97 (7.21)	119.31 (7.21)	118.46 (7.54)	118.66 (7.53)	119.44 (7.81)	119.74 (7.84)	118.72 (7.40)	118.92 (7.43)	0.014	0.011
Neighborhood Safety	3.92 (0.95)	3.89 (0.97)	4.15 (0.78)	4.11 (0.81)	3.32 (1.12)	3.26 (1.13)	3.73 (1.02)	3.72 (1.04)	4.10 (0.83)	4.13 (0.80)	3.84 (0.97)	3.72 (1.03)	<0.001	<0.001
General Cognitive Ability	0.03 (0.77)	−0.02 (0.77)	0.24 (0.69)	0.19 (0.70)	−0.55 (0.71)	−0.60 (0.70)	−0.20 (0.73)	−0.25 (0.73)	0.48 (0.73)	0.43 (0.72)	0.05 (0.77)	−0.13 (0.78)	<0.001	<0.001
Executive Function	0.01 (0.77)	−0.01 (0.77)	0.07 (0.72)	0.05 (0.73)	−0.28 (0.85)	−0.29 (0.84)	−0.01 (0.76)	−0.03 (0.77)	0.40 (0.74)	0.37 (0.74)	0.04 (0.79)	−0.04 (0.79)	<0.001	<0.001
Learning and Memory	0.02 (0.70)	−0.01 (0.70)	0.16 (0.67)	0.12 (0.68)	−0.38 (0.64)	−0.39 (0.64)	−0.09 (0.68)	−0.12 (0.68)	0.12 (0.65)	0.12 (0.65)	0.01 (0.70)	−0.06 (0.71)	<0.001	<0.001
	N (%)	%	N (%)	%	N (%)	%	N (%)	%	N (%)	%	N (%)	%		
Sex														
Female	4821 (48.1)	(49.0)	2595 (47.2)	(48.1)	691 (50.4)	(51.8)	917 (48.0)	(48.7)	106 (51.7)	(52.7)	512 (48.9)	(50.6)	0.204	0.209
Male	5206 (51.9)	(51.0)	2899 (52.8)	(51.9)	680 (49.6)	(48.2)	994 (52.0)	(51.3)	99 (48.3)	(47.3)	534 (51.1)	(49.4)		
Parental Education														
<HS Diploma	384 (3.8)	(4.8)	25 (0.5)	(0.9)	105 (7.7)	(9.1)	226 (11.8)	(12.7)	3 (1.5)	(2.1)	25 (2.4)	(4.3)	<0.001	<0.001
HS Diploma/GED	838 (8.4)	(10.0)	165 (3.0)	(4.3)	311 (22.7)	(25.0)	292 (15.3)	(16.7)	1 (0.5)	(0.7)	69 (6.6)	(11.4)		
Some College	2557 (25.5)	(29.7)	1021 (18.6)	(24.2)	550 (40.1)	(42.1)	655 (34.3)	(37.1)	13 (6.3)	(7.4)	318 (30.4)	(38.6)		
Bachelor	2654 (26.5)	(25.0)	1740 (31.7)	(30.6)	204 (14.9)	(13.0)	365 (19.1)	(17.8)	60 (29.3)	(29.5)	285 (27.2)	(23.3)		
Post Graduate Degree	3594 (35.8)	(30.5)	2543 (46.3)	(40.0)	201 (14.7)	(10.8)	373 (19.5)	(15.6)	128 (62.4)	(60.2)	349 (33.4)	(22.4)		
Married Family														
No	3040 (30.3)	(37.2)	933 (17.0)	(24.7)	960 (70.0)	(76.8)	769 (40.2)	(47.4)	24 (11.7)	(13.6)	354 (33.8)	(44.8)	<0.001	<0.001
Yes	6987 (69.7)	(62.8)	4561 (83.0)	(75.3)	411 (30.0)	(23.2)	1142 (59.8)	(52.6)	181 (88.3)	(86.4)	692 (66.2)	(55.2)		
Household income														
<50 K	2898 (28.9)	(38.2)	688 (12.5)	(21.4)	911 (66.4)	(75.3)	932 (48.8)	(59.5)	25 (12.2)	(16.6)	342 (32.7)	(48.1)	<0.001	<0.001
≥50 K and <100 K	2852 (28.4)	(31.3)	1669 (30.4)	(35.8)	301 (22.0)	(18.8)	572 (29.9)	(28.1)	48 (23.4)	(30.3)	262 (25.0)	(27.8)		
≥100 K	4277 (42.7)	(30.5)	3137 (57.1)	(42.8)	159 (11.6)	(5.9)	407 (21.3)	(12.3)	132 (64.4)	(53.1)	442 (42.3)	(24.2)		

Table 2. Model fit.

	General Cognitive Function		Executive Function		Learning and Memory	
	Model 1 Main Effects	**Model 2 M1 + Interactions**	**Model 1 Main Effects**	**Model 2 M1 + Interactions**	**Model 1 Main Effects**	**Model 2 M1 + Interactions**
N	10,027	10,027	10,027	10,027	10,027	10,027
R-squared	0.29873	0.29954	0.09788	0.09859	0.11803	0.11876
ΔR-squared	5×10^{-5} (0%)	0.03602 (3.6%)	0.00042 (0.04%)	0.01538 (1.54%)	1×10^{-5} (0%)	0.02102 (2.1%)

M1: Model 1.

3.2. Multivariate Analysis without and with Interactions

3.2.1. General Cognitive Performance

Table 3 shows the results of two linear regression models for our first outcome in the overall (pooled) sample, in the absence and presence of the interaction terms. Model 1 (Main Effect Model) showed no effect of high parents' subjective neighborhood safety on general cognitive performance. Model 2 (Interaction Model) showed a statistically significant interaction effect between race/ethnicity and parents' subjective neighborhood safety on general cognitive performance, suggesting that the effect of high parents' subjective neighborhood safety on general cognitive performance is larger for the Other race/ethnicity group compared with non-Hispanic White children (Table 3).

Table 3. Summary of mixed-effects regressions on the association between parent's neighborhood safety and children's cognitive performance (general cognition) overall and by race/ethnicity.

	B	SE	*p*	Sig	B	SE	*p*	Sig
	Model 1				**Model 2**			
Neighborhood safety	−0.00536	0.00754	0.47728		−0.02563	0.01144	0.0250715	*
Race ethnicity (Black)	−0.44009	0.02391	<0.001	***	−0.52985	0.07516	<0.001	***
Race ethnicity (Hispanic)	−0.16041	0.01937	<0.001	***	−0.26985	0.07232	0.0001917	***
Race ethnicity (Asian)	0.12400	0.04341	0.0042891	**	−0.00222	0.21712	0.9918262	
Race ethnicity (Other)	−0.09983	0.02547	<0.001	***	−0.42761	0.10071	<0.001	***
Parental education (HS Diploma/GED)	0.23079	0.04070	<0.001	***	0.22886	0.04070	<0.001	***
Parental education (Some College)	0.41625	0.03699	<0.001	***	0.41515	0.03702	<0.001	***
Parental education (Bachelor)	0.58828	0.03949	<0.001	***	0.58631	0.03953	<0.001	***
Parental education (Post Graduate Degree)	0.76372	0.04015	<0.001	***	0.76006	0.04020	<0.001	***
Household income (≥100 K)	0.23102	0.02386	<0.001	***	0.23030	0.02386	<0.001	***
Household income (≥50 K and <100 K)	0.15282	0.02085	<0.001	***	0.15024	0.02087	<0.001	***
Married Family	0.04128	0.01775	0.020067	*	0.04012	0.01776	0.0239079	*
Age (Month)	0.02517	0.00076	<0.001	***	0.02514	0.00076	<0.001	***
Sex (Male)	0.05630	0.01220	<0.001	***	0.05653	0.01221	<0.001	***
Race ethnicity (Black) × Neighborhood safety	-	-	-	-	0.02140	0.01992	0.2829265	
Race ethnicity (Hispanic) × Neighborhood safety	-	-	-	-	0.02678	0.01789	0.1344755	
Race ethnicity (Asian) × Neighborhood safety	-	-	-	-	0.03097	0.05139	0.5467362	
Race ethnicity (Other) × Neighborhood safety	-	-	-	-	0.08468	0.02526	0.000806	***

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Figure 2a shows no main effect of parents' subjective neighborhood safety on general cognitive performance. Figure 2b shows that the effect of parents' subjective neighborhood safety on general cognitive performance was larger for children in the Other race/ethnic category than non-Hispanic White children.

3.2.2. Executive Functioning

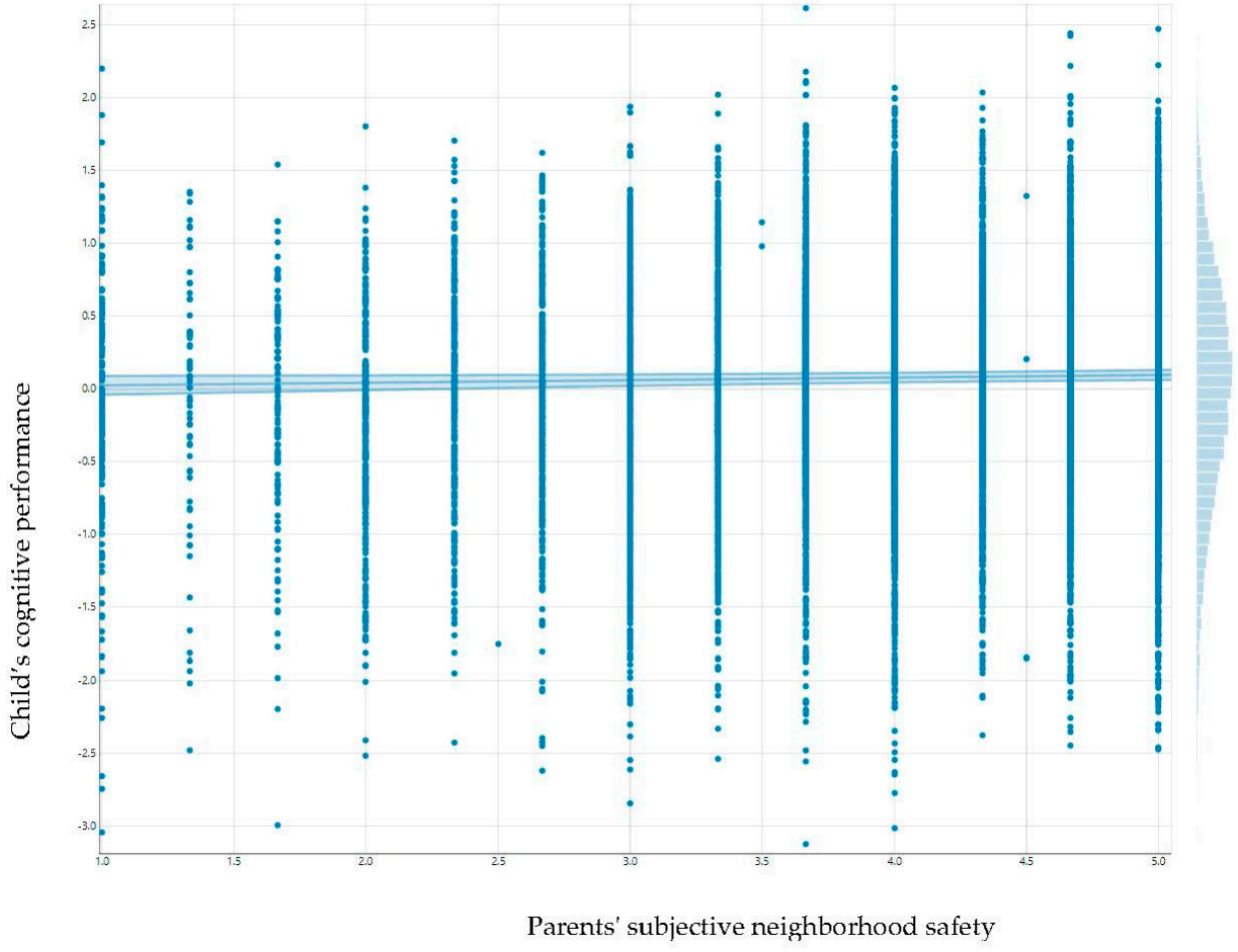
In Table 4, there are two linear regression models that report the association of interest in the overall (pooled) sample in the absence and presence of the interaction terms. Model 1 (Main Effect Model) showed a boosting effect of high parents' subjective neighborhood safety on executive functioning. Model 2 (Interaction Model) showed a statistically significant interaction between the effects of race/ethnicity and parents' subjective neighborhood safety on executive functioning, suggesting that the boosting effect of high parents' subjective neighborhood safety on executive functioning is weaker in Asian than non-Hispanic White children (Table 4).

In Figure 1a, there was an overall and positive association between parents' subjective neighborhood safety and executive functioning. As shown by Figure 1b, the boosting effect of high parents' subjective neighborhood safety on executive functioning was weaker in Asian than non-Hispanic White children.

Table 4. Summary of mixed-effects regressions on the association between parent's neighborhood safety and children's cognitive performance (executive functioning) overall and by race/ethnicity.

	B	SE	*p*	Sig	B	SE	*p*	Sig
	Model 1				Model 2			
Neighborhood safety	0.01774	0.00863	0.0398902	*	0.01715	0.01311	0.1908813	
Race ethnicity (Black)	−0.23662	0.02729	<0.001	***	−0.25957	0.08593	0.0025272	**
Race ethnicity (Hispanic)	0.02423	0.02203	0.271353		0.06024	0.08296	0.467719	
Race ethnicity (Asian)	0.29020	0.04903	<0.001	***	0.76695	0.24729	0.0019313	**
Race ethnicity (Other)	0.00446	0.02950	0.8797325		−0.17563	0.11644	0.1314854	
Parental education (HS Diploma/GED)	−0.06608	0.04603	0.1511709		−0.06552	0.04606	0.1548897	
Parental education (Some College)	0.00054	0.04181	0.9897057		0.00219	0.04187	0.9582504	
Parental education (Bachelor)	0.05473	0.04467	0.2205843		0.05494	0.04473	0.2194424	
Parental education (Post Graduate Degree)	0.07775	0.04544	0.0870891	#	0.07855	0.04551	0.0843971	#
Household income (≥100 K)	0.12898	0.02713	<0.001	***	0.12763	0.02714	<0.001	***
Household income (≥50 K and <100 K)	0.09244	0.02364	<0.001	***	0.09191	0.02367	0.0001036	***
Married Family	−0.00691	0.02012	0.731316		−0.00834	0.02014	0.6786625	
Age (Month)	0.02290	0.00090	<0.001	***	0.02291	0.00090	<0.001	***
Sex (Male)	−0.06641	0.01425	<0.001	***	−0.06553	0.01425	<0.001	***
Race ethnicity (Black) × Neighborhood safety	-	-	-	-	0.00635	0.02280	0.7806586	
Race ethnicity (Hispanic) × Neighborhood safety	-	-	-	-	−0.01003	0.02054	0.6253109	
Race ethnicity (Asian) × Neighborhood safety	-	-	-	-	−0.11508	0.05863	0.049699	*
Race ethnicity (Other) × Neighborhood safety	-	-	-	-	0.04749	0.02927	0.1046771	

# $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.



(**a**) overall association

Figure 1. *Cont.*

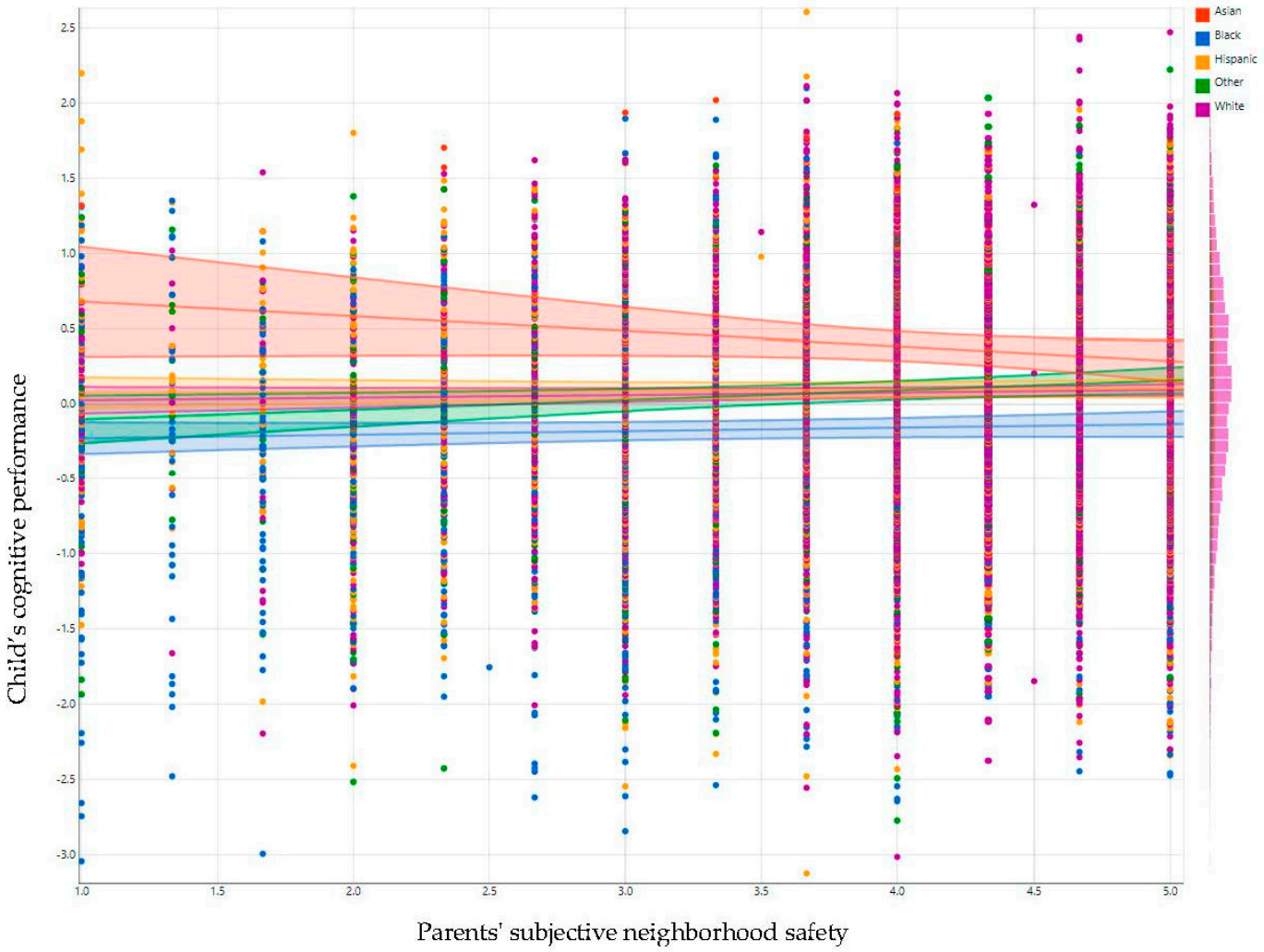


Figure 1. Association between parents' subjective neighborhood safety and children's executive functioning overall and by race/ethnicity.

3.2.3. Learning and Memory

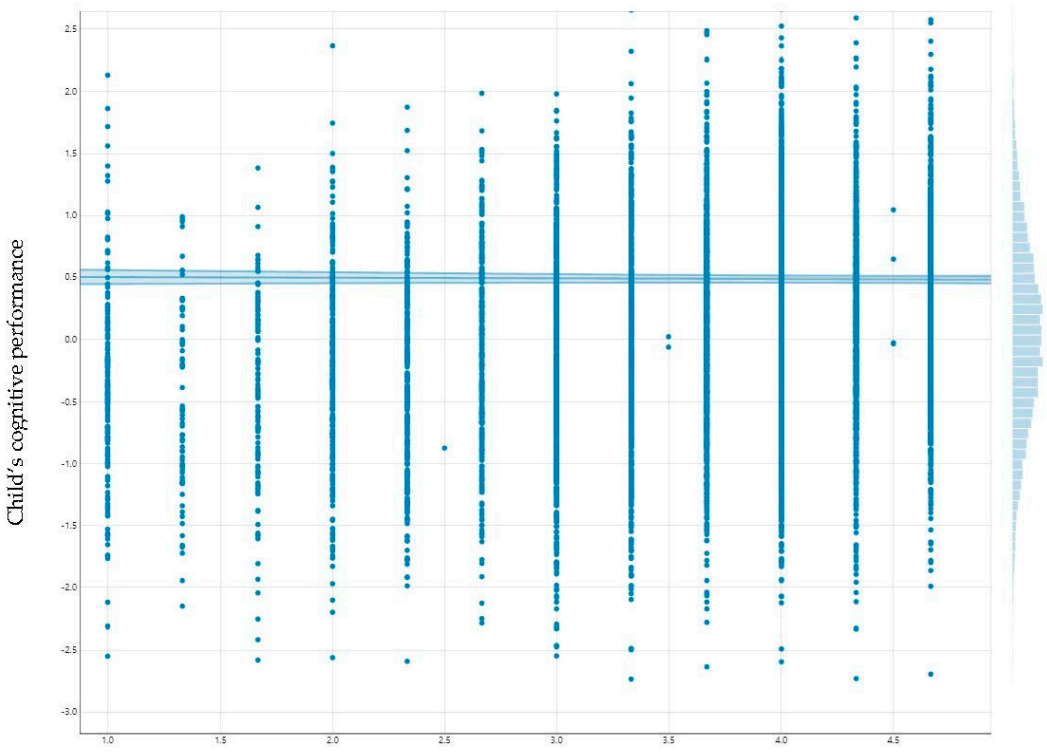
In Table 5, there are two linear regression models that report the association of interest for our third cognitive outcome in the overall (pooled) sample, in the absence and presence of the interaction terms. Model 1 (Main Effect Model) did not show any effect of high parents' subjective neighborhood safety on learning and memory score. Model 2 (Interaction Model) showed a statistically significant interaction between the effects of race/ethnicity and parents' subjective neighborhood safety on learning and memory score, suggesting that the effect of high parents' subjective neighborhood safety on learning and memory score is larger for children from the Other race/ethnicity group than non-Hispanic White children (Table 5).

In Figure 3a, there was no overall association between parents' subjective neighborhood safety and learning and memory score. As shown by Figure 3b, the effect of high parents' subjective neighborhood safety on learning and memory score was larger for the Other race/ethnic group than non-Hispanic White children.

Table 5. Summary of mixed-effects regressions on the association between parent's neighborhood safety and children's cognitive performance (learning and memory) overall and by race/ethnicity.

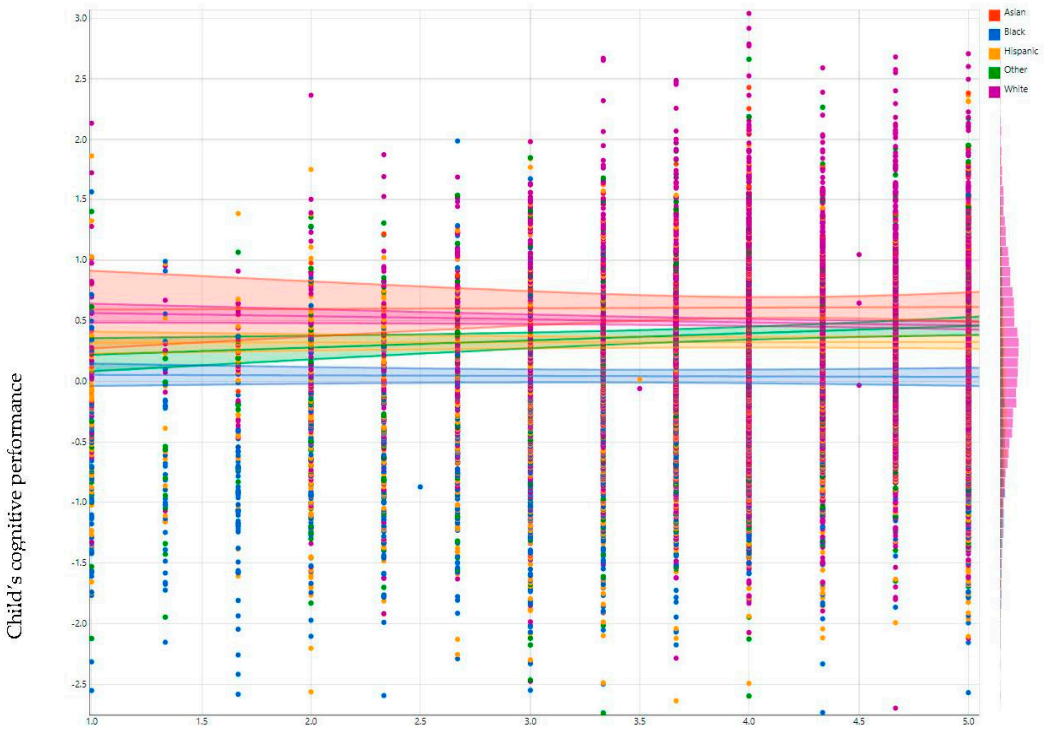
	B	SE	*t*	*p*	Sig	B	SE	*t*	*p*	Sig
	Model 1					**Model 2**				
Neighborhood safety	−0.00240	0.00767	−0.31	0.7542138		−0.00501	0.01164	−0.43	0.6672876	
Race ethnicity (Black)	−0.34615	0.02434	−14.22	<0.001	***	−0.36835	0.07651	−4.81	<0.001	***
Race ethnicity (Hispanic)	−0.10735	0.01971	−5.45	<0.001	***	−0.08510	0.07363	−1.16	0.2477693	
Race ethnicity (Asian)	−0.08212	0.04416	−1.86	0.0629715	#	0.27601	0.22099	1.25	0.2117149	
Race ethnicity (Other)	−0.08833	0.02592	−3.41	0.0006589	***	−0.28939	0.10254	−2.82	0.0047776	**
Parental education (HS Diploma/GED)	0.05842	0.04140	1.41	0.1582436		0.05877	0.04142	1.42	0.1559774	
Parental education (Some College)	0.12629	0.03763	3.36	0.000793	***	0.12785	0.03768	3.39	0.0006932	***
Parental education (Bachelor)	0.22456	0.04018	5.59	<0.001	***	0.22480	0.04023	5.59	<0.001	***
Parental education (Post Graduate Degree)	0.34131	0.04085	8.36	<0.001	***	0.34171	0.04091	8.35	<0.001	***
Household income (≥100 K)	0.07257	0.02428	2.99	0.0028053	**	0.07119	0.02429	2.93	0.0033801	**
Household income (≥50 K and <100 K)	0.04901	0.02121	2.31	0.0208966	*	0.04825	0.02124	2.27	0.0231151	*
Married Family	0.08475	0.01806	4.69	<0.001	***	0.08330	0.01807	4.61	<0.001	***
Age (Month)	0.01108	0.00077	14.33	<0.001	***	0.01108	0.00077	14.33	<0.001	***
Sex (Male)	−0.11215	0.01243	−9.03	<0.001	***	−0.11146	0.01243	−8.97	<0.001	***
Race ethnicity (Black) × Neighborhood safety	-	-	-	-	-	0.00555	0.02028	0.27	0.784387	
Race ethnicity (Hispanic) × Neighborhood safety	-	-	-	-	-	−0.00658	0.01821	−0.36	0.7181036	
Race ethnicity (Asian) × Neighborhood safety	-	-	-	-	-	−0.08618	0.05231	−1.65	0.0995021	#
Race ethnicity (Other) × Neighborhood safety	-	-	-	-	-	0.05275	0.02572	2.05	0.0403252	*

# $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.



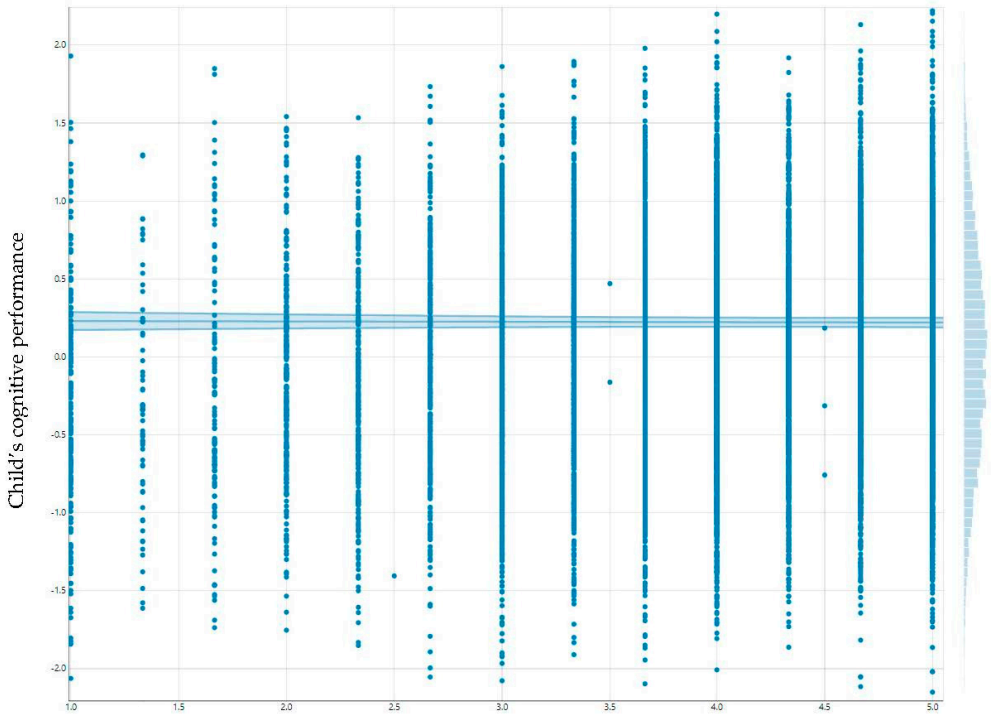
(**a**) overall association

Figure 2. *Cont.*



(**b**) association by race/ethnicity

Figure 2. Association between parents' subjective neighborhood safety and children's general cognitive function overall and by race/ethnicity.



(**a**) overall association

Figure 3. *Cont.*

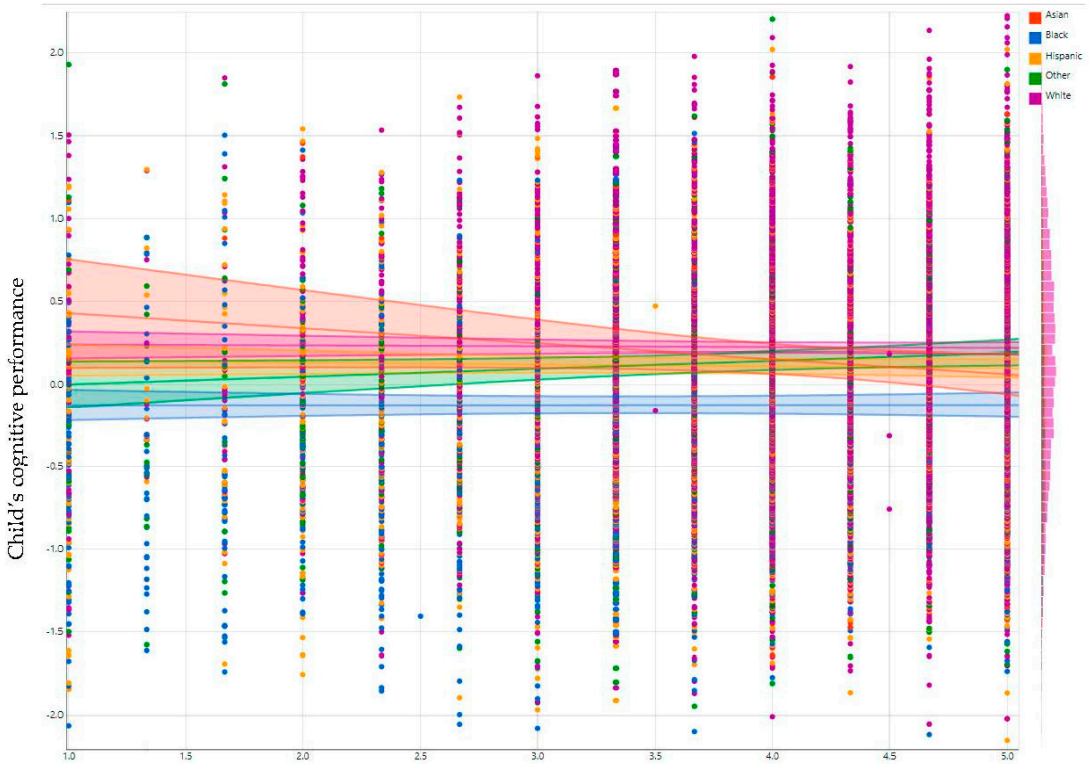


Figure 3. Association between parents' subjective neighborhood safety and children's learning/memory overall and by race/ethnicity.

4. Discussion

Overall, the associations between parents' subjective neighborhood safety and children's cognitive performance were not invariant across children's race/ethnic groups and cognitive domains. Compared to non-Hispanic Whites, Asian American children showed a weaker effect of parents' subjective neighborhood safety on executive function, while "Other" race/ethnic children showed a larger effect of parents' subjective neighborhood safety on general cognitive performance and learning and memory. Our observation in Asian families was in line with our hypothesis, and our observation in "Other" race/ethnic children was against our hypothesis. In line with MDRs, we expected weaker effects of neighborhood safety on cognitive function of racial and ethnic minorities than non-Hispanic Whites.

In this study, there was a weaker effect for executive function for Asian American compared to Non-Hispanic White children. There may be a ceiling effect of neighborhood safety or cognitive function for Asian children. Asian Americans may also experience MDRs due to their marginalized status in the U.S. Similar to other non-White groups, Asians may experience diminished returns of neighborhood safety in relation to their child cognitive development. In one study, parental education showed a weaker effect on Asian American children's than White children's math scores [71]. In another study, while income reduced tobacco use for non-Hispanic Whites, high SES increased the risk of use for Asian Americans [72]. Thus, while other explanations should be kept in mind, MDRs have been previously observed for various racial/ethnic minority groups. Nevertheless, our finding stands in opposition to previous arguments of Asian American parity with non-Hispanic Whites (e.g., model minority stereotype) [73–75] by showing that Asians suffer disadvantages as a racialized minority group.

We observed a stronger effect of neighborhood safety on children's cognitive function of the Other-racial group. It is also unclear why we did not see MDRs for Hispanics. Future research should attempt to identify those who identify as "other" to help illuminate avenues to understanding the complex interrelationship between race, neighborhood safety, and cognitive functioning. This line of work needs more research.

Two competing and complementary models have been used to study the simultaneous and joint effects of race and parents' subjective neighborhood safety on children's outcomes. The first, which has traditionally dominated the field, attributes racial and ethnic gaps in outcomes to the scarcity of economic resources and high prevalence of risk factors in the lives of racial and ethnic minorities [76–79]. Some of the research engaged in this line of work suggests that economic status may partially mediate the effects of race on health outcomes [80]. These studies advocate for enhancing racial and ethnic minority groups' economic status as the main strategy to close the racial differences in children's outcomes [81,82]. The second, the Marginalization-related Diminished Returns (MDRs) [55], refer to weaker effects of economic resources on tangible outcomes of racial and ethnic minorities than non-Hispanic Whites. This model has received overwhelming support, suggesting that various indicators such as subjective neighborhood safety [59] and SES indicators [83] generate fewer desired outcomes for racial and ethnic minorities than non-Hispanic Whites. Our second findings confirm the MDRs of subjective neighborhood safety: neighborhood safety may not generate identical outcomes for diverse groups of children.

Race and ethnic variation in the association between parents' subjective neighborhood safety and children's cognitive performance of diverse racial and ethnic children are in line with the results of previous work on MDRs of SES and neighborhood safety for non-Hispanic Black and Hispanic compared to non-Hispanic White children [84]. Racial and ethnic variations in the returns of resources are repeatedly established at the individual and family levels. These racial and ethnic variations in returns of SES and neighborhood conditions are robust, as they are found to hold across socioeconomic resources (e.g., parental education, income, family structure), developmental phases, outcomes, and sources of marginalization [55]. Racial and ethnic groups differ in the effects of various SES indicators such as income [85] and education [84] on a wide range of cognitive, emotional, behavioral, and health outcomes. Most of the past research, however, has established a difference between the returns of SES between non-Hispanic Whites and non-Hispanic Blacks [85]. While these MDRs are not specific to non-Hispanic Blacks [71], the existing knowledge on other ethnic groups is limited.

In summary, this study suggests that the perception of neighborhood safety is a resource that has important implications for child development, but this resource is inequitably distributed by race/ethnicity (partly due to SES disparities), and that there are diminished returns of this resource, i.e., lower effect of perceived neighborhood safety on cognition in marginalized groups.

A wide range of societal mechanisms may explain how SES and environmental resources or assets may enhance outcomes in some but not other racial/ethnic groups. Racial and ethnic minority communities, families, and individuals face a wide range of stressors that are not due to economic resources but social stratification, racism, and discrimination. These non-economic adversities are environmental, structural, and are related to race, racialization, and marginalization. These adversities can be seen across all economic levels [86]. Economic upward social mobility's health returns may be limited when the likelihood of upward social mobility is difficult and unlikely [87]. Increased exposure to stress is believed to reduce children's ability to benefit from their available SES resources such as parental education and income. For racial and ethnic minority families, an increase in economic status may increase experience [88] and vulnerability [59] to discrimination. This might be because non-White families who have economic resources are more likely to be surrounded by non-Hispanic White families, which increases their exposure to discriminatory events [88]. High levels of racial and ethnic discrimination,

general stress, and fear of neighborhood violence may operate as risk factors for many outcomes, including but not limited to poor cognitive performance. Living in such stressful conditions may reduce the returns of SES and other available resources on children's outcomes [59].

Residential and school segregation may also explain the observed differences across racial and ethnic groups in neighborhood perception of safety. As a result of residential segregation, racial and ethnic minority children, across all economic levels, are often relegated to low-quality housing and schools and reside in unsafe, stressful neighborhoods [89]. This results in the lower-than-expected effects of resources and environmental factors on children's education and schooling for racial and ethnic minority groups. For example, it has been shown that while high SES non-Hispanic White children attend resourced schools that are located in suburban areas with available financial resources and well-prepared teachers, high SES racial and ethnic minority children are more likely to go to schools that have lower levels of resources and less prepared teachers [29]. These disparities might be mitigated if residential and school segregation are eliminated.

Race/ethnic differences in cognitive performance reported here are not due to genetic differences but a longstanding legacy of institutional and structural discrimination [90]. There is a long history of racist narratives that pushed the idea that race is causally and biologically linked to cognitive capacities and general intelligence [91]. This paper breaks with such reductionist and racist assumptions by showing that what was historically taken to be biologically shaped is not due to race per se but various social, environmental, and economic consequences of unjust practices and racist public policies. We conceptualize race as a proxy of racialization, and we exclusively focused on the role of race as a social factor, which bounds the health returns of economic resources. The argument here is that in a race-aware society that has historically held racial and ethnic groups behind, family- and individual-level factors are not enough to secure desired outcomes. This is in part because even when they have high economic resources, families of color still report high levels of stress as they face various societal barriers [92]. Non-Hispanic White families with similar economic status, however, skip such stressors in their daily lives [59]. As evidenced by work in Critical Race Theory, our studies show that racism is a dynamic socio-political process that lessens the life chances and societal standing of racialized groups. These *racialized* groups then experience worse health outcomes including lower cognitive function and higher morbidity and mortality due to society's operational, political, and socio-economic norms [93]. While these conditions may affect biological and physiological factors, the racism of the society, not assumed differences across groups' biology, causes unequal outcomes.

Although neighborhood-level disadvantage imposes risks to families of color across SES levels, those are not the only risks contributing to poor health among racial and ethnic minority families. MDRs introduce another set of disadvantages that sustains above and beyond SES [55]. While the solution to low SES is to equalize access to resources, the solution to racial and ethnic variation in the returns of SES resources requires us to equalize the marginal returns from the same resources. The inequalities that are due to differential marginal returns may be resistant to our policies that aim to close the racial and ethnic gap in economic resources. Future research should decompose inequalities due to differential marginal returns of resources from those due to differential access to resources. Similarly, policymakers should be aware of MDR-related processes as a driver of racial and ethnic inequalities in child development. Racial and ethnic groups, to this end, may experience both limited resources and MDRs of available resources. A potential solution should make economic resources available to the communities of color and, at the same time, ensure that those resources can be utilized and are equally beneficial to individuals and families across racial/ethnic groups [55].

Scholars have recently studied the life experiences of middle-class racial and ethnic minority American families [55]. This line of research has shown that middle-class families of color experience class and SES in a different manner than middle-class non-Hispanic

White families. Previous research has shown that high SES may even operate as a source of vulnerability for racial and ethnic minority families by increasing their exposure and sensitivity to discrimination via placing them in proximity to non-Hispanic Whites [94–97].

Well-documented by the MDRs literature, economic resources of oneself [84] and one's parents [45] generate fewer desired outcomes for racial and ethnic minority groups. Racial and ethnic minority groups differ in their opportunities to mobilize the resources that they access in order to secure tangible outcomes [55]. In the presence of MDRs, racialized children (e.g., Asian, Black, Hispanic) may develop worse-than-expected outcomes when compared to non-Hispanic White children, even when their resources are similar, a pattern frequently reported across economic and health outcomes [55] While these MDRs are shown for the effects of family SES on neurocognitive measures [98], we are not aware of any previous studies on MDRs of neighborhood safety on various domains of cognitive performance.

5. Study Limitations

Our study had a few methodological limitations. Cross-sectional studies such as ours cannot determine causal effects. As cross-sectional data, we only had a single observation from each variable, without time as a variable. Residual bias due to uncontrolled confounders is possible. Several variables such as individual or neighborhood level socioeconomic inequality were not measured. Other variables that were not measured included parental drug abuse/alcohol history, neighborhood deprivation, and region of residence. These omitted variables may have implications for the association of interest. A major limitation is lack of detailed data on the places, cities, and neighborhoods where the participant lives. In our study, it was unclear what characteristics the neighborhoods had. Future research may disaggregate these data by city and neighborhood. Thus, there is more research needed before we can make recommendations to cities for interventions and policies. This could also allow researchers to comment on objective physical and mental health outcomes that require analysis of state-, zip code-, or county-level data. In addition, we had minimal knowledge about racial and ethnic composition of the "Other" racial group, so it is hard to generalize the results related to this group. In addition, we did not study genetic factors, because this was a sociological not a biological study of cognition. The small R-squared values from all the models, including the models with interaction terms, indicate a small explaining power of all the variables included in the models. The change in the ΔR-squared for executive function was only 1.5%, which is not large. None of these limitations, however, are fatal flaws. This study, however, provides a first look at the association between parents' subjective neighborhood safety and child cognitive performance across racial and ethnic groups.

6. Conclusions

The results suggest that diverse racial and ethnic groups differ in their social determinants of cognitive function. Effects of perceived neighborhood quality are not universal and depend on race/ethnicity and cognitive domain. Children's cognitive function is shaped by a complex interaction between the individual and social array of factors; meaning that paths, effects, and correlations may vary across diverse groups. The same intervention may be associated with a different response across diverse racial and ethnic groups.

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Institutional Review Board Statement: This analysis was exempted from a full IRB review by Charles R Drew University of Medicine. The study of origin (ABCD), however, was approved by the Institutional Review Board (IRB) at the University of California, San Diego (UCSD). Assent and consent were received from children and their parents, respectively [67].

Informed Consent Statement: This analysis was exempted from a full IRB review by Charles R Drew University of Medicine. The study of origin (ABCD), however, was approved by the Institutional Review Board (IRB) at the University of California, San Diego (UCSD). Assent and consent were received from children and their parents, respectively [67].

Data Availability Statement: Data used in the preparation of this article were obtained from the Adolescent Brain Cognitive Development (ABCD) Study (https://abcdstudy.org (accessed on 5 May 2021)), held in the NIMH Data Archive (NDA). The ABCD Study is supported by the National Institutes of Health (NIH) and additional federal partners under award numbers U01DA041022, U01DA041025, U01DA041028, U01DA041048, U01DA041089, U01DA041093, U01DA041106, U01DA041117, U01DA041120, U01DA041134, U01DA041148, U01DA041156, U01DA041174, U24DA041123, and U24DA041147. A full list of federal partners is available at https://abcdstudy.org/federal-partners.html (accessed on 5 May 2021). A listing of participating sites and a complete listing of the study investigators can be found at https://abcdstudy.org/principal-investigators.html (accessed on 5 May 2021). This manuscript reflects the views of the authors and may not reflect the opinions or views of the NIH or ABCD consortium investigators. ABCD consortium investigators designed and implemented the study and/or provided data but did not necessarily participate in this report's analysis or writing. The ABCD data repository grows and changes over time. The current paper used the Curated Annual Release 2.0, also defined in NDA Study 634 (doi:10.15154/1503209). DEAP is a software provided by the Data Analysis and Informatics Center of ABCD located at the UC San Diego with generous support from the National Institutes of Health and the Centers for Disease Control and Prevention under award number U24DA041123. The DEAP project information and links to its source code are available under the resource identifier RRID: SCR_016158.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Model Formula.

General cognitive performance
Model 1
neurocog_pc1.bl ~ neighb_phenx_ss_mean_p + race_ethnicity + high.educ.bl + household.income.bl + married.bl + age + sex
Random: ~(1 | rel_family_id)
Model 2
neurocog_pc1.bl ~ neighb_phenx_ss_mean_p + race_ethnicity + high.educ.bl + household.income.bl + married.bl + age + sex + neighb_phenx_ss_mean_p * race_ethnicity
Random: ~(1 | rel_family_id)
Executive functioning
Model 1
neurocog_pc2.bl ~ neighb_phenx_ss_mean_p + race_ethnicity + high.educ.bl + household.income.bl + married.bl + age + sex
Random: ~(1 | rel_family_id)
Model 2
neurocog_pc2.bl ~ neighb_phenx_ss_mean_p + race_ethnicity + high.educ.bl + household.income.bl + married.bl + age + sex + neighb_phenx_ss_mean_p * race_ethnicity
Random: ~(1 | rel_family_id)
Learning and memory
Model 1
neurocog_pc3.bl ~ neighb_phenx_ss_mean_p + race_ethnicity + high.educ.bl + household.income.bl + married.bl + age + sex
Random: ~(1 | rel_family_id)
Model 2
neurocog_pc3.bl ~ neighb_phenx_ss_mean_p + race_ethnicity + high.educ.bl + household.income.bl + married.bl + age + sex + neighb_phenx_ss_mean_p * race_ethnicity
Random: ~(1 | rel_family_id)

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