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Research Article

Racism May Interrupt Age-related Brain Growth of African American Children in the United States

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Abstract

Background: Considerable research has documented age-related growth in brain size as a marker of normal brain development. This is particularly important because brain volume has a significant role in overall cognitive performance. However, less research is done on whether age-related changes in the global brain volume differ across diverse racial and ethnic groups. We hypothesized that age-related growth in brain size would be disrupted in African American children who are historically affected by racism.

Purpose: Considering race as a proxy of racism rather than genetics, this study tested racial and ethnic differences in the effects of age on global brain volume using structural brain imaging data. Built on a sociological, rather than a biological theory, we built our study on Marginalization-related Diminished Returns (MDRs) framework, which argues that under racism, resources and assets are less effective for social groups that are historically racialized, discriminated against, marginalized, and segregated. Considering age as an asset/resource that increases the global brain volume, we expected weaker effects of age on overall brain size of African American and Hispanic children, than White and non-Hispanic children, again as a result of racism.

Methods: We borrowed the structural Magnetic Resonance Imaging (sMRI) data from the Children Brain Cognitive Development (ABCD) study, which included 9,311 9-10 year old children. The independent variable was the child's age treated as a continuous measure (in months). The primary outcome was global brain volume. Sex, parental employment, parental education, household income, and parental marital status were the covariates. Race and ethnicity, as proxies of racism, were the moderators. To analyze the data, we used linear regression models.

Results: Age was positively associated with the global brain size in children. In line with the MDRs, the positive association between age and global brain volume was weaker for African American than White children, while family structure, sex, and family socioeconomic status was controlled.

Conclusions: Under racism, age has unequal effects on global brain size of diverse racial groups. In line with the MDRs, we observe diminished age-related growth of the brain for African American children, which documents detrimental effects of racism. For White children who are not affected by racism, age makes a large difference regarding global brain volume. Age-related growth of global brain size is diminished in African American children, whose daily lives are shaped by racism. School and residential segregation may have a role in reducing the effect of age on children's brain growth in African American families. The results should not be interpreted as inferiority of one group but social processes that hinder normal development of a historically oppressed group.

Keywords: Age; Global brain volume; Brain development; Structural MRI; MRI; Social determinants; Racism

Background

Marginalization-related Diminished Returns (MDRs) [1-3] refer to weaker effects of protective factors, resources, and assets on the development, behaviors, and health of all marginalized social groups. In his 20-year review of Fundamental Cause theory, Clouston and Link refer to these MDRs as indicators of structural racism in the United States (US) [4]. More recently, these MDRs are shown to be a mechanism that explains how racism influences brain development [5-11]. Such effects may explain transgenerational transition of inequalities as a result of racism [5-11]. These MDRs also explain why health inequalities can be also seen in high socioeconomic position (SEP) families [5-11].

Visible and invisible social identities that cause discrimination, different treatment, and decreased access to the opportunity

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structures are believed to generate MDRs. MDRs are shown for race [12,13], place [22], ethnicity [14-16], nativity [17,18], and sexual orientation [19-21]. That is, African American [12,13], Hispanic [14-16], Native American [23], Asian American [24], immigrant [17,18], LGBT [19-21], and even marginalized White [22] people show weaker than expected effects of resources such as socioeconomic position (SEP) [17,18], coping [25], and age [26], on generating outcomes. Observation of MDRs in all marginalized groups including Whites suggests that they are shaped by social forces rather than biological traits [1,2]. Although studies find MDRs for all marginalized groups, they are strongest in African Americans who have had a unique history of slavery and racism in the US [1,2].

As a result of MDRs, racial and ethnic minority children and youth show poorer health, behavioral, and developmental outcomes, despite having access to social, economic, personality, and psychological resources and assets [27-31]. For example, high SEP Hispanic and African American children remain at risk of anxiety [32], depression [33], poor school performance [12,13], as well as high-risk behaviors, [31] such as aggression [31] and substance use [34, 35]. Diminished effects of economic resources for racial and ethnic minority groups of children are robust [36-40]. Similarly, high SEP Hispanic and African American children report higher risk of impulsivity, aggression, anxiety, depression, poor health, poor school performance, and attention-deficit/hyperactivity disorder (ADHD) [14,29,40,41].

While SEP has a protective effect on brain development, and high SEP backgrounds are protective against school drop-out [42], depression [43], suicide [44,45], antisocial behaviors [46], aggression [47], and use of legal [48,49] and illegal substances [50], Hispanic and African American children with high SEP remain at risk of almost all of these domains [14,29,40,41]. This is partly because protective factors, such as SEP [51] are diminished for Hispanic and African American children. Therefore, despite having the resources, Hispanic and African American children do not show optimal brain development that is expected given their resources.

While low access to resources and assets is partially responsible for the worse than expected health status of Hispanics and African Americans, lower access to resources and assets does not explain all the White-African American and White-Hispanic gaps in developmental and health outcomes. Another cause of such gaps is MDRs, which denote weaker effects of available resources and assets for African Americans and Hispanics than non-Hispanic Whites [36,37,39,52-56], protective of high SEP on various behavioral outcomes are attributed to the effects of high family SEP. These MDRs may exist for multiple aspects of brain structures [57] and functions, such as global brain volume [58]. Although there is an extensive body of research on weaker effects of family SEP for racial and ethnic minority groups, we are unaware of previous studies of racial/ethnic differences in the size of the effects of age on a wide range of health, economic, and behavioral outcomes.

Research has established how race(ism) alters the effects of high SEP on children's brain development [59-63]. Due to racism, high SEP African Americans remain at risk of depression, impulsivity, novelty/fun seeking, poor emotion regulation, and poor inhibitory control. These can be, in theory, due to a delay in the brain development of Black children because of environmental stressors in Black families' lives across all SEP spectrums. In this view, the environment's negative effect is so large that it interferes with the effect of age on the brain in a similar way that it diminishes the impact of SEP on brain development of the racialized group [59-63].

Multiple studies have shown an association between SEP and larger global brain volume [58]. Noble and colleagues documented a positive association between family SEP and MRI-assessed global brain volume in children [51], independent of race(sim) and genetic markers [51]. Interestingly, Waldstein and colleagues argued that African American race might be associated with an increased sensitivity to SEP influences on brain health [58]. However, our research shows the opposite [1,2,31]. Our results suggest that racism reduces the significance of individual-level factors, because their influences are bound by the unfair aspects of racism in society [64-67].

Aims

Conceptualizing race as a proxy of racism, this study explored racial and ethnic differences in age-related changes in the global brain volume of 9-10 year old children. We expected racial and ethnic variation in the magnitude of the effect of age on global brain volume to be in line with the MDRs phenomenon [1,2,31]. More specifically, we expected diminished age-related changes, as documented by weaker associations between age and global brain volume for African American and Hispanic than White and non-Hispanic children. In a small study, Waldstein showed similar results for the effects of SEP on global brain volume [58].

Methods

Design and settings

This cross-sectional study was a secondary analysis of the ABCD study data [68-72]. Our analysis used data from wave 1 of the ABCD study, a national brain imaging study of children [68,73]. The ABCD study includes a large, diverse national sample [68-72].

Participants and sampling

In the ABCD study, pre-youth participants were recruited from multiple cities across different states. The ABCD sample primarily relied on the recruitment of pre-youth from US school systems. Schools were selected based on their race, ethnicity, sex, SEP, and urbanicity data. More details of ABCD sampling are published elsewhere [74]. The ABCD sample included 9,311 non-twin Hispanic, non-Hispanic African American, and White 9-10 year old children.

Study variables

Dependent variable: The primary outcome was global brain volume, measured by structural MRI. Prior studies showed that global brain volume was associated with age, stress, SES, and nutrition [75-77].

Independent variable: Age, the main predictor, was a continuous variable ranging from 9.01 to 10.99 years. Parents reported the age of the children.

Moderators: Race, the moderator, was a self-identified variable coded 1 for African American and 0 for White (reference). Ethnicity, a confounder, was coded 1 for Hispanic and 0 for non-Hispanic.

Table 1: Descriptive data overall (n = 9311).

Characteristics	*n*	%
Race		
White	7114	76.4
African American (AA)	2197	23.6
Ethnicity		
Non-Hispanic	7713	82.8
Hispanic	1598	17.2
Sex		
Female	4404	47.3
Male	4907	52.7
Parental Marital Status		
Not- Married	2466	26.7
Married	6781	73.3
Parental Employment		
Not- Employed	2890	31
Employed	6421	69
	Mean	**SD**
Age	9.46	0.50
Parental Education (years)	16.7	2.64
Family Income	7.24	2.40
Subjective Family SEP	0.93	0.16
Global Brain Volume	1209824.2	114274.67

SEP: Socioeconomic Position.

Confounders: Sex was 1 for boys and 0 for girls. Parental family structure was 1 for married/partner and 0 for other. Parental education was a continuous measure ranging from 1 to 21. Family economic hardship was measured by the following seven items: "In the past 12 months, has there been a time when you and your immediate family experienced any of the following": 1) "Needed food but could not afford to buy it or could not afford to go out to get it?"; 2) "Were without telephone service because you could not afford it?"; 3) "Did not pay the full amount of the rent or mortgage because you could not afford it?"; 4) "Were evicted from your home for not paying the rent or mortgage?"; 5) "Had services turned off by the gas or electric company, or the oil company would not deliver oil because payments were not made?"; 6) "Had someone who needed to see a doctor or go to the hospital but did not go because you could not afford it?"; and 7) "Had someone who needed a dentist but could not go because you could not afford it?" Responses to each item were either 0 or 1. We calculated a mean score, a continuous measure with a potential range between 0 and 1, where a higher score showed lower economic hardship [78-84]. Parental employment was 0 for unemployed and 1 for employed parents. Family income was a 1–10 interval measure, where a higher score indicated a higher income. The total combined family income in the past 12 months was asked. Responses were 1 = less than $5000; 2 = $5000; 3 = $12,000; 4 = $16,000; 5 = $25,000; 6 = $35,000; 7 = $50,000; 8 = $75,000; 9 = $100,000; and 10 = $200,000.

Data analysis

We used Statistical Package for the Social Sciences (SPSS) for data analysis. We reported n (%) and mean [standard deviations (SDs) for our univariate analysi, Spearman correlations for our bivariate analyses and four linear regression models for our multivariable analysis. In each regression model the outcome variable was global brain volume and the main predictor (independent) variable was age. Each model all controlled for confounders, such as sex, parental marital status, parental employment, parental education, family income, and family economic hardship. We used a pooled sample for the first two models. No interaction term appears in Model 1. In Model 2, we include two interaction terms age X race and age x ethnicity, with non-Hispanic White as the omitted category. We estimated the next two models using separate samples for Whites (Model 3) and African Americans (Model 4). We reported the regression coefficients (b), standard errors (SE), and p-values. We considered a coefficient to be statistically significant if the p-value was less than or of equal to 0.05. Before performing our linear regression models, we explored the distribution of the dependent variable, and a normal distribution confirmed appropriateness of using linear regression for data analysis. We also confirmed that the error terms were normally distributed.

Ethical aspect

Our analysis was exempt from a full review. The ABCD study protocol, however, was approved by the University of California, San Diego (UCSD) Institutional Review Board (IRB) [73].

Results

Descriptive

The sample included 9,311 9-10 year old children. Table 1 presents the descriptive statistics of the pooled sample.

Bivariate correlations

Table 2 presents the results of the Spearman test overall and also by race(ism). Age was positively correlated with global brain volume in the pooled sample. In Whites, age was positively correlated with global brain volume. Age was not associated with global brain volume in African Americans.

Pooled-sample multivariable associations

Table 3 reports the results of two pooled sample regression models. Model 1 showed that age was positively associated with global brain volume. Model 2 showed an interaction between age and race on global brain volume, meaning that the effect of old age on larger global brain volume was weaker for African American than White children.

Race-stratified multivariable associations

Table 4 reports the results of the two regression models by race. Model 3, performed in Whites, showed that older age was associated with larger global brain volume. Model 4, conducted in African Americans, did not show an effect of age on global brain volume.

Race-stratified multivariable associations

We did not show ethnicity-specific models because the results did not differ by ethnicity (Hispanic vs. non-Hispanic). For both Hispanic and non-Hispanic pre-youth, age was positively associated with global brain volume.

Discussion

Older age is linked to a larger global brain volume. This pattern is

Table 2: Bivariate associations (n = 9311).

	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
All										
1 Age (10)	1.00	0.00	-0.02	0.02	0.00	0.01	0.00	0.03*	0.02	0.03**
2 Race (AA)		1.00	-0.12**	-0.01	-0.38**	-0.05**	-0.30**	-0.40**	-0.27**	-0.27**
3 Ethnicity (Hispanic)			1.00	-0.01	-0.04**	-0.04**	-0.19**	-0.20**	-0.07**	-0.09**
4 Sex (Male)				1.00	0.01	-0.01	-0.01	0.00	-0.01	0.48**
5 Marital Status (Maried)					1.00	.03**	0.29**	0.50**	0.27**	0.17**
6 Parental Employment (Employed)						1.00	0.25**	0.22**	0.13**	0.04**
7 Parental Education							1.00	0.61**	0.34**	0.20**
8 Family Income								1.00	0.47**	0.24**
9 Subjective Family SEP									1.00	0.14**
10 Global Brain Volume										1.00
Whites										
1 Age (10)	1.00	-	-0.02	0.01	0.00	0.01	-0.01	.032**	.024*	.042**
2 Race (AA)		-	-	-	-	-	-	-	-	-
3 Ethnicity (Hispanic)			1.00	-0.01	-0.14**	-0.06**	-0.29**	-0.33**	-0.16**	-0.17**
4 Sex (Male)				1.00	0.01	0.00	-0.03*	0.00	-0.02	0.50**
5 Marital Status (Maried)					1.00	-0.02	0.17**	0.38**	0.19**	0.07**
6 Parental Employment (Employed)						1.00	0.23**	0.20**	0.13**	0.02
7 Parental Education							1.00	0.54**	0.31**	0.13**
8 Family Income								1.00	0.43**	0.14**
9 Subjective Family SEP									1.00	0.08**
10 Global Brain Volume										1.00
African Americans (AA)										
1 Age (10)	1.00	-	0.01	0.03	0.02	0.03	0.03	0.03	0.01	0.01
2 Race (AA)		-	-	-	-	-	-	-	-	-
3 Ethnicity (Hispanic)			1.00	-0.02	0.03	-0.01	0.05*	0.08**	0.02	0.07**
4 Sex (Male)				1.00	0.01	-0.03	0.01	0.01	-0.02	0.47**
5 Marital Status (Maried)					1.00	0.10**	0.26**	0.49**	0.17**	0.07**
6 Parental Employment (Employed)						1.00	0.29**	0.35**	0.11**	0.04*
7 Parental Education							1.00	0.62**	0.19**	0.12**
8 Family Income								1.00	0.33**	0.18**
9 Subjective Family SEP									1.00	0.04
10 Global Brain Volume										1.00

SEP: Socioeconomic Position; *P <0.05; **P <0.01.

also known as age-related growth in global brain volume. However, this age-related change in global brain volume is diminished for African American when compared with White children. We see this finding as a manifestation of racism in the United States.

The literature has shown a wide range of factors that influence children's brain growth and development [85]. One series of predictors is family SEP indicators [85] (e.g., poverty, household income, and parental education) that promote children's brain development [86]. Another group of determinants of children's global brain volume includes: stress, trauma, adversities, and maternal depression. These determinants all hinder healthy brain growth and development [75-77,87-94]. Finally, age is a primary driver of brain development. This pattern is known as age-related brain growth [85].

Our findings suggest that some of the racial variation in childhood brain development is due to diminishing returns of age, or slower age-related change in global brain volume, in African American than White children. We interpret this finding through a sociological rather than a biological mechanism. Doing so suggests a third type of jeopardy for African American children. The first type of risk for African American children is that they are more likely than white children to live in low SEP families. The second type of risk is that their SEP shows a diminished impact on their normal brain development. Finally, the weakened effect of age and high SEP for African American children may be due to other unique stressors in

Table 3: Two regression models in the pooled sample (n = 9311).

	Model 1 Main Effects					Model 2 M1 + Interaction				
	b	SE	95% CI		p	b	SE		95% CI	p
Race (African American)	-51753.83	2861.83	-57363.71	-46143.95	<0.001	104612.15	46326.99	13800.02	195424.29	0.024
Ethnicity (Hispanic)	-22296.05	2889.03	-27959.26	-16632.84	<0.001	-23965.58	52213.52	-126316.74	78385.58	0.646
Sex (Male)	107082.33	2035.95	103091.37	111073.3	<0.001	107136.26	2035.01	103147.14	111125.39	<0.001
Married Household	703.65	2841.17	-4865.73	6273.04	0.804	796.82	2839.73	-4769.73	6363.37	0.779
Parental Employment	-4825.83	2347.47	-9427.45	-224.22	0.04	-4760.21	2346.26	-9359.44	-160.97	0.043
Parental Education	2746.35	521.64	1723.8	3768.9	<0.001	2772.48	521.43	1750.35	3794.61	<0.001
Family Income	5704.69	666.08	4399.01	7010.37	<0.001	5692.69	665.78	4387.6	6997.78	<0.001
Subjective family SEP	15095.12	7099.08	1179.21	29011.03	0.034	15119.46	7095.19	1211.16	29027.75	0.033
Age	5144.85	2028.06	1169.36	9120.33	0.011	8821.63	2516.13	3889.41	13753.85	<0.001
Age x Race	-	-	-	-	-	-16514.77	4883.13	-26086.89	-6942.65	0.001
Age x Ethnicity	-	-	-	-	-	193.87	5520.6	-10627.84	11015.58	0.972

SEP: Socioeconomic Position.

Table 4: Race-specific linear regressions (n = 9311).

	Model 3 Whites					Model 4 African Americans				
	b	SE	95% CI		p	b	SE		95% CI	p
Ethnicity (Hispanic)	-30648.7	3186.51	-36895.29	-24402.12	<0.001	25299.52	7777.78	10045.4	40553.63	0.001
Sex (Male)	108660.79	2278.24	104194.72	113126.87	<0.001	102074.2	4453.15	93340.5	110807.9	<0.001
Married Household	1376.25	3406.36	-5301.3	8053.8	0.686	250.23	5152.67	-9855.4	10355.87	0.961
Parental Education	-6014.1	2629.31	-11168.4	-859.81	0.022	2656.44	5157	-7457.7	12770.58	0.607
Family Income	3263.82	594.71	2097.99	4429.65	<0.001	529.91	1083.91	-1595.9	2655.71	0.625
Subjective Family SEP	4303.44	819.69	2696.58	5910.29	<0.001	6966.42	1193.7	4625.29	9307.55	<0.001
Age	21612.27	9500.44	2988.36	40236.17	0.023	6012.46	10806.8	-15182.3	27207.22	0.578
Intercept	8832.56	2277.95	4367.05	13298.07	<0.001	-7724.97	4379.03	-16313.31	863.37	0.078

SEP: Socioeconomic Position.

African Americans' lives across all SEP levels [95-97]. In this view, high stress, poor environment, and chronic poverty may hinder the healthy age-related brain development for African American children [85].

We see racism, the social environment, and social stratification as the drivers of our observed inequalities. In contrast to Murry's argument on racial differences in non-modifiable, genetically determined IQ and brain [98], we do not believe these differences are genetically determined, . Instead, we attribute the observed differences to the environments that hinder African Americans' growth, development, and flourishing. In our papers, we have argued that social policies can undo the effect of historic racism in the lives of African American communities. For example, we have shown that the association between household income and brain development is identical for African American and White children, suggesting that these inequalities are preventable and modifiable [9,99-101].

Sociological and epidemiological studies have reported more significant effects of SEP, coping, and other resources on a wide range of behavioral, developmental, and health outcomes for White than African American children [36, 37,102]. For example, as a result of MDRs, we see a high risk of ADHD [41], anxiety [32], aggression [31], tobacco dependence [31], weak school bonding [103], poor school performance [13,104], obesity [29], and poor health [28] for African American children across all SEP levels.

Similarly, we see high impulsivity [27], poor inhibitory control[105], and high fun seeking[106] in African American children across all SEP levels. As a result of this pattern African American children in high SEP families exhibit higher-than-expected risks of smoking, obesity, aggression, and poor education [29,40,41]. Researchers call this pattern MDRs and the pattern seems robust, as it holds across outcomes, settings, birth cohorts, SEP indicators, and age and population groups [1,2]. The present studies' findings showed MDRs for age-related changes in brain volume.

Under racism, and due to differential effects of age, family SEP, and coping for African American relative to White families, MDRs contribute to the transgenerational transmission of inequalities and poverty [27-31]. Differential impact of resources and assets such as age and SEP means that the same resource may generate unequal outcomes for the next generation of African American communities. In other words, due to MDRs, inequalities reproduce themselves across generations. That said, most of the previous studies on MDRs relied on self-reported outcomes. Thus, we lack biological studies that test differential effects of resources and assets on children's brain development. This paper extends the existing literature by testing such patterns on brain development.

As shown by this study and previous work [1], under racism, age

[26], coping [107,108], and SEP [27-30] all have weaker influences on a wide range of behavioral outcomes of African American than White children [38,109], youth [110], adults [111], and older adults [112,113]. Under racism, employment [114], marital status [39], parental education [31], educational attainment [14,21,34], and even coping style [107,108] generate fewer outcomes for African Americans than Whites. Regardless of their type, if it is age [26], SEP [27-30], or a psychological asset [107,108], resources systematically generate diminishing returns for oppressed (African American) than privileged (White) people. This pattern might be due to racism, segregation, discrimination, social stratification, and unequal treatment that are multilevel, deeply rooted, structural and societal causes of inequalities [115-124].

This study conceptualized race and ethnicity as social factors that reflect social status and treatment by society. Across various brain structural measures, we focused on global brain size [51], which is linked to behaviors and cognitive performance [125]. An alteration of global brain volume predicts brain function across various domains [125-127]. Our past results have suggested that, racism alters the implications of family SEP and other resources for brain development [51], which is core to brain function across many domains [128-132].

Under racism, the effect of age on global brain size is unequal across diverse racial groups. Given the existing structural inequalities in the US, the marginal return of age, in terms of global brain size, is smaller in African American than White children. Therefore, policy solutions that wish to achieve racial equality should go beyond just addressing SEP inequalities. Instead, policy solutions should work to equalize the social environment of African American and White individuals so that age, SEP, and other resources and assets generate equal brain development across all racial and ethnic groups. The root cause of these inequalities is racism.

Conclusions

To summarize our findings, in a large national sample of American children, like the previously shown pattern for SEP and psychological assets, age shows a weaker effect on global brain volume for African Americans than Whites. In areas that Whites reside, stimulating intellectual inputs enhance the healthy age-related development of the brain. In contrast, African Americans often reside in areas with high levels of stress, and less stimulating intellectual inputs. For example, African American children attend worse schools with limited resources and less prepared teachers. In such a context, an increase in age is associated with less brain development for African American than for White children.

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