Original Paper

Dimensional Change Card Sorting of American Children:

Marginalization-Related Diminished Returns of Age

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Abstract

Background: While age is associated with an increase in cognitive flexibility and executive functioning as a result of normal development during childhood, less is known about the effect of racial variation in children's age-related cognitive development. The Marginalization-related Diminished Returns (MDRs) phenomenon suggests that, under racism, social stratification, segregation, and discrimination, individual-level economic and non-economic resources and assets show weaker effects on children's development for marginalized, racialized, and minoritized families. Aim: We conducted this study to compare racial groups of children for age-related changes in their card sorting abilities. Methods: This cross-sectional study included 10,414 9-10-year-old American children. Data came from the Adolescent Brain Cognitive Development (ABCD) study. The independent variable was age, a continuous variable measured in months. The dependent variable was Dimensional Change Card Sort (DCCS) score, which reflected cognitive flexibility, and was measured by the NIH Dimensional Change Card Sort. Ethnicity, sex, parental education, and marital status were the covariates. Results: Older age was associated with higher DCCS score, reflecting a higher card-sorting ability and cognitive flexibility. However, age showed a weaker association with DCCS for Black than for White children. This was documented by a significantly negative interaction between race and age on children's DCCS scores. Conclusion: Age shows a weaker correlation with the cognitive flexibility of Black than of White children. A similar pattern can be seen when comparing low-income with high-income children. Conceptualizing race as a social factor that alters normal childhood development is a finding that is in line with MDRs.

Marginalization due to social stratification and racism interfere with the normal age-related cognitive development of American children.

Keywords

age, children, pre-adolescents, card sorting, cognitive flexibility, executive function

1. Introduction

Dimensional Change Card Sort (DCCS) is a useful tool to measure cognitive flexibility and executive function of children and adults (Zelazo, 2006), which are main components of cognitive performance Although overall, the DCCS is believed to generate a valid and reliable measure of cognition (Zelazo, 2006), it is still unclear to what degree it can be applied to compare cognitive function across racial and ethnic groups.

The association between race, socioeconomic status (Zelazo, 2006) (SES), and cognitive function is not only a scientific matter, but also a sensitive political issue(Herrnstein & Murray, 2010). Over the past several decades, there has been an ongoing political debate on whether it is appropriate to study race, SES, and cognitive performance. Specifically, whether race and SES correlate with cognitive function, and whether such effects are due to social forces or biological differences (Nisbett, 1995). Murray's Bell Curve, that argued on the lower cognitive performance of Black individuals, generated an extreme backlash by the scientific community (Nisbett, 2009). In response to a biological claim, scientists questioned the validity of the argument that racial variation in cognitive performance is caused by biology (Nisbett, 1998, 2005; Nisbett et al., 2012a) and genetics (Brown & Day, 2006; Jensen, 1976; Nisbett et al., 2012b; Rushton & Jensen, 2005). Since then, the research community has provided considerable evidence suggesting that lower cognitive scores of Blacks compared to Whites may be an artifact and measurement bias as opposed to a true difference that reflects poor performance of Black people. Others have argued that we can always better measure cognitive function in White populations, rather than Blacks, which refutes any valid racial comparison of cognitive comparison across racial groups based on tests that are not well-validated in both groups (Nisbett, 2013; Turkheimer, Harden, & Nisbett, 2017). A recent research finding that cognitive scores predict the mortality of White but not Black people (Assari, 2020a) is another support for the argument that existing cognitive measures may fail to capture Black populations' true cognitive performance (Assari, 2020a; Dotson, Kitner-Triolo, Evans, & Zonderman, 2009; Goldsmith, Darity Jr., & Veum, 1998; Nisbett, 2009). In addition, others have argued that low education quality, low SES, and other ecological reasons rather than a biological difference are in play (Rowe, Vesterdal, & Rodgers, 1998). Finally, Minorities' Diminished Returns (MDRs) (Assari, 2017b; Assari, 2018) suggests that SES resources and potentials better translate to actual outcomes for Whites than for Blacks, again providing a social theory for explaining cognitive differences between race, particularly among middle-class families (Assari, 2018; Assari, 2018f, 2020b). Lack of predictive power of cognitive scores for Black people may also be due to MDRs (Assari, 2017b;

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Assari, 2018). The MDRs reflect weaker health effects of personal assets and resources including SES, coping, and cognition for any marginalized group such as Black (Assari, 2018; Assari, 2018f), Hispanic (Assari, 2018e; Assari, 2019; Assari, Farokhnia, & Mistry, 2019; Shervin & Ritesh, 2019), Asian American (Assari, Boyce, Bazargan, & Caldwell, 2020b), and Native American (Assari & Mohsen Bazargan, 2019) people.

Most of the research on MDRs have focused on economic resources such as parental education (Assari, Caldwell, & Bazargan, 2019), family income (Assari, Caldwell, & Mincy, 2018a; Assari, Thomas, Caldwell, & Mincy, 2018), and marital status (Assari & Bazargan, 2019). These studies have shown that economic resources generate fewer developmental, health, emotional, and behavioral outcomes for racial and ethnic minority group members than for Whites (Assari & Caldwell, 2018a; Assari, Caldwell, et al., 2019; Assari, Caldwell, & Mincy, 2018a; Assari, Caldwell, & Mincy, 2018b; Assari, Thomas et al., 2018). To give a few examples, high SES shows weaker effects on impulsivity (Assari, Caldwell, & Mincy, 2018a), depression (Assari & Caldwell, 2018a), anxiety (Assari, Caldwell, & Zimmerman, 2018), aggression (Assari, Caldwell et al., 2019), and substance use (Assari, Caldwell et al., 2019) for Black than for White children. As a result of these MDRs,   Black children with a high SES background does not greatly reduce their risk of impulsivity (Assari, 2020a; Assari, Caldwell, & Mincy, 2018a), reward sensitivity y (Assari, Akhlaghipour, Boyce, Bazargan, & Caldwell, 2020; Assari, Boyce, Akhlaghipour, Bazargan, & Caldwell, 2020), attention deficit hyperactivity disorder (ADHD) (Assari & Caldwell, 2019a), obesity (Assari, Boyce, Bazargan, Mincy, & Caldwell, 2019), aggression (Assari, Caldwell et al., 2019), chronic disease (Assari, Caldwell et al., 2019), anxiety (Assari, Caldwell, & Zimmerman, 2018), depression (Assari & Caldwell, 2018a), and suicide (Assari, Boyce, Bazargan, & Caldwell, 2020a), attention (Assari, Boyce, & Bazargan, 2020), school attachment (Assari, 2019b), and Grade Point Average (GPA) (Assari, 2019; Assari & Caldwell, 2019b; Assari, Caldwell et al., 2019).

There are other non-economic resources essential for cognitive development as well, including neighborhood quality (Assari, 2016b), social network (Assari, 2017c), emotion regulation (Assari, 2016a; Assari & Burgard, 2015; Assari, Moazen-Zadeh, Lankarani, & Micol-Foster, 2016), and coping (Assari, 2017a; Assari & Lankarani, 2016b). These all show weaker effects for Black than for White families, a pattern fully in line with the MDRs phenomenon. That is, non-economic resources may show weaker effects for Black than for White families. One of these resources and assets is age (Chalian, Khoshpouri, & Assari, 2019), which is the precursor of age-related cognitive development (Sowell, Delis, Stiles, & Jernigan, 2001; Sowell et al., 2004; Sowell, Thompson, Tessner, & Toga, 2001). In other age-dependent domains, MDRs were also observed., meaning that age showed a weaker effect for Blacks than for Whites (Chalian et al., 2019). However, less is known about the MDRs of age-related changes in children's cognitive development. If we observe weaker effect of age on cognitive performance in Black children, we have indirect support for a social, rather than a biological explanation for racial variation in cognitive function of children.

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2. Aims

Built on the MDRs framework (Assari, 2018; Assari, 2018f, 2020b), we first estimated the overall effect of age on DCCS score, a proxy of cognitive flexibility. Then we compared racial groups of children for the effect of age on DCCS scores. Finally, we also compared groups based on household income for the effect of age on DCCS scores. We expected a positive association between age and DCCS (i.e., cognitive flexibility) overall. However, we expected this association to be weaker (diminished) for Black and low-income than for White and high-income children. Again, a similar finding in Black and low-income sub-group would be another evidence supporting our sociological explanation of racial differences in cognitive function (due to MDRs).

3. Methods

3.1 Design and Settings

This secondary analysis used a cross-sectional design and borrowed data from the Adolescent Brain Cognitive Development (ABCD) study (Alcohol Research: Current Reviews Editorial, 2018; Casey et al., 2018; Karcher, O'Brien, Kandala, & Barch, 2019; Lisdahl et al., 2018; Luciana et al., 2018). ABCD baseline data collection was conducted from 2016 in 21 sites across the United States. For more information on the ABCD study, consult here (Alcohol Research: Current Reviews Editorial, 2018; Auchter et al., 2018).

3.2 Participants and Sampling

The ABCD participants were 9–10-year-old children who were selected from multiple cities across the states. ABCD recruitment primarily relied on the US school system. For a detailed description of the sampling and recruitment in the ABCD, consult here (Garavan et al., 2018). Our analysis's eligibility was having valid data on all our study variables, including race, age, and cognitive flexibility. The analytical sample of this paper was 10,414.

3.3 Study Variables

The study variables included race, ethnicity, sex, age, household income, parental education, marital status, and cognitive flexibility. Race was self-identified: Blacks, Asians, Mixed/Other, and Whites (reference category). Parents reported the age of their children in months. The sex of the child was 1 for males and 0 for females. Parental marital status was reported by the parents and was 1 for married and 0 for others. Household income, reported by the parent, was a three-level categorical measure: less than 50K, 50-100K, and 100+K. Cognitive flexibility was evaluated by the Dimensional Change Card Sort (DCCS). This measure is one of the components of the NIH toolbox for assessment of neurological and behavioral function. The DCCS is an easily administered and widely used measure that evaluates cognitive flexibility and executive function for a wide range of ages. In this test, children are asked to sort a series of bivalent test cards, first according to one dimension (e.g., color), and then according to the other (e.g., shape). While children under three cannot properly switch and exhibit a pattern of

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inflexibility similar to patients with prefrontal cortical damage, children older than five years of age can successfully switch when asked to. The performance score on the DCCS test provides a standard index of cognitive flexibility and executive function development. The DCCS is highly age-dependent and is impaired in children with psychiatric and developmental disorders such as autism, Attention-Deficit/Hyperactivity Disorder (ADHD), and schizophrenia (Zelazo, 2006).

3.4 Data Analysis

We used Data Exploration and Analysis Portal (DEAP) for data analysis. DEAP uses the R package for statistical calculations. We reported the mean (Standard Deviation [SD]) and frequency (%) of our variables overall and by race. We also performed the Chi-square and ANOVA for our bivariate analysis. We used three mixed-effects regression models for multivariable modeling that allowed us to adjust to our data's nested nature. This was because participants are nested to families that are nested to sites and states. All models were performed in the overall sample. *Model 1* did not have interaction terms. *Model 2* included interaction terms between race and age. *Model 3* included interaction terms between household income and age. In all models, the DCCS score was the outcome. Regression coefficient (b), SE, and *p*-value were reported. Our **Appendices 1** and **2** show our variables distributions and also our modeling strategy.

3.5 Ethical Aspect

The ABCD study has an Institutional Review Board (IRB) approval, and all participants have provided assent or consent, depending on their age (Auchter et al., 2018). Given that our analysis was performed on fully de-identified data, our analysis was exempt from a full IRB review.

4. Results

4.1 Descriptives

Overall, 10,414 9-10-year-old children were analyzed. Most participants were Whites (n = 6,897; 66.2%), followed by other/mixed race (n = 1,768; 17.0%), and Black (n = 1,515; 14.5%). Only 234 (2.2%) children were Asian.

Table 1 presents the descriptive data overall and by race. This table also compares racial groups for study variables. As this table shows, Black and mixed/other race participants had the lowest parental education and income. White and Asian children had the highest parental education and household income. DCCS score was also lower for Black than for White children.

Table 1. Descriptive Characteristics by Race (n = 10414)

level	All	White	Black	Asian	Other/Mixed	p
N	10,414	6,897	1,515	234	1,768	
	n (%)	n (%)	n (%)	n (%)	n (%)	
Sex						
Female	4,996 (48.0)	3,254 (47.2)	760 (50.2)	117 (50.0)	865 (48.9)	0.128
Male	5,418 (52.0)	3,643 (52.8)	755 (49.8)	117 (50.0)	903 (51.1)	
Parental Education						
<HS Diploma	385 (3.7)	145 (2.1)	123 (8.1)	6 (2.6)	111 (6.3)	<0.001
HS Diploma/GED	862 (8.3)	327 (4.7)	340 (22.4)	3 (1.3)	192 (10.9)	
Some College	2,674 (25.7)	1,462 (21.2)	600 (39.6)	18 (7.7)	594 (33.6)	
Bachelor	2,766 (26.6)	2,057 (29.8)	230 (15.2)	65 (27.8)	414 (23.4)	
Post Graduate Degree	3,727 (35.8)	2,906 (42.1)	222 (14.7)	142 (60.7)	457 (25.8)	
Married Family						
No	3,165 (30.4)	1,415 (20.5)	1,058 (69.8)	33 (14.1)	659 (37.3)	<0.001
Yes	7,249 (69.6)	5,482 (79.5)	457 (30.2)	201 (85.9)	1,109 (62.7)	
Household Income						
<50K	2,997 (28.8)	1,259 (18.3)	999 (65.9)	36 (15.4)	703 (39.8)	<0.001
50K-100K	2,974 (28.6)	2,104 (30.5)	335 (22.1)	54 (23.1)	481 (27.2)	
>=100K	4,443 (42.7)	3,534 (51.2)	181 (11.9)	144 (61.5)	584 (33.0)	
Hispanic						
No	8,451 (81.2)	5,737 (83.2)	1,439 (95.0)	215 (91.9)	1,060 (60.0)	<0.001
Yes	1,963 (18.8)	1,160 (16.8)	76 (5.0)	19 (8.1)	708 (40.0)	
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	
Age (Months)	118.95 (7.46)	119.03 (7.49)	118.88 (7.23)	119.40 (7.77)	118.65 (7.51)	0.192
Card Sorting Score	97.10 (15.26)	98.29 (15.07)	91.31 (13.98)	102.36 (17.94)	96.73 (15.46)	<0.001

Table 2 presents the descriptive data overall and by levels of household income. From our participants, 2,997 (28.8%) had a household income of <50K, 2,974 children (28.6%) had a househld income of between 50K and 100K, and 4,443 children (42.7%) were living in households with 100k+ income. Children in families with higher household income showed higher DCCS scores than low-income children.

Table 2. Descriptive Characteristics by Household Income (n = 10414)

level	All	< 50K	> =50K& < 100K	> =100K	p
	10,414	2,997	2,974	4,443	
	n (%)	n (%)	n (%)	n (%)	
Race					
White	6,897 (66.2)	1,259 (42.0)	2,104 (70.7)	3,534 (79.5)	< 0.001
Black	1,515 (14.5)	999 (33.3)	335 (11.3)	181 (4.1)	
Asian	234 (2.2)	36 (1.2)	54 (1.8)	144 (3.2)	
Other/Mixed	1,768 (17.0)	703 (23.5)	481 (16.2)	584 (13.1)	
Hispanic					
No	8,451 (81.2)	2,039 (68.0)	2,396 (80.6)	4,016 (90.4)	< 0.001
Yes	1,963 (18.8)	958 (32.0)	578 (19.4)	427 (9.6)	
Sex					
Female	4,996 (48.0)	1,461 (48.7)	1,423 (47.8)	2,112 (47.5)	0.582
Male	5,418 (52.0)	1,536 (51.3)	1,551 (52.2)	2,331 (52.5)	
Parental Education					
<HS Diploma	385 (3.7)	361 (12.0)	22 (0.7)	2 (0.0)	< 0.001
HS Diploma/GED	862 (8.3)	678 (22.6)	151 (5.1)	33 (0.7)	
Some College	2,674 (25.7)	1,379 (46.0)	923 (31.0)	372 (8.4)	
Bachelor	2,766 (26.6)	393 (13.1)	1,016 (34.2)	1,357 (30.5)	
Post Graduate Degree	3,727 (35.8)	186 (6.2)	862 (29.0)	2,679 (60.3)	
Married Family					
No	3,165 (30.4)	2,001 (66.8)	791 (26.6)	373 (8.4)	< 0.001
Yes	7,249 (69.6)	996 (33.2)	2,183 (73.4)	4,070 (91.6)	
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	
Age (Months)	118.95 (7.46)	118.59 (7.40)	118.78 (7.49)	119.31 (7.47)	< 0.001
Card Sorting Score	97.10 (15.26)	92.87 (14.03)	97.58 (14.91)	99.63 (15.69)	< 0.001

4.2 Multivariate Models

Table 3 presents the results of three mixed-effects regression models in the overall sample. *Model 1* showed a positive association between age and cognitive flexibility (**Figure 1**). *Model 2* showed an interaction between age and race on cognitive flexibility. This interaction indicated that the boosting effect of age and cognitive flexibility is weaker for Black than for White children (**Figure 2**). *Model 3*

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showed an interaction between age and household income on cognitive flexibility. This interaction indicated that the boosting effect of age and cognitive flexibility is larger for high income than for low-income children (**Figure 3**).

Table 3. Mixed Effects Regressions overall (n = 10414)

	b	SE	p
Model 1			
Age (Months)	0.08***	0.02	< 0.001
Race (Black)	-4.25***	0.50	< 0.001
Race (Asian)	2.82**	1.01	0.005
Race (Mixed/Other)	-0.05	0.42	0.903
Model 2			
Age (Months)	0.10***	0.02	< 0.001
Race (Black)	11.36#	6.90	0.100
Race (Asian)	-20.28	15.11	0.180
Race (Mixed/Other)	4.87	6.26	0.437
Race (Black) x Age	-0.13*	0.06	0.023
Race (Asian) x Age	0.19	0.13	0.126
Race (Mixed/Other) x Age	-0.04	0.05	0.432
Model 3			
Age (Months)	0.03	0.04	0.407
Race (Black)	-4.24***	0.50	< 0.001
Race (Asian)	2.79**	1.01	0.006
Race (Mixed/Other)	-0.05	0.42	0.897
Income (> =50K& < 100K)	-1.00	6.13	0.871
Income (> 100K)	-10.57#	5.63	0.060
Income (> =50K& < 100K) x Age	0.02	0.05	0.636
Income (> 100K) x Age	0.11*	0.05	0.022

$\# p < 0.1$ $* p < 0.05$ $** p < 0.01$ $*** p < 0.001$
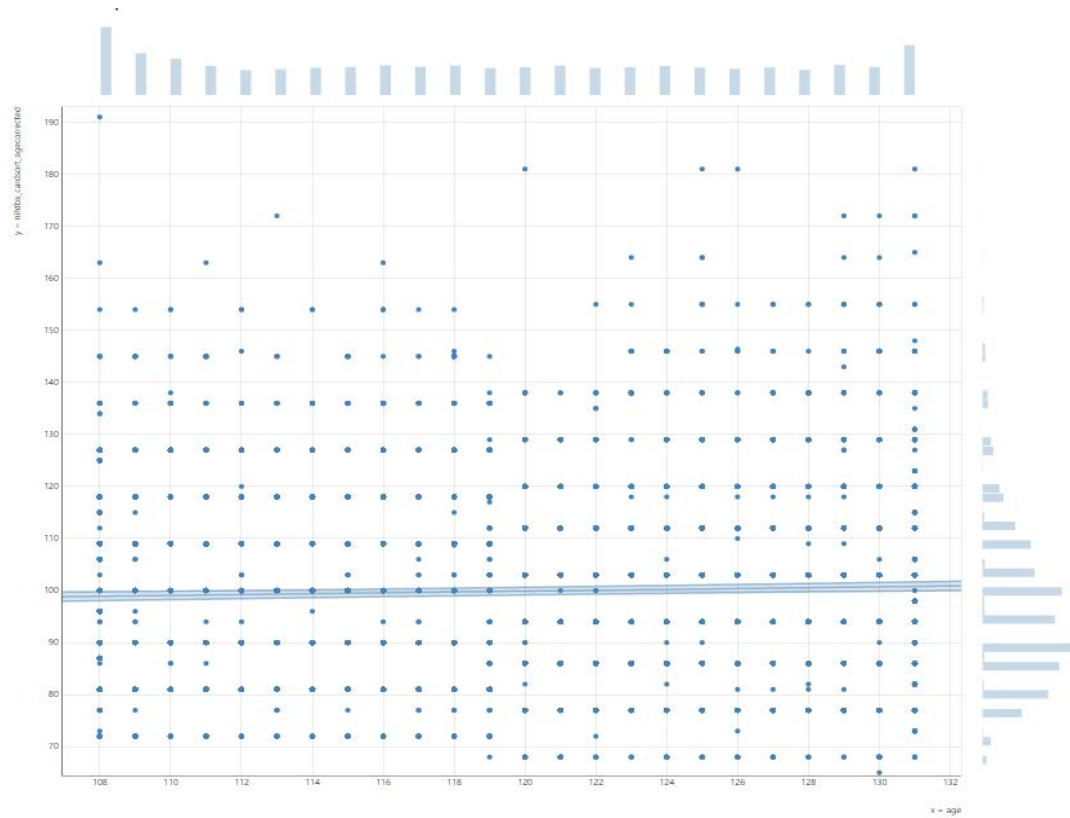
Figure 1. Association between Age and DCCS Score (Cognitive Flexibility) overall
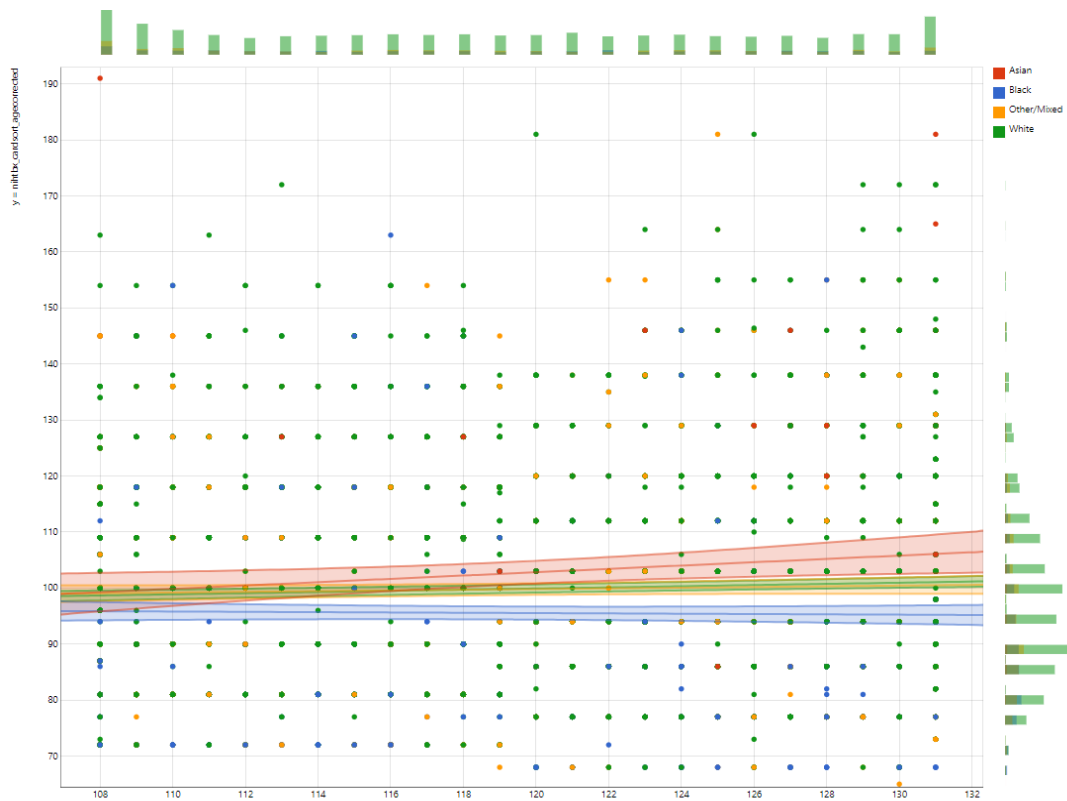

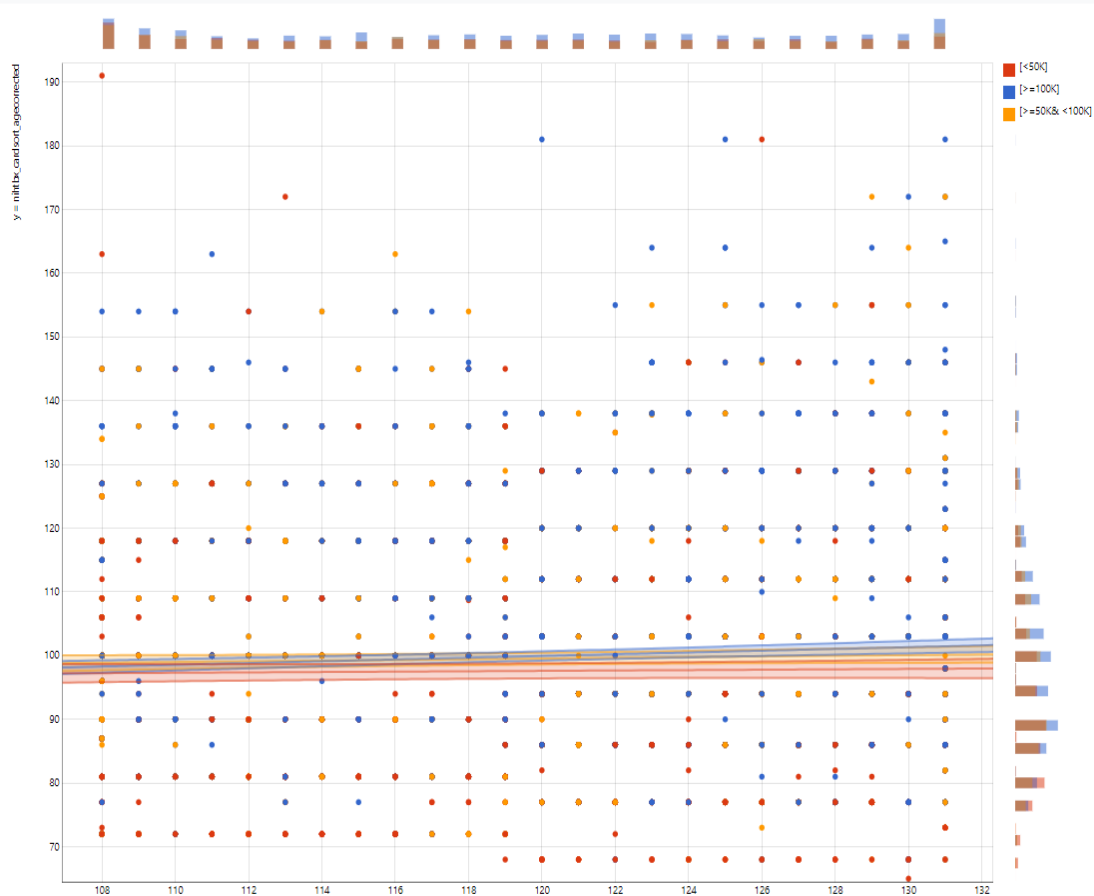**Figure 2. Association between Age and DCCS Score (Cognitive Flexibility) by Race**

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Figure 3. Association between Age and DCCS Score (Cognitive Flexibility) by Income

5. Discussion

This study showed a positive association between age and DCCS score (cognitive flexibility) overall; however, this association was stronger for White and high-income than for Black and low-income children. That is, while age boosts the cognitive flexibility for American children, this effect is weaker in Black and low-income than in White and high-income families. As a result, older Black children and older poor children have low cognitive flexibility, a pattern which is absent for White and high-income children. In White and high-income families, age shows a substantial boosting effect on cognitive flexibility. We argue that due to structural inequalities, age-related development of cognitive flexibility is hindered in Black and low-income children.

Our finding is in line with MDRs of age on cognitive flexibility for Black children. This finding is in full harmony with what is already established on the MDRs of economic resources effect on children's impulsivity (Assari, Akhlaghipour et al., 2020), reward responsiveness (Assari, Boyce, Akhlaghipour et al., 2020), impulsivity (Assari, Caldwell, & Mincy, 2018a), inhibitory control (Assari, 2020d), attention (Assari, Boyce, & Bazargan, 2020), and ADHD (Assari & Caldwell, 2019a) in Black families. Similar MDRs are also reported for the effects of family SES indicators such as parental education, household

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income, marital status on behavioral risks such as aggression (S. Assari, C. H. Caldwell, et al., 2019), substance use (Assari, Caldwell et al., 2019), and mental health risks such as anxiety (Assari, Caldwell, & Zimmerman, 2018), depression (Assari & Caldwell, 2018a), and suicide (Assari, Boyce, Bazargan, & Caldwell, 2020a) in Black children. These are all diminishing returns of economic resources for Black compared to White youth (Assari, 2018a, 2018c, 2019a; Assari, Farokhnia et al., 2019). As we found similar results for race and income (MDRs in poor as well as Black families), the observed MDRs in Black families are attributed to social rather than biological processes.

The observed MDRs are not specific to one specific domain or outcome, suggesting that they are due to society but not culture, behavior, or biology. Thus, the decreased association between age and cognitive flexibility seen in Black children is not due to genetics, nor is it due to an innate difference in their cognitive ability.   This is evident because similar MDRs are shown for all marginalized groups with all types of marginalizing identities (Assari, 2017b; Assari, 2018). Thus, they are not only specific to Blacks (Assari, Thomas et al., 2018) but also to Hispanics (Assari, 2018e; Assari, 2019; Assari, Farokhnia et al., 2019; Shervin & Ritesh, 2019), Asian Americans (Assari, Boyce, Bazargan, & Caldwell, 2020b), Native Americans (Assari & Bazargan, 2019), LGBTQs (Assari, 2019a), immigrants (Assari, 2020b), and even marginalized Whites (Assari, Boyce, Bazargan, Caldwell, & Zimmerman, 2020). These MDRs are also not specific to a particular age group, as documented for children (Assari, Caldwell, & Mincy, 2018a; Assari, Caldwell, & Mincy, 2018b; Assari, Thomas et al., 2018), adults (Assari, 2018a), and older adults (Assari & Lankarani, 2016a). Finally, these MDRs are relevant to economic resources such as SES (Assari, Preiser, Lankarani, & Caldwell, 2018), (Assari, Farokhnia et al., 2019), (Assari, Caldwell, & Mincy, 2018a), (Assari, 2018d), (Assari, Caldwell, & Zimmerman, 2018), and non-economic assets such as self-efficacy (Assari, 2017a; Assari & Lankarani, 2016b). This paper extends the MDRs literature to the effects of age on cognitive performance in Black families (Chalian et al., 2019). A recent study established similar results for immigrants compared to non-immigrants, again emphasizing that these effects are social rather than biological (Assari, Boyce, Bazargan, & Caldwell, 2020).

A wide range of sociological and economic mechanisms explain the MDRs of age and economic resources on cognitive flexibility for Black related to White families (and also in low-income families). Black families experience high levels of stress across all SES levels (Bowden, Bartkowski, Xu, & Lewis Jr., 2017). Social mobility is more taxing for Black than for White families (Chetty, Hendren, Kline, & Saez, 2014). At all SES levels, exposure (Assari, 2018b; Assari, Gibbons, & Simons, 2018a; Assari, Gibbons, & Simons, 2018b; Assari, Lankarani, & Caldwell, 2018; Assari & Moghani Lankarani, 2018) and vulnerability (Assari, Preiser et al., 2018) to discrimination is high for Black families. While low SES Black families struggle with food insecurity, poverty, and neighborhood disorder, high SES Black families experience discrimination due to proximity to Whites (Assari, Gibbons et al., 2018a; Assari, Gibbons et al., 2018b). As discrimination reduces the chance of healthy brain development (Assari & Caldwell, 2018b; Assari, Lankarani et al., 2018; Assari, Preiser et al., 2018), Black children may remain

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at risk of impulsivity across the whole SES spectrum. This offers an explanation to why age, the main driver of development, shows weaker Black effects than White children.

While low SES and poor outcomes are one type of disadvantage in Black communities, MDRs reflect a qualitatively different set of disadvantages (Assari, 2017b; Assari, 2018). The former reflects unequal outcomes and opportunities, and the latter is reflective of low response to the presence of individual-level resources such as age and SES. It is due to the latter that policymakers may observe sustained inequality despite investments. To address the latter, there is a need to address the systemic causes of inequalities. As a result of the combination of these two, Black families experience double jeopardies: not only resources such as SES are scarce, their influences are also hindered and dampened, given the many constrains in their environment (Assari, 2018; Assari, 2018f).

Multilevel economic and environmental mechanisms are in play that reduce the marginal returns of economic and non-economic resources and assets such as family SES and age (Assari, 2018; Assari, 2018f). MDRs are probably caused by social stratification, racism, and marginalization. These processes function across multiple societal institutions and levels (Assari, 2018; Assari, 2018f). Racial injustice, prejudice, and discrimination have historically interfered with the gain of resources and assets for the Black communities (Hudson, Sacks, Irani, & Asher, 2020; Hudson, Bullard et al. 2012; Hudson, Neighbors, Geronimus, & Jackson, 2012). Black children live in poorer neighborhoods and attend worse schools compared to their White counterparts, even when they are from the very same SES backgrounds (Assari, Boyce, Caldwell, Bazargan, & Mincy, 2020; Boyce, Bazargan, Caldwell, Zimmerman, & Assari, 2020). Another known cause of MDRs is childhood poverty (Bartik & Hershbein, 2018). As a result of environmental and structural injustice, we observe MDRs across resources, assets, outcomes, settings, and age groups. This paper broadens the effect of MDRs as it shows that it can also interfere with normal age-related cognitive development of Black children.

6. Limitations

The current study has some methodological shortcomings. First, because of a cross-sectional design, it is inappropriate for us to draw any causal inferences. However, age is a known determinant of cognitive development. The direction of the association between age and cognitive flexibility is from age to cognitive performance, not vice versa. Still, the findings reported here should be interpreted as correlations, not causes. To establish stronger causal evidence, we need to use longitudinal data with multiple observations of cognitive performance over time. Such research will help us map changes and trajectories of cognitive function that occur as the child ages to structural barriers that surrounds Black and low-income families. Our expectation is that the age-related trajectories in cognitive development would only be hindered in Black children who receive fewer cognition-promoting stimuli, live in worse neighborhoods, and attend worse schools when compared to their White counterparts.

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Similarly, we only tested the MDRs of age. Previous work had established MDRs of family SES on cognitive and emotional outcomes (Assari, Caldwell, & Mincy, 2018a), (S. Assari, 2020c; Assari, Akhlaghipour et al., 2020; Assari, Boyce, Akhlaghipour et al., 2020). Future research should test if MDRs in any other domain, such as SES, can explain the observed MDRs of age. In addition, we only controlled for family-SES, and all our confounders were individual-level. It is imperative to control for contextual and neighborhood-level indicators as well as physical and mental health status. For example, we did not control for autism, ADHD, and other conditions that can interfere with cognitive development of children. Finally, we did not study how these MDRs emerge or change over time. Such research is necessary if we wish to find a window of opportunity for intervention. More research is needed on how the observed MDRs-related Black-White inequalities in cognitive performance narrow, maintain, or widen over time and how they contribute to the future Black-White gap in educational and economic success.

7. Conclusions

Relative to their White counterparts, Black children show lower cognitive flexibility at all age groups. This Black-White gap is shaped by social forces rather than biological differences as we found the same pattern in low- vs high- income families. These diminished returns of age on cognitive development are important because cognitive flexibility is a driver for a wide range of education and economic outcomes later in life. To minimize the Black-White gap in brain development, there is a need to address societal barriers that cause MDRs of age and other economic and non-economic resources and assets in Black communities. There is a need for public and social policies beyond individual-level risk factors and address systemic, structural, and societal causes of inequalities. Enhancing quality of education in predominantly Black neighborhoods is needed.

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Appendices

Appendix 1. Distribution of Predictor (a), Outcome (b), Qnantiles (c), and Residuals (d)

a   b   c   d
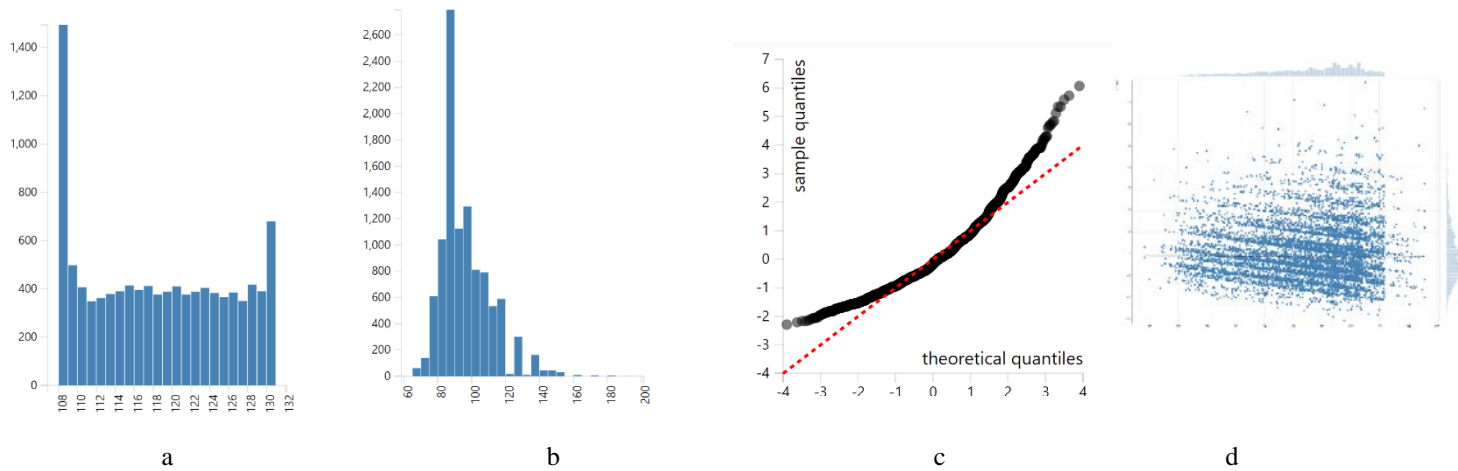
Appendix 2. Model Formula

Model 1

nihtbx_cardsort_agecorrected ~ age + race.4level + sex + high.educ.bl + married.bl +

household.income.bl + hisp

Model 2

nihtbx_cardsort_agecorrected ~ age + race.4level + sex + high.educ.bl + married.bl +

household.income.bl + hisp + age x race.4level

Model 3

nihtbx_cardsort_agecorrected ~ age + race.4level + sex + high.educ.bl + married.bl +

household.income.bl + hisp + age x household.income.bl

All Models: Random: ~(1|abcd_site/rel_family_id)