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Original Paper

Not Race or Age but Their Interaction Predicts Pre-Adolescents' Inhibitory Control

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Abstract

Background: *African American pre-adolescents are at a higher risk of risky behaviors such as aggression, drug use, alcohol use, and subsequent poor outcomes compared to Caucasian pre-adolescents. All these high-risk behaviors are connected to low levels of Inhibitory Control (IC).* ***Aim:*** *We used the Adolescent Brain Cognitive Development (ABCD) data to compare Caucasian and African American pre-adolescents for the effect of age on pre-adolescents IC, a driver of high-risk behaviors.* ***Methods:*** *This cross-sectional analysis included 4,626 pre-adolescents between ages 9 and 10 from the ABCD study. Regression was used to analyze the data. The predictor variable was age measured in months. The main outcome was IC measured by a Stop-Signal Task (SST). Race was the effect modifier.* ***Results:*** *Overall, age was associated with IC. Race also showed a statistically significant interaction with age on pre-adolescents' IC, indicating weaker effects of age on IC for African American than Caucasian pre-adolescents.* ***Conclusion:*** *Age-related changes in IC are more pronounced for Caucasian than African American pre-adolescents. To eliminate the racial gap in brain development between African American and Caucasian pre-adolescents, we should address structural and societal barriers that alter age-related development for racial minority pre-adolescents. Social and public policies, rather than health policies, are needed to address structural and societal barriers that hinder African American adolescents' brain development. Interventions should add resources to the urban areas that many African American families live in so their children can have better age-related brain*

development. Such changes would be essential given IC in pre-adolescents is a predictor of a wide range of behaviors.

Keywords

Race, ethnicity, age, age-related development, pre-adolescents, impulse, brain, inhibitory control

1. Introduction

Inhibitory Control (IC), the ability to control one's own impulses in order to select a more appropriate behavior in line with long-term goals (Chikara, Lo, & Ko, 2020; Deater-Deckard, Li, Lee, King-Casas, & Kim-Spoon, 2019), is closely correlated with a wide range of risk behaviors and factors such as poor diet and unhealthy eating, obesity and high body mass index, poor academic performance, weak social relations, problem behaviors, aggression, substance use, and early sexual debut (Bartholdy et al., 2019; Bessette et al., 2020; Cabello, Gutierrez-Cobo, & Fernandez-Berrocal, 2017; Dieter et al., 2017; Ely et al., 2020; Huijbregts, Warren, de Sonneville, & Swaab-Barneveld, 2008; Humphrey & Dumontheil, 2016; Porter et al., 2018; Troller-Renfree et al., 2019). Low IC is also a characteristic of Attention Deficit Hyperactivity Disorder (ADHD) (Neely et al., 2017). Pre-adolescents from high Socioeconomic Status (SES) non-Hispanic Caucasian families who show high IC levels would be less likely to engage in a wide range of risk behaviors, relative to high SES pre-adolescents when compared to their counterparts from low SES and African American families (Deater-Deckard et al., 2019; Froeliger et al., 2017; Hao, 2017; Hsieh & Chen, 2017; Nakamichi, 2017). Some research suggests that IC may be specifically crucial for boys' risk-taking behaviors, such as aggressive behavior (Cabello et al., 2017). Low IC may be one of the many mechanisms explaining racial and economic disparities in high-risk behaviors (Cueli, Areces, Garcia, Alves, & Gonzalez-Castro, 2020; Deater-Deckard et al., 2019; Mora-Gonzalez et al., 2020; Porter et al., 2018; Zhang, Wang, Liu, Song, & Yang, 2017).

Compared to Caucasian pre-adolescents, African American pre-adolescents are at an increased risk of aggression (Cotten et al., 1994) and early sexual debut (Cavazos-Rehg et al., 2009). As these undesired behavioral outcomes early in life are shown to be gateways for a wide range of future economic, emotional, and behavioral outcomes later in life (Burchinal et al., 2011; Cohen & Sherman, 2005; Gorey, 2009; Hair, Hanson, Wolfe, & Pollak, 2015), there is a need to study why and how IC is lower in African American and Caucasian pre-adolescents. Such knowledge has the potential to help with closing racial inequalities later in life (Burchinal et al., 2011; Cohen & Sherman, 2005; Gorey, 2009; Hair et al., 2015). There is a close overlap between race and SES in the United States of America, meaning that African Americans have lower SES and experience a higher level of a wide range of adversities (Ahmad, Zulaily, Shahril, Syed Abdullah, & Ahmed, 2018; Merz, Tottenham, & Noble, 2018; Valencia, Tran, Lim, Choi, & Oh, 2019). As such, African American adolescents face high levels of food insecurity, housing insecurity, family instability, economic adversities, stress, trauma, and financial difficulties (DeSantis et al., 2007; Dismukes et al., 2018; Hanson et al., 2015; Miller & Taylor, 2012). However, an open question

is whether the effects of race and associated SES are direct (Alvarado, 2018; Barreto, de Figueiredo, & Giatti, 2013; Hemovich, Lac, & Crano, 2011; Schreier & Chen, 2013) or may operate by delaying healthy age-related changes in the brain. While Caucasians, through low access to SES and associated buffers and resources, live in a context in which age-related development may naturally occur (Alvarado, 2018; Barreto et al., 2013; Hemovich et al., 2011; Schreier & Chen, 2013), the same may not be accurate for African Americans whose daily life means low access to resources, high stress, and trauma (Kaufman, Cooper, & McGee, 1997) that may interfere with healthy age-related brain development.

Both mediation (Bell, Sacks, Thomas Tobin, & Thorpe, 2020; Fuentes, Hart-Johnson, & Green, 2007; Kaufman et al., 1997; Samuel, Roth, Schwartz, Thorpe, & Glass, 2018) and moderation (Assari, 2017d; Assari, 2018a) explanations have been tested for racial health inequalities across age groups, including but not limited to pre-adolescents and adolescents. The first clusters of hypotheses, more traditional ones, have attributed racial gaps in pre-adolescents outcomes to the existing SES or stress gaps between African American and Caucasian families (Bell et al., 2020; Fuentes et al., 2007; Kaufman et al., 1997; Samuel et al., 2018). In these hypotheses, low SES and high stress emerge across racial minorities, including African American pre-adolescents (Assari, 2016, 2017b; Assari, Khoshpouri, & Chalian, 2019). If these hypotheses are supported, then a real solution to closing racial inequalities is eliminating the SES gap through economic policies that redistribute income (e.g., tax policies, minimum wage). As such, African American families' economic empowerment becomes the core strategy for closing the racial inequalities in pre-adolescents and beyond (Williams, 1999; Williams, Costa, Odunlami, & Mohammed, 2008).

The alternative explanation, however, argues that SES indicators (Assari, 2017d; Assari, 2018a), age, and other resources show weaker effects for African Americans than Caucasians, a pattern known as Minorities' Diminished Returns (MDRs) Supported by extensive recent literature under the umbrella term MDRs, all economic and non-economic resources such as education (Assari, Farokhnia, & Mistry, 2019) parental education (Assari, 2018d; Assari, 2018b; Assari, 2018e), income (S. Assari, C. H. Caldwell, & R. Mincy, 2018a; Assari, Thomas, Caldwell, & Mincy, 2018), marital status (Assari & Bazargan, 2019a), and coping (Assari, 2017a, 2017c; Assari & Lankarani, 2016b) all generate less-than-expected tangible developmental outcomes for African Americans than Caucasians. This is partly due to the qualitative difference between African American and Caucasian families' lives, so the latter gets and the former does not get the opportunities to mobilize their resources to secure tangible outcomes (Assari, 2017d, 2018a, 2018e; Assari, Caldwell, & Mincy, 2018a; Assari, Caldwell, & Zimmerman, 2018; Assari & Hani, 2018). As a result of these MDRs, we observe worse than expected outcomes across all SES levels of African American families (Assari, 2017d; Assari, 2018a; Assari, Caldwell, & Mincy, 2018a; S. Assari, C. H. Caldwell, & R. B. Mincy, 2018b; Assari, Thomas, et al., 2018). That is, low and high SES African American adolescents show the same (high) level of impulsivity (Assari, Caldwell, & Mincy, 2018a), ADHD (Assari & Caldwell, 2019a), depression (Assari

& Caldwell, 2018a), anxiety (Assari, Caldwell, & Zimmerman, 2018), aggression (Assari, Caldwell, & Bazargan, 2019), grade point average (GPA) (Assari S, 2019; Assari & Caldwell, 2019b; Assari, Caldwell, et al., 2019), and substance use (Assari, Caldwell, et al., 2019) while for Caucasian adolescents, high SES means low risk. If MDRs are true (Assari & Caldwell, 2018a; Assari, Caldwell, et al., 2019; Assari, Caldwell, & Mincy, 2018a; Assari, Caldwell, & Mincy, 2018b; Assari, Thomas, et al., 2018), then a real solution requires moving beyond SES and targeting structural inequalities that hinder one group and promote the other.

1.1 Aims

To fill the literature gap on social and developmental determinants of IC, which itself is a mechanism for a wide range of undesired behaviors (Bartholdy et al., 2019; Bessette et al., 2020; Cabello et al., 2017; Dieter et al., 2017; Ely et al., 2020; Huijbregts et al., 2008; Humphrey & Dumontheil, 2016; Porter et al., 2018; Troller-Renfree et al., 2019), and to expand the MDRs literature, we studied the separate, additive, and interactive effects of race and age on pre-adolescents IC. To do so, we compared African American and Caucasian pre-adolescents for the effects of age on IC. As suggested by the MDRs, we expected age-related changes in IC, however, we expected these changes to be smaller for African American than Caucasian pre-adolescents. The results would have implications for pre-adolescents, and beyond, IC is a core predictor of high-risk behaviors (Bartholdy et al., 2019; Bessette et al., 2020; Cabello et al., 2017; Dieter et al., 2017; Ely et al., 2020; Humphrey & Dumontheil, 2016; Porter et al., 2018; Troller-Renfree et al., 2019) and may explain why family SES and race are linked to many high-risk behaviors pre-adolescents (Bruce et al., 2013; Holochwost, Volpe, Gueron-Sela, Propper, & Mills-Koonce, 2018; Skowron, Cipriano-Essel, Gatzke-Kopp, Teti, & Ammerman, 2014; Swingler, Isbell, Zeytinoglu, Calkins, & Leerkes, 2018; Zaidman-Zait & Shilo, 2018).

2. Methods

2.1 Design and Settings

A secondary analysis was performed with a cross-sectional design. We used 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, a landmark study of brain development from pre-adolescence to emerging adults, is a unique study in the United States. Although details of the ABCD methods, measures, design, sample, and sampling are described elsewhere (Alcohol Research: Current Reviews Editorial, 2018; Auchter et al., 2018), here we briefly review them.

2.2 Participants and Sampling

In the ABCD, we only included pre-adolescents who were between the ages of 9 and 10 years. The ABCD pre-adolescents were enrolled from multiple cities across the states. Overall, pre-adolescents were recruited to the ABCD study from a total of 21 sites. The primary strategy for sampling in the

ABCD study was recruiting from school systems (Garavan et al., 2018). In the current analysis, the sample was 4626 participants. Our analysis's inclusion criteria were having valid data on race, ethnicity, age, family SES, and task-based IC. Additionally, participants should only be African American or Caucasian.

2.3 Study Variables

The study variables included race, ethnicity, age, sex, family SES (parental education), family marital status, and task-based IC.

Inhibitory Control (IC). The ABCD study applied the Stop-signal Task (SST) to measure pre-adolescents' IC levels. The SST used in the ABCD applied two runs of 180 trials. Pre-adolescent subjects were shown images of a black arrow that were either pointing to right or left. These pictures were displayed on the monitor while the participant was in the scanner. Participants were asked to click the appropriate button that corresponds with the arrow direction as soon as they can see the image. Participants were instructed that they should all use their dominant hand. From all 180 trials, 30 did not display either of the options, signaling the participant to inhibit their answers. These were randomly dispersed throughout the trial. IC in this study was defined as a successful inhibition of motor response. Impulsivity was defined as answering with a wrong answer or an unsuccessful inhibition. For this study, IC was captured as the total number of "Stop" trials answered incorrectly (tfmri_sst_all_beh_incrs_nt). IC was treated as a continuous measure. A higher score was indicative of a higher level of IC (Carver, Livesey, & Charles, 2001; Clark, King, & Turner, 2020; Dupuis et al., 2019; Hiraoka, Kinoshita, Kunimura, & Matsuoka, 2018).

Race. Race, a self-identified variable, was a binary variable: 1 for African Americans and 0 for Caucasians (reference category).

Age. Age (months), calculated as the difference between birth and the time of enrollment to the study, measured in months, was reported by parents.

Sex. A dichotomous variable, sex was coded as below: males = 1, females = 0.

Marital status. Parental marital status, a dichotomous variable, was self-reported by the parents and was coded as married = 1 vs. other = 0.

Parental Educational Attainment. Participants were asked, "What is the highest grade or level of school you have completed or the highest degree you have received?" Responses ranged from 0 for never attended or kindergarten only to 21 for a doctoral degree. This variable, with a range between 1 and 21, was treated as an interval variable.

2.4 Data Analysis

*T*he statistical package, SPSS, was applied for data analysis. Mean, Standard Deviation (SD), frequency, and relative frequency (%) were used to describe the study variables. We also performed an independent t-test and Chi-square test for bivariate comparison of the groups for the study variables. For multivariable modeling, four regression models were applied. *Model 1,* an overall model, was performed without the

interaction terms. *Model 2*, another overall model, also added an interaction term between race and age (months). *Model 3* and *Model 4* were tested in Caucasian and African American pre-adolescents. In our models, age was used as the predictor, sex and family SES as the covariates, IC as the outcome, and race as the effect modifier. Unstandardized coefficient (b), SE, 95% CI, and p-value were reported for our model. p equal or less 0.05 was significant.

2.5 Ethics

The ABCD study protocol received Institutional Review Board (IRB) approval from several institutions, including but not limited to the University of California, San Diego (UCSD). All participating pre-adolescents provided assent. All participating parents signed informed consent (Auchter et al., 2018). As we only performed a secondary analysis of fully de-identified data, our study did not require an IRB review (exempt from a full IRB review).

3. Results

3.1 Descriptives

A total number of 4626 9-10 years old pre-adolescents were analyzed. Participants were mainly Caucasian (n = 3513; 75.5%), and only 24.1 (n=1113) were African Americans. Table 1 presents a summary of the descriptive statistics for the total sample and Caucasian and African American pre-adolescents.

Table 1. Data overall and by Race (n = 4,626)

	All		***Caucasians***		***African Americans***	
	n	**%**	***n***	**%**	***n***	**%**
Race						
Caucasian	3513	75.9	3513	100.0	-	-
African American	1113	24.1	-	-	1113	100.0
Ethnicity						
Non-Hispanic	3872	83.7	2855	81.3	1017	91.4
Hispanic	754	16.3	658	18.7	96	8.6
Sex						
Male	2273	49.1	1713	48.8	560	50.3
Female	2353	50.9	1800	51.2	553	49.7
Marital status*						
Other	1437	31.1	692	19.7	745	66.9
Married	3189	68.9	2821	80.3	368	33.1
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
Age (Year)	118.44	7.41	118.36	7.44	118.69	7.32
Parental Educational Attainment*	16.82	2.53	17.26	2.36	15.42	2.55

Financial Difficulties*	0.07	0.15	0.04	0.12	0.14	0.21
Family Income*	7.26	2.43	7.90	1.95	5.26	2.70
IC (Total number of "Stop" trials answered incorrect)	27.01	7.20	27.16	6.77	26.54	8.41

IC= Inhibitory Control, SD= Standard Deviation

* $p < 0.05$

3.2 Multivariate Analysis: All

Table 2 shows a summary of the two regression models' results in the overall (pooled) sample. *Model 1* (Main Effect Model) did not show a significant effect of age on IC. *Model 2* (Interaction Model) showed an interaction between race and age on IC, suggesting that the effect of age on IC is weaker for African American compared to Caucasian pre-adolescents.

Table 2. Overall Regression Models (n = 4,626)

	Model 1 Main Effects					Model 2 Interaction Effects				
	B	SE	95% CI		p	B	SE	95% CI		P
Race (African American)	-0.44	0.29	-1.02	0.13	.132	7.37	3.99	-0.45	15.19	.065
Ethnicity (Hispanic)	-0.36	0.30	-0.95	0.22	.225	-0.37	0.30	-0.95	0.22	.218
Sex (Male)	1.40	0.21	0.99	1.82	< .001	1.40	0.21	0.99	1.82	< .001
Married household	0.04	0.29	-0.53	0.60	.898	0.05	0.29	-0.52	0.62	.866
Parental Educational Attainment	0.04	0.05	-0.06	0.15	.419	0.05	0.05	-0.06	0.15	.401
Financial Difficulty	-0.16	0.76	-1.66	1.34	.834	-0.14	0.76	-1.63	1.36	.857
Family Income	0.03	0.07	-0.10	0.17	.633	0.03	0.07	-0.11	0.16	.684
Age	0.02	0.01	-0.01	0.05	.196	0.03	0.02	0.00	0.07	.037
Age x Race	-	-	-	-	-	-0.07	0.03	-0.13	0.00	.050

Outcome: IC: Total number of "Stop" trials answered incorrect

b= Unstandardized Regression Coefficient

SE= Standard Error

CI= Confidence Interval

3.3 Multivariate Analysis: Each race

Table 3 summarizes two regression models, one in Caucasians, and one in African Americans. We found the effect of age on IC for Caucasian but not African American pre-adolescents.

Table 3. Race-specific Regression Models (n = 4,626)

	Model 3 Caucasians					Model 4 African Americans				
	B	SE	95% CI		p	B	SE	95% CI		p
Ethnicity (Hispanic)	-0.48	0.32	-1.10	.128	-1.52	-1.00	0.91	.270	0.78	-1.10
Sex (Male)	1.41	0.23	0.96	.000	6.20	1.35	0.50	.008	2.34	2.67
Married household	-0.07	0.32	-0.70	.822	-0.23	0.36	0.63	.575	1.60	0.56
Parental Educational Attainment	0.05	0.06	-0.07	.412	0.82	0.05	0.12	.661	0.29	0.44
Financial Difficulty	-0.47	1.03	-2.48	.647	-0.46	0.03	1.25	.980	2.49	0.02
Family Income	-0.07	0.08	-0.23	.403	-0.84	0.15	0.13	.240	0.41	1.17
Age	0.03	0.02	0.00	.026	2.23	-0.03	0.03	.370	0.04	-0.90

Outcome: IC: Total number of “Stop” trials answered incorrect

b= Unstandardized Regression Coefficient

SE= Standard Error

CI= Confidence Interval

4. Discussion

We found that IC correlates with age for Caucasian but not African American pre-adolescents. Due to the race by age interaction, age-related brain development in pre-adolescents may be delayed/hindered. This finding is an indicator of diminished age-related brain development of African American than Caucasian pre-adolescents.

Diminishing returns of age on IC is in line with the MDRs of family SES on IC (Assari, 2020c). It is also in line with the diminished returns of SES on impulsivity (Assari, Caldwell, & Mincy, 2018a), attention deficit hyperactivity disorder (Assari & Caldwell, 2019a), depressed mood (Assari & Caldwell, 2018a), anxious mood (Assari, Caldwell, & Zimmerman, 2018), aggressive behaviors (Assari, Caldwell, et al., 2019), academic achievement (Assari S, 2019; Assari & Caldwell, 2019b; Assari, Caldwell, et al., 2019), and tobacco use (Assari, Caldwell, et al., 2019). In other studies, MDRs were found for childhood trauma and stress (Assari, 2020a; Assari, 2020b).

This is not the first study on MDRs, but it extends the literature by documenting MDRs of age-related brain development in African American when compared with Caucasian pre-adolescents. Many empirical studies have already documented MDRs for African Americans (Assari, 2018a, 2018c; S. Assari, 2019a; Assari, Farokhnia, et al., 2019). Past research shows that MDRs are not limited to pre-adolescents as they can be seen for all age groups such as adolescents (Assari, Caldwell, & Mincy, 2018a; Assari, Caldwell, & Mincy, 2018b; Assari, Thomas, et al., 2018), adults (Assari, 2018a), and older adults (Assari & Lankarani, 2016a). Also, MDRs is not a pattern that can be exclusively seen for African Americans (Assari, Thomas, et al., 2018). In fact, same patterns are shown for Hispanic (Assari,

2018g; Shervin Assari, 2019; Assari, Farokhnia, et al., 2019; Shervin & Ritesh, 2019) Asian American (Assari, Boyce, Bazargan, & Caldwell, 2020), Native American (Assari & Bazargan, 2019a), Lesbian, Gay, Bisexual (LGB) (S. Assari, 2019a), poor Caucasian (Assari, Boyce, Bazargan, Caldwell, & Zimmerman, 2020), and even immigrant (Assari, 2020b) people.

Several potential intuitive mechanisms may explain MDRs of age-related brain development in African American pre-adolescents. African American families and their pre-adolescents face many stressors and adversities, including financial stress, race-related stress, and environmental pollutants (Marshall et al., 2020). Unfortunately, these structural aspects impact the lives of African Americans across SES levels (Assari, 2018a; Assari, 2018h). African Americans have a low chance of upward social mobility (Chetty, Hendren, Kline, & Saez, 2014) and pay very high costs when they succeed (Hudson, Sacks, Irani, & Asher, 2020). For African American families, stress and discrimination are always high, regardless of SES (Assari, 2018b; Assari, Gibbons, & Simons, 2018a; Assari, Gibbons, & Simons, 2018b; Assari, Lankarani, & Caldwell, 2018; Assari & Lankarani, 2018). For African American families, low SES means living in poor areas, and high SES means high exposure to Caucasian families, which means very high levels of exposure to discrimination (Assari, Gibbons, et al., 2018a; Assari, Gibbons, et al., 2018b). Stress across domains, including but not limited to race-related discrimination, interferes with normal brain development (Assari & Caldwell, 2018b; Assari, Lankarani, et al., 2018; Assari, Preiser, Lankarani, & Caldwell, 2018).

An example of structural causes of inequalities that generates MDRs in the USA is residential segregation. As a result of residential segregation, African American families live in resource-scarce environments full of stress and poverty. Due to residential segregation, African American pre-adolescents attend poor schools across SES levels (Assari, Boyce, Bazargan, Caldwell, et al., 2020; Boyce, Bazargan, Caldwell, Zimmerman, & Assari, 2020; Boyce, 2020). As a result, African American adolescents do not access many educational resources that stimulate brain development (Assari, 2019b; Assari, 2019; Assari & Caldwell, 2019b). However, poor education and schooling are only among the many differences in the lives of Caucasian and African American families (Jefferson et al., 2011). African American parents report a high level of stress across all SES levels (Assari, 2020a; Assari & Bazargan, 2019b). High SES African American families experience more, not less, discrimination compared to low SES African American families (Assari, Gibbons, et al., 2018a; Assari, Gibbons, et al., 2018b; Assari, Lankarani, et al., 2018; Hudson, Bullard, et al., 2012; Hudson, Puterman, Bibbins-Domingo, Matthews, & Adler, 2013), which is in part due to proximity to Whites (Assari, 2018b; Assari & Lankarani, 2018).

It is important to note that MDRs reflect a particular class of disadvantage for racial minorities (Assari, 2017d; Assari, 2018a). While some disadvantages are due to lack of access to SES resources, MDRs of SES and age mean that African Americans experience poor outcomes across the same resources and assets (e.g., SES or age). Thus, research, practice, and policy should not merely focus on differential

access to SES and different profiles of exposure to risk factors as causes of inequality. Policymakers and researchers should be aware that some observed inequalities are due to differential returns of age, SES, and other resources and assets. This type of disadvantage places African Americans at high risk across all levels of resources. It is also more difficult to undo MDRs-related inequalities than those that are due to poverty and low SES (Assari, 2018a; Assari, 2018h).

MDRs theory is a sociological rather than a biological explanation of health inequality. Among multilevel causes of MDRs, including economic, psychological, and societal mechanisms (Assari, 2018a; Assari, 2018h), racism and discrimination have a leading role. Racism operates across multiple institutions and social structures (Assari, 2018a; Assari, 2018h). If MDRs are due to racism, then a real solution to health disparities should also address MDRs-related inequalities. Such an approach requires increasing racial justice in the US. Age can only generate the same brain development when all racial groups have the same opportunity for brain development (Hudson et al., 2020; Hudson, Bullard et al., 2012; Hudson, Neighbors, Geronimus, & Jackson, 2012).

African American families may stay in poor neighborhoods at all SES levels(Assari, Boyce, Caldwell, Bazargan, & Mincy, 2020). Caucasians, however, live in low-stress environments when they have high SES (Assari, 2018b; Assari, Preiser, & Kelly, 2018). Thus, even when they have similar SES, African American families' living conditions drastically differ from those of their Caucasian counterparts (Assari, 2018f; Assari & Bazargan, 2019b; Assari & Bazargan, 2019b; Assari S; Assari, 2019; Assari, Gibbons et al., 2018a; Assari, Gibbons et al., 2018b; Assari, Lankarani et al., 2018). Similarly, across all SES levels, African American adolescents spend time with high-risk peers(Boyce et al., 2020; Shanika Boyce, 2020). However, high SES Caucasian adolescents have low-risk peers and family members (Assari, Boyce, Bazargan, & Caldwell, 2020; Assari, Caldwell et al., 2019). The current study only documented MDRs of age-related brain development without digging into their societal and contextual causes. We argue that age shows a weaker effect on the brain development of children in less enriched environments.

4.1 Implications

The major implications of knowledge regarding MDRs-related inequalities are that it helps us rethink the structural causes of inequalities. Such knowledge is essential for finding the societal causes of racial disparities. It even helps us move our policies beyond equal access as a goal. In the presence of MDRs, equal access fails to generate equal outcomes. Due to MDRs of resources/assets such as SES and age, equality does not generate equity. To achieve equity, we need to equalize access to SES and the very societal conditions that surround African American children's development. The daily experiences of African American families should be improved. Thus, age-related brain development would be more equal across racial groups.

4.2 Limitations

All studies, particularly secondary analysis of some existing data, are limited in their methodology. As our study used a cross-sectional approach, we cannot make causal inferences. While IC does not cause

age, age may impact IC. Still, longitudinal data are needed for establishing racial differences in the causal link between age and IC. More research is needed on MDRs of age as a source of brain development. MDRs are commonly shown for SES indicators such as parental education, family income, and marital status; however, less is unknown about MDRs of age-related brain development. Finally, we only described the MDRs of age-related brain development without exploring the mechanisms of the observed MDRs. Future work is needed on the role of SES, trauma, stress, context, and family in explaining the observed MDRs of age-related brain development in African American adolescents.

5. Conclusion

For 9-10-year old American children, age is a predictor of IC for Caucasian children. For African American pre-adolescents, however, IC remains poor at all ages. That means the brain's age-related development that shapes IC differs for African American and Caucasian pre-adolescents. The results may help us understand why high-risk behaviors such as alcohol use, aggression, and early sexual debut are more common in African American than Caucasian children and adolescents.

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References

Ahmad, A., Zulaily, N., Shahril, M. R., Syed Abdullah, E. F. H., & Ahmed, A. (2018). Association between socioeconomic status and obesity among 12-year-old Malaysian adolescents. *PLoS One*, *13*(7), e0200577. https://doi.org/10.1371/journal.pone.0200577

Alcohol Research: Current Reviews Editorial, S. (2018). NIH's Adolescent Brain Cognitive Development (ABCD) Study. *Alcohol Res*, *39*(1), 97. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/30557152

Alvarado, S. E. (2018). The impact of childhood neighborhood disadvantage on adult joblessness and income. *Soc Sci Res*, *70*, 1-17. https://doi.org/10.1016/j.ssresearch.2017.10.004

Assari, S. (2016). Distal, intermediate, and proximal mediators of racial disparities in renal disease mortality in the United States. *J Nephropathol*, *5*(1), 51-59. https://doi.org/10.15171/jnp.2016.09

Assari, S. (2017a). General Self-Efficacy and Mortality in the USA; Racial Differences. *J Racial Ethn Health Disparities*, *4*(4), 746-757. https://doi.org/10.1007/s40615-016-0278-0

Assari, S. (2017b). Number of Chronic Medical Conditions Fully Mediates the Effects of Race on Mortality; 25-Year Follow-Up of a Nationally Representative Sample of Americans. *J Racial Ethn Health Disparities*, *4*(4), 623-631. https://doi.org/10.1007/s40615-016-0266-4

Assari, S. (2017c). Race, sense of control over life, and short-term risk of mortality among older adults in the United States. *Arch Med Sci*, *13*(5), 1233-1240. https://doi.org/10.5114/aoms.2016.59740

Assari, S. (2017d). Unequal Gain of Equal Resources across Racial Groups. *Int J Health Policy Manag*, *7*(1), 1-9. https://doi.org/10.15171/ijhpm.2017.90

Assari, S. (2018a). Blacks' Diminished Return of Education Attainment on Subjective Health; Mediating Effect of Income. *Brain Sci*, *8*(9). https://doi.org/10.3390/brainsci8090176

Assari, S. (2018b). Does School Racial Composition Explain Why High Income Black Youth Perceive More Discrimination? A Gender Analysis. *Brain Sci*, *8*(8). https://doi.org/10.3390/brainsci8080140

Assari, S. (2018c). Family Income Reduces Risk of Obesity for White but Not Black Children. *Children (Basel)*, *5*(6). https://doi.org/10.3390/children5060073

Assari, S. (2018a). Health Disparities due to Diminished Return among Black Americans: Public Policy Solutions. *Social Issues and Policy Review*, *12*(1), 112-145. https://doi.org/10.1111/sipr.12042

Assari, S. (2018d). Parental Education Attainment and Educational Upward Mobility; Role of Race and Gender. *Behav Sci (Basel)*, *8*(11). https://doi.org/10.3390/bs8110107

Assari, S. (2018b). Parental Education Better Helps White than Black Families Escape Poverty: National Survey of Children's Health. *Economies*, *6*(2), 30. Retrieved from http://www.mdpi.com/2227-7099/6/2/30

Assari, S. (2018e). Parental Educational Attainment and Mental Well-Being of College Students; Diminished Returns of Blacks. *Brain Sci*, *8*(11). https://doi.org/10.3390/brainsci8110193

Assari, S. (2018f). Race, Intergenerational Social Mobility and Stressful Life Events. *Behav Sci (Basel)*, *8*(10). https://doi.org/10.3390/bs8100086

Assari, S. (2018g). Socioeconomic Status and Self-Rated Oral Health; Diminished Return among Hispanic Whites. *Dent J (Basel)*, *6*(2). https://doi.org/10.3390/dj6020011

Assari, S. (2018h). Unequal Gain of Equal Resources across Racial Groups. *Int J Health Policy Manag*, *7*(1), 1-9. https://doi.org/10.15171/ijhpm.2017.90

Assari, S. (2019a). Education Attainment and ObesityDifferential Returns Based on Sexual Orientation. *Behav Sci (Basel)*, *9*(2). https://doi.org/10.3390/bs9020016

Assari, S. (2019b). Parental Educational Attainment and Academic Performance of American College Students; Blacks' Diminished Returns. *J Health Econ Dev*, *1*(1), 21-31. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/31372601

Assari, S. (2019). Socioeconomic Determinants of Systolic Blood Pressure; Minorities' Diminished Returns. *Journal of Health Economics and Development*, *1*(1), 1-11. Retrieved from http://www.hedjournal.com/article_88938_d0f03c9e2607bdaeee1aa93938267b33.pdf

Assari, S. (2020a). College Graduation and Wealth Accumulation: Blacks' Diminished Returns. *World J Educ Res*, *7*(3), 1-18. https://doi.org/10.22158/wjer.v7n3p1

Assari, S. (2020a). Family Socioeconomic Status and Exposure to Childhood Trauma: Racial Differences. *Children*, *7*(6), 57. Retrieved from https://www.mdpi.com/2227-9067/7/6/57

Assari, S. (2020b). Income and Mental Well-Being of Middle-Aged and Older Americans: Immigrants' Diminished Returns. *International Journal of Travel Medicine and Global Health*, *8*(1), 37-43. https://doi.org/10.34172/ijtmgh.2020.06

Assari, S. (2020b). Parental Education and Spanking of American Children: Blacks' Diminished Returns. *World J Educ Res*, *7*(3), 19-44. https://doi.org/10.22158/wjer.v7n3p19

Assari, S. (2020c). Parental Education on Youth Inhibitory Control in the Adolescent Brain Cognitive Development (ABCD) Study: Blacks' Diminished Returns. *Brain Sciences*, *10*(5), 312. Retrieved from https://www.mdpi.com/2076-3425/10/5/312

Assari S. (2019). Parental Educational Attainment and Academic Performance of American College Students; Blacks' Diminished Returns. *Journal of Health Economics and Development*, *1*(1), 21-31.

Assari, S., & Bazargan, M. (2019a). Being Married Increases Life Expectancy of White but Not Black Americans. *J Family Reprod Health*, *13*(3), 132-140. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/32201487

Assari, S., & Bazargan, M. (2019a). Protective Effects of Educational Attainment Against Cigarette Smoking; Diminished Returns of American Indians and Alaska Natives in the National Health Interview Survey. *International Journal of Travel Medicine and Global Health*.

Assari, S., & Bazargan, M. (2019b). Unequal Associations between Educational Attainment and Occupational Stress across Racial and Ethnic Groups. *International journal of environmental research and public health*, *16*(19), 3539. Retrieved from https://www.mdpi.com/1660-4601/16/19/3539

Assari, S., & Bazargan, M. (2019b). Unequal Effects of Educational Attainment on Workplace Exposure to Second-Hand Smoke by Race and Ethnicity; Minorities' Diminished Returns in the National Health Interview Survey (NHIS). *J Med Res Innov*, *3*(2). https://doi.org/10.32892/jmri.179

Assari S, B. M. Unequal Effects of Educational Attainment on Workplace Exposure to Second-Hand Smoke by Race and Ethnicity; Minorities' Diminished Returns in the National Health Interview Survey (NHIS). . *J Med Res Innov.*, *3*(2), e000179. https://doi.org/HTTPS://DOI.ORG/10.32892/jmri.179

Assari S, B. M. (2019). Second-hand exposure home Second-Hand Smoke Exposure at Home in the United States; Minorities' Diminished Returns. *Int J Travel Med Glob Health*, *7*(3).

Assari, S., Boyce, S., Bazargan, M., & Caldwell, C. H. (2020). Mathematical Performance of American Youth: Diminished Returns of Educational Attainment of Asian-American Parents. *Education Sciences*, *10*(2), 32. Retrieved from https://www.mdpi.com/2227-7102/10/2/32

Assari, S., Boyce, S., Bazargan, M., Caldwell, C. H., & Zimmerman, M. A. (2020). Place-Based Diminished Returns of Parental Educational Attainment on School Performance of Non-Hispanic White Youth. *Frontiers in Education*, *5*(30). https://doi.org/10.3389/feduc.2020.00030

Assari, S., Boyce, S., Caldwell, C. H., Bazargan, M., & Mincy, R. (2020). Family Income and Gang Presence in the Neighborhood: Diminished Returns of Black Families. *Urban Science*, *4*(2), 29. Retrieved from https://www.mdpi.com/2413-8851/4/2/29

Assari, S., & Caldwell, C. H. (2018a). High Risk of Depression in High-Income African American Boys. *J Racial Ethn Health Disparities*, *5*(4), 808-819. https://doi.org/10.1007/s40615-017-0426-1

Assari, S., & Caldwell, C. H. (2018b). Social Determinants of Perceived Discrimination among Black Youth: Intersection of Ethnicity and Gender. *Children (Basel)*, *5*(2). https://doi.org/10.3390/children5020024

Assari, S., & Caldwell, C. H. (2019a). Family Income at Birth and Risk of Attention Deficit Hyperactivity Disorder at Age 15: Racial Differences. *Children (Basel)*, *6*(1). https://doi.org/10.3390/children6010010

Assari, S., & Caldwell, C. H. (2019b). Parental Educational Attainment Differentially Boosts School Performance of American Adolescents: Minorities' Diminished Returns. *J Family Reprod Health*, *13*(1), 7-13. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/31850092

Assari, S., Caldwell, C. H., & Bazargan, M. (2019). Association Between Parental Educational Attainment and Youth Outcomes and Role of Race/Ethnicity. *JAMA Netw Open*, *2*(11), e1916018. https://doi.org/10.1001/jamanetworkopen.2019.16018

Assari, S., Caldwell, C. H., & Mincy, R. (2018a). Family Socioeconomic Status at Birth and Youth Impulsivity at Age 15; Blacks' Diminished Return. *Children (Basel)*, *5*(5). https://doi.org/10.3390/children5050058

Assari, S., Caldwell, C. H., & Mincy, R. B. (2018b). Maternal Educational Attainment at Birth Promotes Future Self-Rated Health of White but Not Black Youth: A 15-Year Cohort of a National Sample. *J Clin Med*, *7*(5). https://doi.org/10.3390/jcm7050093

Assari, S., Caldwell, C. H., & Zimmerman, M. A. (2018). Family Structure and Subsequent Anxiety Symptoms; Minorities' Diminished Return. *Brain Sci*, *8*(6). https://doi.org/10.3390/brainsci8060097

Assari, S., Farokhnia, M., & Mistry, R. (2019). Education Attainment and Alcohol Binge Drinking: Diminished Returns of Hispanics in Los Angeles. *Behav Sci (Basel)*, *9*(1). https://doi.org/10.3390/bs9010009

Assari, S., Gibbons, F. X., & Simons, R. (2018a). Depression among Black Youth; Interaction of Class and Place. *Brain Sci*, *8*(6). https://doi.org/10.3390/brainsci8060108

Assari, S., Gibbons, F. X., & Simons, R. L. (2018b). Perceived Discrimination among Black Youth: An 18-Year Longitudinal Study. *Behav Sci (Basel)*, *8*(5). https://doi.org/10.3390/bs8050044

Assari, S., & Hani, N. (2018). Household Income and Children's Unmet Dental Care Need; Blacks' Diminished Return. *Dent J (Basel)*, *6*(2). https://doi.org/10.3390/dj6020017

Assari, S., Khoshpouri, P., & Chalian, H. (2019). Combined Effects of Race and Socioeconomic Status on Cancer Beliefs, Cognitions, and Emotions. *Healthcare (Basel)*, *7*(1). https://doi.org/10.3390/healthcare7010017

Assari, S., & Lankarani, M. M. (2016a). Education and Alcohol Consumption among Older Americans; Black-White Differences. *Front Public Health*, *4*, 67. https://doi.org/10.3389/fpubh.2016.00067

Assari, S., & Lankarani, M. M. (2016b). Reciprocal Associations between Depressive Symptoms and Mastery among Older Adults; Black-White Differences. *Front Aging Neurosci*, *8*, 279. https://doi.org/10.3389/fnagi.2016.00279

Assari, S., Lankarani, M. M., & Caldwell, C. H. (2018). Does Discrimination Explain High Risk of Depression among High-Income African American Men? *Behav Sci (Basel)*, *8*(4). https://doi.org/10.3390/bs8040040

Assari, S., & Moghani Lankarani, M. (2018). Workplace Racial Composition Explains High Perceived Discrimination of High Socioeconomic Status African American Men. *Brain Sci*, *8*(8). https://doi.org/10.3390/brainsci8080139

Assari, S., Preiser, B., & Kelly, M. (2018). Education and Income Predict Future Emotional Well-Being of Whites but Not Blacks: A Ten-Year Cohort. *Brain Sci*, *8*(7). https://doi.org/10.3390/brainsci8070122

Assari, S., Preiser, B., Lankarani, M. M., & Caldwell, C. H. (2018). Subjective Socioeconomic Status Moderates the Association between Discrimination and Depression in African American Youth. *Brain Sci*, *8*(4). https://doi.org/10.3390/brainsci8040071

Assari, S., Thomas, A., Caldwell, C. H., & Mincy, R. B. (2018). Blacks' Diminished Health Return of Family Structure and Socioeconomic Status; 15 Years of Follow-up of a National Urban Sample of Youth. *J Urban Health*, *95*(1), 21-35. https://doi.org/10.1007/s11524-017-0217-3

Auchter, A. M., Hernandez Mejia, M., Heyser, C. J., Shilling, P. D., Jernigan, T. L., Brown, S. A., . . . Dowling, G. J. (2018). A description of the ABCD organizational structure and communication framework. *Dev Cogn Neurosci*, *32*, 8-15. https://doi.org/10.1016/j.dcn.2018.04.003

Barreto, S. M., de Figueiredo, R. C., & Giatti, L. (2013). Socioeconomic inequalities in youth smoking in Brazil. *BMJ Open*, *3*(12), e003538. https://doi.org/10.1136/bmjopen-2013-003538

Bartholdy, S., O'Daly, O. G., Campbell, I. C., Banaschewski, T., Barker, G., Bokde, A. L. W., . . . Consortium, I. (2019). Neural Correlates of Failed Inhibitory Control as an Early Marker of Disordered Eating in Adolescents. *Biol Psychiatry*, *85*(11), 956-965. https://doi.org/10.1016/j.biopsych.2019.01.027

Bell, C. N., Sacks, T. K., Thomas Tobin, C. S., & Thorpe, R. J., Jr. (2020). Racial Non-equivalence of Socioeconomic Status and Self-rated Health among African Americans and Whites. *SSM Popul Health*, *10*, 100561. https://doi.org/10.1016/j.ssmph.2020.100561

Bessette, K. L., Karstens, A. J., Crane, N. A., Peters, A. T., Stange, J. P., Elverman, K. H., . . . Langenecker, S. A. (2020). A Lifespan Model of Interference Resolution and Inhibitory Control: Risk for Depression and Changes with Illness Progression. *Neuropsychol Rev*. https://doi.org/10.1007/s11065-019-09424-5

Boyce, S., Bazargan, M., Caldwell, C. H., Zimmerman, M. A., & Assari, S. (2020). Parental Educational Attainment and Social Environment of Urban Public Schools in the U.S.: Blacks' Diminished Returns. *Children*, *7*(5), 44. Retrieved from https://www.mdpi.com/2227-9067/7/5/44

Bruce, J., Fisher, P. A., Graham, A. M., Moore, W. E., Peake, S. J., & Mannering, A. M. (2013). Patterns of brain activation in foster children and nonmaltreated children during an inhibitory control task. *Dev Psychopathol*, *25*(4 Pt 1), 931-941. https://doi.org/10.1017/S095457941300028X

Burchinal, M., McCartney, K., Steinberg, L., Crosnoe, R., Friedman, S. L., McLoyd, V., . . . Network, N. E. C. C. R. (2011). Examining the Black-White achievement gap among low-income children

using the NICHD study of early child care and youth development. *Child Dev*, *82*(5), 1404-1420. https://doi.org/10.1111/j.1467-8624.2011.01620.x

Cabello, R., Gutierrez-Cobo, M. J., & Fernandez-Berrocal, P. (2017). Parental Education and Aggressive Behavior in Children: A Moderated-Mediation Model for Inhibitory Control and Gender. *Front Psychol*, *8*, 1181. https://doi.org/10.3389/fpsyg.2017.01181

Carver, A. C., Livesey, D. J., & Charles, M. (2001). Age related changes in inhibitory control as measured by stop signal task performance. *Int J Neurosci*, *107*(1-2), 43-61. https://doi.org/10.3109/00207450109149756

Casey, B. J., Cannonier, T., Conley, M. I., Cohen, A. O., Barch, D. M., Heitzeg, M. M., . . . Workgroup, A. I. A. (2018). The Adolescent Brain Cognitive Development (ABCD) study: Imaging acquisition across 21 sites. *Dev Cogn Neurosci*, *32*, 43-54. https://doi.org/10.1016/j.dcn.2018.03.001

Cavazos-Rehg, P. A., Krauss, M. J., Spitznagel, E. L., Schootman, M., Bucholz, K. K., Peipert, J. F., . . . Bierut, L. J. (2009). Age of sexual debut among US adolescents. *Contraception*, *80*(2), 158-162. https://doi.org/10.1016/j.contraception.2009.02.014

Chetty, R., Hendren, N., Kline, P., & Saez, E. (2014). Where is the land of opportunity? The geography of intergenerational mobility in the United States. *The Quarterly Journal of Economics*, *129*(4), 1553-1623.

Chikara, R. K., Lo, W. C., & Ko, L. W. (2020). Exploration of Brain Connectivity during Human Inhibitory Control Using Inter-Trial Coherence. *Sensors (Basel)*, *20*(6). https://doi.org/10.3390/s20061722

Clark, S. V., King, T. Z., & Turner, J. A. (2020). Cerebellar Contributions to Proactive and Reactive Control in the Stop Signal Task: A Systematic Review and Meta-Analysis of Functional Magnetic Resonance Imaging Studies. *Neuropsychol Rev*. https://doi.org/10.1007/s11065-020-09432-w

Cohen, G. L., & Sherman, D. K. (2005). Stereotype threat and the social and scientific contexts of the race achievement gap. *Am Psychol*, *60*(3), 270-271; discussion 271-272. https://doi.org/10.1037/0003-066X.60.3.270

Cotten, N. U., Resnick, J., Browne, D. C., Martin, S. L., McCarraher, D. R., & Woods, J. (1994). Aggression and fighting behavior among African-American adolescents: individual and family factors. *Am J Public Health*, *84*(4), 618-622. https://doi.org/10.2105/ajph.84.4.618

Cueli, M., Areces, D., Garcia, T., Alves, R. A., & Gonzalez-Castro, P. (2020). Attention, inhibitory control and early mathematical skills in preschool students. *Psicothema*, *32*(2), 237-244. https://doi.org/10.7334/psicothema2019.225

Deater-Deckard, K., Li, M., Lee, J., King-Casas, B., & Kim-Spoon, J. (2019). Poverty and Puberty: A Neurocognitive Study of Inhibitory Control in the Transition to Adolescence. *Psychol Sci*, *30*(11), 1573-1583. https://doi.org/10.1177/0956797619863780

DeSantis, A. S., Adam, E. K., Doane, L. D., Mineka, S., Zinbarg, R. E., & Craske, M. G. (2007). Racial/ethnic differences in cortisol diurnal rhythms in a community sample of adolescents. *J Adolesc Health*, *41*(1), 3-13. https://doi.org/10.1016/j.jadohealth.2007.03.006

Dieter, J., Hoffmann, S., Mier, D., Reinhard, I., Beutel, M., Vollstadt-Klein, S., . . . Lemenager, T. (2017). The role of emotional inhibitory control in specific internet addiction - an fMRI study. *Behav Brain Res*, *324*, 1-14. https://doi.org/10.1016/j.bbr.2017.01.046

Dismukes, A., Shirtcliff, E., Jones, C. W., Zeanah, C., Theall, K., & Drury, S. (2018). The development of the cortisol response to dyadic stressors in Black and White infants. *Dev Psychopathol*, *30*(5), 1995-2008. https://doi.org/10.1017/S0954579418001232

Dupuis, A., Indralingam, M., Chevrier, A., Crosbie, J., Arnold, P., Burton, C. L., & Schachar, R. (2019). Response Time Adjustment in the Stop Signal Task: Development in Children and Adolescents. *Child Dev*, *90*(2), e263-e272. https://doi.org/10.1111/cdev.13062

Ely, A. V., Jagannathan, K., Hager, N., Ketcherside, A., Franklin, T. R., & Wetherill, R. R. (2020). Double jeopardy: Comorbid obesity and cigarette smoking are linked to neurobiological alterations in inhibitory control during smoking cue exposure. *Addict Biol*, *25*(2), e12750. https://doi.org/10.1111/adb.12750

Froeliger, B., McConnell, P. A., Bell, S., Sweitzer, M., Kozink, R. V., Eichberg, C., . . . McClernon, F. J. (2017). Association Between Baseline Corticothalamic-Mediated Inhibitory Control and Smoking Relapse Vulnerability. *JAMA Psychiatry*, *74*(4), 379-386. https://doi.org/10.1001/jamapsychiatry.2017.0017

Fuentes, M., Hart-Johnson, T., & Green, C. R. (2007). The association among neighborhood socioeconomic status, race and chronic pain in black and white older adults. *J Natl Med Assoc*, *99*(10), 1160-1169. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/17987920

Garavan, H., Bartsch, H., Conway, K., Decastro, A., Goldstein, R. Z., Heeringa, S., . . . Zahs, D. (2018). Recruiting the ABCD sample: Design considerations and procedures. *Dev Cogn Neurosci*, *32*, 16-22. https://doi.org/10.1016/j.dcn.2018.04.004

Gorey, K. M. (2009). Comprehensive School Reform: Meta-Analytic Evidence of Black-White Achievement Gap Narrowing. *Educ Policy Anal Arch*, *17*(25), 1-17. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/27453681

Hair, N. L., Hanson, J. L., Wolfe, B. L., & Pollak, S. D. (2015). Association of Child Poverty, Brain Development, and Academic Achievement. *JAMA Pediatr*, *169*(9), 822-829. https://doi.org/10.1001/jamapediatrics.2015.1475

Hanson, J. L., Nacewicz, B. M., Sutterer, M. J., Cayo, A. A., Schaefer, S. M., Rudolph, K. D., . . . Davidson, R. J. (2015). Behavioral problems after early life stress: contributions of the hippocampus and amygdala. *Biol Psychiatry*, *77*(4), 314-323. https://doi.org/10.1016/j.biopsych.2014.04.020

Hao, J. (2017). Do Children with Better Inhibitory Control Donate More? Differentiating between Early and Middle Childhood and Cool and Hot Inhibitory Control. *Front Psychol*, *8*, 2182. https://doi.org/10.3389/fpsyg.2017.02182

Hemovich, V., Lac, A., & Crano, W. D. (2011). Understanding early-onset drug and alcohol outcomes among youth: the role of family structure, social factors, and interpersonal perceptions of use. *Psychol Health Med*, *16*(3), 249-267. https://doi.org/10.1080/13548506.2010.532560

Hiraoka, K., Kinoshita, A., Kunimura, H., & Matsuoka, M. (2018). Effect of variability of sequence length of go trials preceding a stop trial on ability of response inhibition in stop-signal task. *Somatosens Mot Res*, *35*(2), 95-102. https://doi.org/10.1080/08990220.2018.1475351

Holochwost, S. J., Volpe, V. V., Gueron-Sela, N., Propper, C. B., & Mills-Koonce, W. R. (2018). Sociodemographic risk, parenting, and inhibitory control in early childhood: The role of respiratory sinus arrhythmia. *J Child Psychol Psychiatry*, *59*(9), 973-981. https://doi.org/10.1111/jcpp.12889

Hsieh, I. J., & Chen, Y. Y. (2017). Determinants of aggressive behavior: Interactive effects of emotional regulation and inhibitory control. *PLoS One*, *12*(4), e0175651. https://doi.org/10.1371/journal.pone.0175651

Hudson, D., Sacks, T., Irani, K., & Asher, A. (2020). The Price of the Ticket: Health Costs of Upward Mobility among African Americans. *Int J Environ Res Public Health*, *17*(4). https://doi.org/10.3390/ijerph17041179

Hudson, D. L., Bullard, K. M., Neighbors, H. W., Geronimus, A. T., Yang, J., & Jackson, J. S. (2012). Are benefits conferred with greater socioeconomic position undermined by racial discrimination among African American men? *J Mens Health*, *9*(2), 127-136. https://doi.org/10.1016/j.jomh.2012.03.006

Hudson, D. L., Neighbors, H. W., Geronimus, A. T., & Jackson, J. S. (2012). The relationship between socioeconomic position and depression among a US nationally representative sample of African Americans. *Soc Psychiatry Psychiatr Epidemiol*, *47*(3), 373-381. https://doi.org/10.1007/s00127-011-0348-x

Hudson, D. L., Puterman, E., Bibbins-Domingo, K., Matthews, K. A., & Adler, N. E. (2013). Race, life course socioeconomic position, racial discrimination, depressive symptoms and self-rated health. *Soc Sci Med*, *97*, 7-14. https://doi.org/10.1016/j.socscimed.2013.07.031

Huijbregts, S. C., Warren, A. J., de Sonneville, L. M., & Swaab-Barneveld, H. (2008). Hot and cool forms of inhibitory control and externalizing behavior in children of mothers who smoked during pregnancy: an exploratory study. *J Abnorm Child Psychol*, *36*(3), 323-333. https://doi.org/10.1007/s10802-007-9180-x

Humphrey, G., & Dumontheil, I. (2016). Development of Risk-Taking, Perspective-Taking, and Inhibitory Control During Adolescence. *Dev Neuropsychol*, *41*(1-2), 59-76. https://doi.org/10.1080/87565641.2016.1161764

Jefferson, A. L., Gibbons, L. E., Rentz, D. M., Carvalho, J. O., Manly, J., Bennett, D. A., & Jones, R. N. (2011). A life course model of cognitive activities, socioeconomic status, education, reading ability, and cognition. *J Am Geriatr Soc*, *59*(8), 1403-1411. https://doi.org/10.1111/j.1532-5415.2011.03499.x

Karcher, N. R., O'Brien, K. J., Kandala, S., & Barch, D. M. (2019). Resting-State Functional Connectivity and Psychotic-like Experiences in Childhood: Results From the Adolescent Brain Cognitive Development Study. *Biol Psychiatry*, *86*(1), 7-15. https://doi.org/10.1016/j.biopsych.2019.01.013

Kaufman, J. S., Cooper, R. S., & McGee, D. L. (1997). Socioeconomic status and health in blacks and whites: the problem of residual confounding and the resiliency of race. *Epidemiology*, 621-628.

Lisdahl, K. M., Sher, K. J., Conway, K. P., Gonzalez, R., Feldstein Ewing, S. W., Nixon, S. J., . . . Heitzeg, M. (2018). Adolescent brain cognitive development (ABCD) study: Overview of substance use assessment methods. *Dev Cogn Neurosci*, *32*, 80-96. https://doi.org/10.1016/j.dcn.2018.02.007

Luciana, M., Bjork, J. M., Nagel, B. J., Barch, D. M., Gonzalez, R., Nixon, S. J., & Banich, M. T. (2018). Adolescent neurocognitive development and impacts of substance use: Overview of the adolescent brain cognitive development (ABCD) baseline neurocognition battery. *Dev Cogn Neurosci*, *32*, 67-79. https://doi.org/10.1016/j.dcn.2018.02.006

Marshall, A. T., Betts, S., Kan, E. C., McConnell, R., Lanphear, B. P., & Sowell, E. R. (2020). Association of lead-exposure risk and family income with childhood brain outcomes. *Nat Med*, *26*(1), 91-97. https://doi.org/10.1038/s41591-019-0713-y

Merz, E. C., Tottenham, N., & Noble, K. G. (2018). Socioeconomic Status, Amygdala Volume, and Internalizing Symptoms in Children and Adolescents. *J Clin Child Adolesc Psychol*, *47*(2), 312-323. https://doi.org/10.1080/15374416.2017.1326122

Miller, B., & Taylor, J. (2012). Racial and socioeconomic status differences in depressive symptoms among black and white youth: An examination of the mediating effects of family structure, stress and support. *J Youth Adolesc*, *41*(4), 426-437. https://doi.org/10.1007/s10964-011-9672-4

Mora-Gonzalez, J., Esteban-Cornejo, I., Solis-Urra, P., Migueles, J. H., Cadenas-Sanchez, C., Molina-Garcia, P., . . . Ortega, F. B. (2020). Fitness, physical activity, sedentary time, inhibitory control, and neuroelectric activity in children with overweight or obesity: The ActiveBrains project. *Psychophysiology*, e13579. https://doi.org/10.1111/psyp.13579

Nakamichi, K. (2017). Differences in Young Children's Peer Preference by Inhibitory Control and Emotion Regulation. *Psychol Rep*, 33294117709260. https://doi.org/10.1177/0033294117709260

Neely, K. A., Wang, P., Chennavasin, A. P., Samimy, S., Tucker, J., Merida, A., . . . Huang-Pollock, C. (2017). Deficits in inhibitory force control in young adults with ADHD. *Neuropsychologia*, *99*, 172-178. https://doi.org/10.1016/j.neuropsychologia.2017.03.012

Porter, L., Bailey-Jones, C., Priudokaite, G., Allen, S., Wood, K., Stiles, K., . . . Lawrence, N. S. (2018). From cookies to carrots; the effect of inhibitory control training on children's snack selections. *Appetite*, *124*, 111-123. https://doi.org/10.1016/j.appet.2017.05.010

Samuel, L. J., Roth, D. L., Schwartz, B. S., Thorpe, R. J., & Glass, T. A. (2018). Socioeconomic Status, Race/Ethnicity, and Diurnal Cortisol Trajectories in Middle-Aged and Older Adults. *J Gerontol B Psychol Sci Soc Sci*, *73*(3), 468-476. https://doi.org/10.1093/geronb/gbw080

Schreier, H. M., & Chen, E. (2013). Socioeconomic status and the health of youth: a multilevel, multidomain approach to conceptualizing pathways. *Psychol Bull*, *139*(3), 606-654. https://doi.org/10.1037/a0029416

Shanika Boyce, M. B., Cleopatra Caldwell, Marc Zimmerman, Shervin Assari (2020). Protective Effects of Parental Educational Attainment on School Social Environmental Risk: Blacks' Diminished Returns in Urban Public Schools. *Children*.

Shervin, A., & Ritesh, M. (2019). Diminished Return of Employment on Ever Smoking Among Hispanic Whites in Los Angeles. *Health Equity*, *3*(1), 138-144. https://doi.org/10.1089/heq.2018.0070

Skowron, E. A., Cipriano-Essel, E., Gatzke-Kopp, L. M., Teti, D. M., & Ammerman, R. T. (2014). Early adversity, RSA, and inhibitory control: Evidence of children's neurobiological sensitivity to social context. *Dev Psychobiol*, *56*(5), 964-978. https://doi.org/10.1002/dev.21175

Swingler, M. M., Isbell, E., Zeytinoglu, S., Calkins, S. D., & Leerkes, E. M. (2018). Maternal behavior predicts neural underpinnings of inhibitory control in preschoolers. *Dev Psychobiol*, *60*(6), 692-706. https://doi.org/10.1002/dev.21742

Troller-Renfree, S. V., Buzzell, G. A., Bowers, M. E., Salo, V. C., Forman-Alberti, A., Smith, E., . . . Fox, N. A. (2019). Development of inhibitory control during childhood and its relations to early temperament and later social anxiety: unique insights provided by latent growth modeling and signal detection theory. *J Child Psychol Psychiatry*, *60*(6), 622-629. https://doi.org/10.1111/jcpp.13025

Valencia, M. L. C., Tran, B. T., Lim, M. K., Choi, K. S., & Oh, J. K. (2019). Association Between Socioeconomic Status and Early Initiation of Smoking, Alcohol Drinking, and Sexual Behavior Among Korean Adolescents. *Asia Pac J Public Health*, *31*(5), 443-453. https://doi.org/10.1177/1010539519860732

Williams, D. R. (1999). Race, socioeconomic status, and health the added effects of racism and discrimination.

Williams, D. R., Costa, M. V., Odunlami, A. O., & Mohammed, S. A. (2008). Moving upstream: How interventions that address the social determinants of health can improve health and reduce disparities. *J Public Health Manag Pract, 14 Suppl*, S8-17. https://doi.org/10.1097/01.PHH.0000338382.36695.42

Zaidman-Zait, A., & Shilo, I. (2018). Parental ADHD Symptoms and Inhibitory Control in Relation to Parenting Among Mothers of Children With and Without ADHD. *J Atten Disord*, 1087054718808063. https://doi.org/10.1177/1087054718808063

Zhang, Z., Wang, Q., Liu, X., Song, P., & Yang, B. (2017). Differences in Inhibitory Control between Impulsive and Premeditated Aggression in Juvenile Inmates. *Front Hum Neurosci*, *11*, 373. https://doi.org/10.3389/fnhum.2017.00373