

## RESEARCH ARTICLE

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# Executive function and school performance among American children: Blacks' diminished returns

Shervin Assari, Shanika Boyce, Mohsen Bazargan, Cleopatra H Caldwell

## ABSTRACT

**Aims:** In the United States, racial minorities experience weaker effects of economic and non-economic resources on tangible outcomes such as school performance, a pattern called Minorities' Diminished Returns (MDRs). These MDRs are frequently documented for the effects of family economic resources on Black children's school performance. However, the existing knowledge is limited regarding MDRs of non-economic assets, such as executive function on children's school performance. We compared White and Black children for the association between executive function and children's school performance.

**Methods:** This cross-sectional analysis included 4909 White or Black children from the Adolescent Brain Cognitive Development (ABCD) study. The predictor variable was executive function measured by the stop-signal task. The primary outcome was children's school performance ranging from 1 to 6. Linear regression was used to perform data analysis.

**Results:** Overall, higher task-based executive function was associated with higher school performance. Race,

however, showed a statistically significant interaction with executive function on children's school performance. This interaction suggested that high executive function has a weaker positive association with Black children's school performance than White children.

**Conclusion:** The positive association between executive function and school performance is weaker for Black than White children. To eliminate the racial gap in school performance, we need to address the diminished returns of Black families' resources and assets. Not only should we equalize resources and assets but also increase their marginal returns for racial minorities, particularly Black families. Such efforts require public policies at multiple sectors and institutions. We need to empower Black families to better leverage their resources and assets and turn them into tangible outcomes. Simultaneously, we need to reduce discrimination at school and enhance schooling quality in urban areas. Finally, we need to address daily life stressors and barriers that Black families face in their daily lives.

**Keywords:** Cognition, Ethnicity, Executive function, Race, School performance, Socioeconomic status

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## INTRODUCTION

Compared to White children, racial minority children, particularly Blacks, are at an increased risk of poor school performance [1]. Black children are also at

an increased risk of dropping out of school [2]. As poor school performance and dropping out are gateways to subsequent undesired economic and health problems [3–6], closing racial inequalities in school is essential to creating more equitable outcomes later in life [7–11]. There is some hope that eliminating racial inequalities in school performances can considerably reduce if not closing subsequent disparities later in life [3–6].

As race and socioeconomic status (SES) closely overlap [12], racial inequalities in school performance are commonly attributed to the racial gap in SES [13–15]. This traditional approach attributes lower school performance to lower resources and assets in racial minority families, such as Blacks [12, 16–18]. In statistical terms, resources and assets (e.g., family SES) are believed to mediate the association between racial minority status and children's outcomes [19–21]. In this view, closing the racial differences in access to resources and assets (e.g., SES) would be a reasonable strategy for the elimination of racial gaps and inequalities [22, 23]. Some example policies include enhancing family SES through income redistribution policies, tax policies, and empowering racial minorities to secure gain income and accumulate wealth [22, 23].

A complementary explanation of the above explanation is Minorities' Diminished Returns (MDRs) [24, 25]. The MDRs framework refers to weaker effects of resources and assets such as family SES on Blacks' tangible children outcomes compared to Whites. This view suggests that as a result of social stratification, racism, segregation, and other structural inequalities, parental education [26], family income [27, 28], and marital status [29] all generate fewer tangible outcomes for Black than White children. Thus, there is a need to empower racial and ethnic minority populations to mobilize their own [30] and parental [31–33] resource and asset groups. Policy solutions would be helping Black families to take advantage of their opportunities, mobilize their available resources, navigate the systems, and secure tangible outcomes [25, 27, 32, 34–36]. In this view, policy solutions should go above and beyond merely providing access by addressing the barriers that hinder racial and ethnic minorities from utilizing the existing resources and translating them to outcomes [24, 25, 27, 28, 37].

Executive function, attention, and cognitive capacity are among major determinants of school performance [38–40]. Individuals with poor executive function, commonly seen in individuals diagnosed with attention-deficit/hyperactivity disorder (ADHD), report a lower school function [41, 42]. Although other psychological and cognitive assets have shown diminishing returns on health outcomes [43–45], and family SES has shown weaker effects for Blacks than Whites [13–15], we are not aware of many previous investigations on the differential effect of executive function on children's school performance between Black than White children.

## Aims

To extend the existing knowledge on the racial gap in school performance [11, 14, 15, 46], build on the MDRs literature [24, 25, 47], and to expand our past work on racial differences in correlates of school performance, we compared Black and White children for the association between executive function and children's school performance. In line with the MDRs framework [24, 25, 47], we expected a weaker association between executive function and children's school performance for Black than White children.

## MATERIALS AND METHODS

### Design

This is a secondary analysis of existing data. We used a cross-sectional design for our analysis. Data came from the Adolescent Brain Cognitive Development (ABCD) study [48–52]. Adolescent Brain Cognitive Development is one of the main brain development studies of children in the United States [48, 53].

### Sampling

Participants of the ABCD study were 9–10-year-old children. The ABCD mainly recruited children from the US school systems of multiple cities across various states. Although ABCD sampling is fully described here [54], we provide a brief summary of the study sampling. Although the sampling was not a multi-stage sampling design, schools were carefully selected for the final sample to represent the United States in terms of race, ethnicity, sex, and socioeconomic status. A total number of 4909 children entered our analysis. Eligible children for enrollment to this analysis were Black or White children with valid data on race, task-based executive function, and school performance. Participants were eligible regardless of Hispanic ethnicity. Asian Americans and other racial groups, as well as children with mixed-race, were excluded.

### Variables

Variables in our analysis included race, ethnicity, age, sex, family SES, task-based executive function, and school performance.

### Independent variable

#### *Children's executive function*

The stop-signal task (SST) was used to measure the executive function of the participating children. The SST in this study applied two runs each, including 180 trials. These trials showed images of a black arrow pointing either to the right or to the left. These arrows were displayed

while the participant was in the scanner. Participants were instructed to click the appropriate button that would correspond to the arrow direction. They were asked to click as quickly as they could see the arrows. All participants were asked to use their dominant hand. From the overall number of the 180 trials, 30 displayed neither option. These cases signaled the participant to inhibit answering with either option. These trials were randomly dispersed between the runs. Executive function was measured as the mean response time number of correct “Go” trials in a run (variable `tfmri_sst_all_beh_crgo_mrt` in the ABCD study). This variable was continuous with a higher score indicating worse executive function. As such, we calculated the reverse ordered response time number of correct “Go” trials, which was reflective of higher executive function [55–58].

## Dependent variable

Parents were asked to report their child’s grades. They answered the question, “What kind of grades does your child get on average?” Responses included 1 = A’s/Excellent A/Excelente; 2 = B’s/Good B/Bien; 3 = C’s/Average C/Promedio; 4 = D’s/Below Average D/ Pordebajo del promedio; 5 = F’s/Struggling a lot F. We reverse coded the responses so a higher score reflected better grades. This variable reflects average grades that the child is attaining regardless of they have been acquired in a specific timeframe. The variable was a continuous measure ranging from 1 to 6, with a higher score reflecting higher grades.

## Moderator

### Race

Race, self-identified, and a categorical variable, was coded 1 for Blacks and 0 for Whites (reference category).

## Confounders

### Ethnicity

Ethnicity, self-identified, and a categorical variable, was coded 1 for Hispanic and 0 for non-Hispanic.

### Age

Parents were asked to report the age of their children. Age was a continuous measure in years.

### Sex

Sex was a dichotomous variable: males = 1, females = 0.

## Parental marital status

Parental marital status was a dichotomous variable. This variable was coded as married = 1 versus other = 0.

## Parental employment

Parental employment was self-reported by the parent and was coded 1 for employed and 0 for unemployed.

## Financial stress

This study measured financial stress using the following seven items. The questions were “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 couldn’t afford to buy it or couldn’t afford to go out to get it?,” (2) “Were without telephone service because you could not afford it?” (3) “Didn’t 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 wouldn’t deliver oil because payments were not made?” (6) “Had someone who needed to see a doctor or go to the hospital but didn’t go because you could not afford it?” and (7) “Had someone who needed a dentist but couldn’t go because you could not afford it?” With responses to each question being either 0 or 1, we calculated a mean score that was treated as a continuous measure. This variable ranged between 0 and 1, where 1 indicated the highest financial stress. Financial stress reflects some aspects of the SES, which are not captured by objective SES measures, such as education, income, and employment [59–65]. Financial stress, also called financial difficulties, economic stress, and economic difficulties, correlates with objective measures of SES such as education and income but predicts a wide range of health outcomes independent of them [59, 61, 62, 66–68].

## Analysis and statistics

We used Statistical Package for the Social Sciences (SPSS) for data analysis. First, the mean (standard deviation [SD]) or frequency (relative %) were used to provide a description of the study variables, depending on their type and level of measurement. We applied Pearson bivariate to rule out multicollinearity between the study variables. For multivariable analysis, linear regression models were used. Our first two regression models were performed in the overall sample. Our last two models were estimated in each race. Model 1 was performed without the executive function by race interaction term. Model 2 added the interaction term between race and executive function. Model 3 was run in Whites. Model 4 was tested in Blacks. Our models used sex, age, marital status, parental employment, and financial stress as covariates. Unstandardized regression coefficient (b) and p were reported.

## Ethics

The ABCD study protocol was approved by multiple Institutional Review Boards (IRBs), including but not

limited to that of the University of California, San Diego (UCSD). All children signed assent. Parents signed informed consent (53). Our analysis was exempt from an IRB review.

## RESULTS

### Descriptives

As shown in Table 1, data of 4909, 9–10-year-old children were analyzed. Most were White (n = 3627; 73.9%) and the rest were Black (n = 1282; 26.1%). Table 1 shows the overall and race-specific summary of the variables. This table also compares Black and White children. White children were more likely to have married parents than Black children.

Similarly, White children were more likely to have employed parents than Black children. Finally, while White children had a higher grade point average (GPA) than Black children, Black children had higher financial stress levels than White children. White and Black children did not differ in age and sex.

### Multivariate analysis (Pooled Sample)

As Table 2 shows, we performed two linear regression models in the overall sample. Model 1 (Main Effect Model) showed a boosting effect of executive function on school performance. Model 2 (Interaction Model) showed a statistically significant interaction term between race and executive function on school performance, suggesting that the boosting effect of high executive function on school performance is weaker for Black children than their White counterparts (Table 2).

### Multivariate analysis in whites and blacks

As shown in Table 3, executive function only predicted White children’s school function but not Black children. As shown by Model 3, there was a boosting effect of high executive function on White children’s school performance. As shown by Model 4, we could not show any protective effect of executive function on school performance for Black children (Table 3).

Table 1: Description of socio-demographic data in the overall sample (n = 4909)

	All		White		Black	
	n	%	n	%	n	%
<b>Child race</b>						
White	3627	73.9	3627	100.0		
Black	1282	26.1			1282	100.0
<b>Child ethnicity*</b>						
Non-Hispanic	4083	83.2	2909	80.2	1174	91.6
Hispanic	826	16.8	718	19.8	108	8.4
<b>Child sex</b>						
Female	2404	49.0	1759	48.5	645	50.3
Male	2505	51.0	1868	51.5	637	49.7
<b>Parental marital status*</b>						
Non-Married	1612	32.8	748	20.6	864	67.4
Married	3297	67.2	2879	79.4	418	32.6
<b>Parental employment*</b>						
Unemployed	1466	29.9	1034	28.5	432	33.7
Employed	3443	70.1	2593	71.5	850	66.3
	<b>Mean</b>	<b>SD</b>	<b>Mean</b>	<b>SD</b>	<b>Mean</b>	<b>SD</b>
Age	9.45	0.50	9.44	0.50	9.46	0.51
Family financial stress(0–1)*	0.07	0.16	0.04	0.13	0.14	0.21
Child executive function (positive)	350.00	81.53	349.37	80.85	351.76	83.44
Grade point average (1–6)*	5.11	1.22	5.19	1.24	4.89	1.13

\*p < 0.05 for comparison of Black and White. SD: standard deviation.

Table 2: Linear regression models on the association between executive function and school performance in the overall sample (n = 4909).

	Model 1					Model 2				
	Main effects					M 1 + interaction				
	b	SE	95% CI	t	p	b	SE	95% CI	t	p
Child race (Blacks)	-0.17	(0.04)	-0.26 to 0.09	-3.90	<0.001	0.20	(0.17)	-0.14 to 0.54	1.17	0.242
Child ethnicity (Hispanic)	-0.11	(0.05)	-0.20 to 0.01	-2.27	0.023	-0.11	(0.05)	-0.20 to -0.01	-2.26	0.024
Child sex (male)	-0.24	(0.04)	-0.31 to -0.17	-6.91	<0.001	-0.24	(0.04)	-0.31 to -0.17	-6.89	<0.001
Child age	0.05	(0.03)	-0.02 to 0.12	1.42	0.156	0.05	(0.03)	-0.02 to 0.12	1.42	0.157
Married families	0.21	(0.04)	0.13-0.29	5.02	<0.001	0.21	(0.04)	0.13-0.29	5.03	<0.001
Family financial difficulty (0-1)	-0.49	(0.12)	-0.72 to -0.27	-4.28	<0.001	-0.49	(0.12)	-0.72 to -0.27	-4.28	<0.001
Parents employed	0.00	(0.04)	-0.07 to 0.08	0.06	0.952	0.00	(0.04)	-0.07 to 0.08	0.07	0.944
Executive function (positive)	0.01	(0.00)	0.00-0.01	4.51	<0.001	0.01	(0.00)	0.00-0.01	5.04	<0.001
Executive function × Blacks						-0.01	(0.00)	-0.01 to 0.00	-2.26	0.024
Constant	4.38	(0.33)	3.74-5.02	13.48	<0.001	4.28	(0.33)	3.64-4.92	13.05	<0.001

SE: standard error; CI: confidence interval; b: regression coefficient; t: t value; p: p value.

Table 3: Linear regression models on the association between executive function and school performance in White and Black youth (n = 4909)

	Model 3					Model 4				
	Whites					Blacks				
	b	SE	95% CI	t	p	b	SE	95% CI	t	p
Child ethnicity (Hispanic)	-0.14	(0.05)	-0.25 to -0.04	-2.71	0.007	0.14	(0.11)	-0.09 to 0.36	1.21	0.226
Child sex (male)	-0.22	(0.04)	-0.30 to -0.14	-5.24	<0.001	-0.31	(0.06)	-0.43 to -0.18	-4.76	<0.001
Child age	0.08	(0.04)	0.00-0.16	1.92	0.055	-0.04	(0.06)	-0.16 to 0.09	-0.56	0.572
Married families	0.21	(0.05)	0.11-0.32	4.02	<0.001	0.17	(0.07)	0.03-0.30	2.45	0.015
Family financial difficulty (0-1)	-0.55	(0.17)	-0.88 to -0.23	-3.30	0.001	-0.40	(0.15)	-0.70 to -0.11	-2.66	0.008
Parents employed	-0.01	(0.05)	-0.10 to 0.08	-0.28	0.778	0.04	(0.07)	-0.09 to 0.17	0.61	0.544
Executive function (positive)	0.01	(0.00)	0.00-0.01	4.61	<0.001	0.00	(0.00)	0.00-0.00	1.12	0.263
Constant	4.03	(0.39)	3.26-4.79	10.33	<0.001	5.18	(0.58)	4.04-6.32	8.90	<0.001

SE: standard error; CI: confidence interval; b: regression coefficient; t: t value; p: p value.

## DISCUSSION

Overall, high task-based executive function was associated with higher school performance. However, the positive association between executive function and school performance was diminished for Black than White children.

The observed diminished return of executive function on school performance for Black than White children is similar to previous research for other economic [30, 34, 69, 70] and non-economic [45, 71] resources. Minorities' Diminished Returns are frequently established across SES resources, developmental phases, outcome variables, and sources of marginalization [24, 25]. These are shown

for individual and household income [27], educational attainment of oneself and parents [30], occupation [72], and marital status [35]. Family SES results in more gain for White than Black children [27, 28, 37], adults [34], and older adults [73]. Also, MDRs not only apply to Black [28], Hispanic [30, 47, 74, 75], Asian American [76], or Native American [77] people, they also hold for lesbian, gay, bisexual, transgender, questioning (LGBTQ) [69], immigrant, and even poor White people.

There are several possible mechanisms and reasons why MDRs of resources and assets (e.g., executive function) emerge on securing tangible outcomes for Black families. Stress may reduce children's ability to gain from their available resources and assets, such as executive function and family SES (parental education and income). It is shown that for Black families, high SES is associated with an increase in experience [78–82] and vulnerability [62] to discrimination. This is partly because high SES Black families are surrounded by White families, which means a higher level of exposure to discrimination [78, 79]. A high level of discrimination means reduced gains of SES [62, 81, 83].

Some other mechanisms may be involved in explaining the weaker effect of executive function on the school performance of Black than White children. First diminishing stereotype threat [84]. It is known that stereotype threat reduces school performance, particularly the results of tests [85–87]. Second, discrimination by teachers and principals may be associated with the worse performance [14]. A large body of research has documented Black children's discrimination experiences within and beyond schools [11, 14, 80, 88]. The third explanation is low school quality for Black children across all SES and executive functions [89]. Considerable evidence exists in poor school quality and low education resources in urban areas [11, 90, 91]). A recent study showed that across all SES levels, Black children are more likely to attend schools with high-risk peers and environment [89].

## LIMITATIONS

Given our use of cross-sectional data, we cannot draw causal inferences between executive function and school performance. Similarly, we only tested the MDRs of executive function. Other factors that shape school performance include discipline, parental involvement, resources, etc. Future research may test if similar MDRs can be found for other determinants of school performance (e.g., cognition, IQ, etc.). Future investigation is important to know why high SES and talented Black children still report suboptimal school outcomes. Finally, we only described MDRs of executive function on school performance. There is a need for studies that explore various contextual factors that may result in the observed MDRs.

## CONCLUSION

Compared to White children, Black children show a weaker positive association between executive function and school performance. This may also explain why Black children from high SES families show worse than expected school performance. These findings are indicative of multiple layers of adversities for Black children. Not only are their executive functioning and school performance are lower, but their school performance also shows weaker effects of executive function in Blacks than Whites. These findings may indicate why some early childhood programs, such as head start, have shown less than expected effects. A real solution is to equalize Blacks and Whites' living conditions, which needs to eliminate racism and social stratification. There is also a need to enhance school quality in urban areas.

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## Author Contributions

Shervin Assari – Conception of the work, Design of the work, Analysis of data, Interpretation of data, Drafting the work, Revising the work critically for important intellectual content, Final approval of the version to be published, Agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved

Shanika Boyce – Conception of the work, Interpretation of data, Drafting the work, Revising the work critically for important intellectual content, Final approval of the version to be published

Mohsen Bazargan – Conception of the work, Interpretation of data, Drafting the work, Revising the work critically for important intellectual content, Final approval of the version to be published

Cleopatra H Caldwell – Conception of the work, Design of the work, Acquisition of data, Analysis of data, Revising the work critically for important intellectual content, Final approval of the version to be published

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Authors declare no conflict of interest.

**Data Availability**

All relevant data are within the paper and its Supporting Information files.

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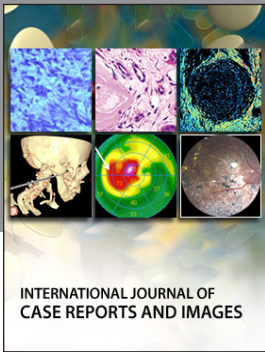
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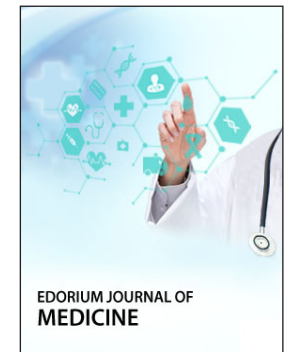
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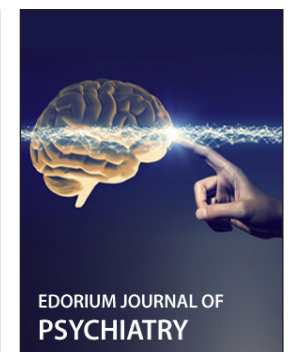
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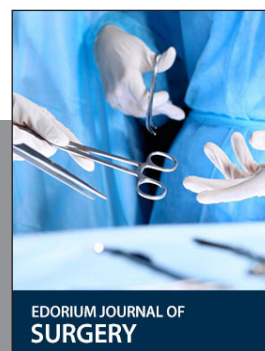
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