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Post-secondary education and late-life cognitive outcomes among Black and White participants in the Project Talent Aging Study: Can early-life cognitive skills account for educational differences in late-life cognition?

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Abstract

Background: Higher education consistently predicts improved late-life cognition. Racial differences in educational attainment likely contribute to inequities in dementia risk. However, few studies of education and cognition have controlled for prospectively measured early-life confounders or evaluated whether the education–late-life cognition association is modified by race/ethnicity.

Methods: Among 2,343 Black and White Project Talent Aging Study participants who completed telephone cognitive assessments, we evaluated whether the association between years of education and cognition (verbal fluency, memory/recall, attention, and a composite cognitive measure) differed by race, and whether these differences persisted when adjusting for childhood factors, including cognitive ability.

Results: In fully adjusted linear regression models, each additional year of education was associated with higher composite cognitive scores for Black (β=.137; 95% CI=.068, .206) and White respondents (β=.056; CI=.034, .078) with an interaction with race (p=.03). Associations

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between education and memory/recall among Black adults (β=.036; CI=−.037, .109) and attention among White adults (β=.022; CI=−.002, .046) were non-significant. However, there were significant race–education interactions for the composite (p=.03) and attention measures (p<.001) but not verbal fluency (p=.61) or memory/recall (p=.95).

Conclusion: Education predicted better overall cognition for both Black and White adults, even with stringent control for prospectively measured early-life confounders.

Keywords

aging; cognition; education; racial disparities

INTRODUCTION

Significant racial inequities have been documented for Alzheimer's Disease and related disorders (ADRD),[1–4] but the explanations for these inequalities remain uncertain. Although increased education reduces risk of late-life cognitive impairment, prior research suggests that differences in educational attainment do not fully explain racial inequalities in dementia risk. An important limitation of prior research is that it has generally not accounted for potential differences in the impact of the educational experience by race/ethnicity. Cognitive benefits conferred by educational experiences may differ for Black and White Americans due to racialized structural forces permeating within and surrounding educational institutions (e.g., racial composition, education quality). For example, Black students in highly segregated schools have historically had greater exposure to school poverty resulting in fewer resources for high-quality education.[5] Further, Black students pursuing education in predominantly White institutions are likely to increase their exposure to inter-personal racial discrimination,[6–8] which may increase ADRD risk via stress regulation pathways.

A related gap in prior literature on education and late-life cognition is the absence of rigorous studies controlling for prospectively measured confounders among Black individuals. Many factors, including socioeconomic status and childhood cognitive skills, may confound the association of education and late-life cognition. The majority of studies in cognitive aging include, at best, retrospective assessments of early-life conditions. These factors have been evaluated prospectively in only a handful of studies, which were nearly entirely comprised of White participants (e.g., Wisconsin Longitudinal Study and the British 1948 birth cohort study followed from childhood).[9,10] No prior study with substantial Black participation has also included prospectively measured childhood socioeconomic status and cognition.

Understanding possible racial differences in the cognitive outcomes associated with educational attainment is important to understand the drivers of racial disparities in dementia risk. It can also offer insight into why and how education impacts late-life cognitive outcomes. Although increases in education over the past 60 years may be contributing to the recently observed declines in age-specific dementia incidence,[11] racial/ethnic inequities in dementia persist at all levels of educational attainment.[12] Evaluating differential returns to educational attainment is therefore necessary to understand whether current inequalities in education investments for Black and White children are likely to have long term consequences for population-level inequities in dementia burden and risk of cognitive decline.[13–15]

Educational attainment may also have differential protection across cognitive domains, warranting evaluation. The Project Talent Aging Study (PTAS) is a late-life follow-up of Project Talent, a large nationally representative cohort of high school students initiated in 1960. PTAS is well suited to investigate the intersectional effects of race/ethnicity and education on various cognitive measures. We aimed to evaluate whether race/ethnicity modifies the association between education and cognition overall, and within specific cognitive measures: verbal fluency, memory/recall, and attention. Few other datasets include comparable lifecourse information. We therefore also assessed the importance of childhood and adolescent factors as confounders of the education–cognition association to inform interpretation of prior research that did not control for early-life measures.[2,4] Given Black-White inequities in educational quality,[3,16] we hypothesized that the association between increased education and better cognitive outcomes would be larger for White compared to Black adults.

METHODS

Study Sample

PTAS is a longitudinal lifecourse study of cognitive, physical, and psychosocial aging among a subset of participants in the 1960 Project Talent study.[17] Project Talent was a large nationally representative study to examine early-life predictors of adult economic, educational, and occupational outcomes, as well as psychosocial and physical well-being.[17] Students were sampled from 1,226 United States (US) public, private, and parochial junior high (or “feeder”) and high schools (grades 9–12). The sample comprised 5% of all US schools. Over 2 days, 377,016 students completed a questionnaire and battery of tests. When Project Talent participants were roughly age 75 years (2018–2019), PTAS was fielded. For PTAS Stage 1, 22,584 participants were identified from survivors of the original sample to overrepresent students who attended racially integrated or predominantly Black high schools. Respondents to Stage 1 (n=6,421) were eligible for Stage 2 where interviewer-administered surveys were completed by telephone interview and supplemented by self-reported demographic, socioeconomic, and health information via web/tablet. The present study uses data from 2,347 PTAS respondents who completed the Stage 2 self-administered cognitive assessments and included all racial/ethnic groups aged 71–79. We excluded participants who were missing cognitive measures (n=4), leaving 2,343 participants for primary analyses (Supplemental Digital Content [SDC] 1, which illustrates sample selection).

Exposure Assessment

Participants reported the highest level of education they completed. We converted levels of education to years: less than high school=11, high school diploma=12, some college=13, Associate degree=14, Bachelor’s degree=16, Masters or Doctoral degree=18.

Race/ethnicity (hereafter race) was self-reported in the PTAS and classified as Non-Hispanic White, Non-Hispanic Black, Hispanic, Asian, and other racial groups (American Indian/Alaskan Native, Middle Eastern/North African, Native Hawaiian/Other Pacific Islander or other). We evaluated White, Black, and other racial/ethnic (i.e., non-White and non-Black) participant groups. To maximize statistical power, we retained all respondents in the analysis but do not report main results for the 'other' race category because the heterogeneity in this group obscures interpretation.

Outcome Assessment

We considered three independent measures of cognition – verbal fluency, memory/recall, and attention – and a composite measure of all three to assess overall cognition. Each independent cognitive measure was converted to a z-score for comparability (i.e., transformed to have mean zero with one-unit standard deviations [SD] ranging −3 to 3).

Verbal fluency.—Phonemic and semantic fluency were assessed. In the *animal fluency test*,[18] respondents were asked to name as many animals as they could think of within a 45 second period (score range 0–38). Separately, *letter "f" fluency* was assessed,[18] asking respondents to name as many words beginning with the letter "*f*" as they could think of within 60 seconds (score range 0–31). Raw scores of the two fluency tests were averaged and summary scores ranged from 0 to 29.5 with higher scores reflecting better verbal fluency.

Memory/recall.—*Immediate recall* was assessed using a CERAD 10-word list recall test.[19] Scores from three trials were summed resulting in a raw summary score ranging from 0 to 30. *Delayed recall* was assessed in one trial asking participants to recall words presented during the immediate recall task.[19] The number of words recalled with delay were divided by the last immediate recall trial score. The resulting delayed recall raw score, a proportional score (0–10), was rescaled and ranged from 0 to 30 for comparability with immediate recall. The two recall tests were averaged, and raw summary scores ranged from 0 to 26 with higher scores reflecting better recall.

Attention.—Using a *serial seven subtraction test*, respondents were asked to count backwards from 100 by counts of 7 (i.e., 93, 86, etc.) for 5 intervals of subtraction. Raw attention scores ranged from 0 to 5 with higher scores reflecting better attention.

Overall cognition.—The *composite cognitive measure* was generated by averaging the combined z-standardized verbal fluency, memory/recall measure, and attention measures.

Covariates

Variables that plausibly confound the education–cognition association were selected *a priori* based on our conceptual understanding of factors that may have influenced both educational attainment and late-life cognition. All models included an interaction term for education and race. To facilitate evaluating the importance of confounding factors, we considered three sets of confounders:

Model 1: We first evaluated a minimal set of control variables; the interaction of self-reported race at cognitive assessment, self-reported sex (male/female) from the 1960 Project Talent, and age at cognitive assessment.

Model 2: We then incorporated additional childhood confounders from Project Talent. *Childhood socioeconomic status* (cSES) was comprised of 9 socioeconomic indicators as recorded by adolescent respondents and assesses mother and father's education, father's occupation, and ownership of household items (e.g., appliances [automatic washer, dishwasher], technology [telephone, television], and assets [silverware, own room/desk]). Each cSES variable was coded continuously or ordinally and summed to generate a composite measure with higher scores reflecting higher cSES (range 67–126). *Childhood self-reported health* in the last three years (cSRH) was scored on a 5-point Likert scale with higher scores reflecting better health (very poor=1 to excellent=5).

Model 3: Our most comprehensive covariate set included adolescent confounders from Project Talent. Self-reported number of *adolescent school absences* was measured as a 6-level ordinal variable (e.g., None, 1 to 4 days, 5 to 9 days, etc.) with higher levels reflecting more absences. *Adolescent cognitive ability* was measured using 3 scales: reading comprehension (48 items), abstract reasoning (15 items), and arithmetic reasoning (16 items). The adolescent cognitive score is a weighted sum of scores on each scale and was assessed as a continuous variable ranging from 20 to 279 with higher values reflecting better cognitive performance.[20]

Statistical Analysis

We evaluated whether a linear model for the association between education and cognition was appropriate using indicator variables for each year of education and assessing approximate dose-response increases (SDC 2, which presents regression estimates). We then used multiple imputation by chained equations (MICE),[21,22] which is valid under a missing at random assumption, to replace missing values for linear regressions. We used 20 imputations to impute values for age, cSES, cSRH, adolescent school absences, and adolescent cognitive ability. We used these models to estimate associations between years of education and each cognitive outcome (the three measures and the composite), adjusting successively for each of the three covariate sets in Black participants and in White participants, and to test the null hypothesis that race did not modify the effect of education on cognition ($p<0.05$). To characterize the importance of additional control variables, we estimated the percent attenuation in coefficients across covariate sets, for example as: $((\beta_{model2}-\beta_{model1})/\beta_{model1})*100$.

We performed sensitivity analysis to assess the robustness of findings. Because racial inequities in dementia show that Black adults are at the greatest risk,[2,4] any health returns on education found to be protective for Black adults may benefit all minoritized racial groups. To determine whether the intersection of race and education is most relevant for Black adults or for any non-White adults, we collapsed the 'Black' and 'other' racial groups and evaluated one dichotomous race measure (non-White and White).

We then used linear regressions of separate models comparing Black to White and non-White to White adults that were restricted to participants that had complete data for key variables of interest to assess the potential magnitude and direction of any bias introduced by excluding participants with missing values. All analyses were conducted using RStudio Version 1.3.1093 (R Studio, Boston, MA, USA).

RESULTS

Table 1 presents the sample distribution of PTAS participant characteristics. The average age of participants was 75 years. Approximately half of participants were female (52%) and the average years of education was 14 years. During childhood, the average health of participants was good and average SES was middle-class. Compared to White participants, Black participants averaged worse childhood health, lower childhood socioeconomic status, and lower cognitive scores in adolescence.

Figure 1 depicts estimates from imputed multivariable linear regression models of late-life cognition on years of education for Black and White PTAS participants (SDC 3 presents regression estimates). In minimally adjusted models (Model 1), each additional year of education predicted higher scores for both White and Black respondents on all cognitive measures. The estimates were significantly larger among Black compared to White respondents for the composite measure (Black adults: β=.218; 95% confidence interval [CI]=.145, .290; White adults: β=.137; CI=.115, .158; interaction p-value=.036) and for attention (Black adults: β=.227; CI=.152, .302; White adults: β=.078; CI=.056, .100; interaction p-value<.001), but there were no race–education interactions for measures of verbal fluency (p=.68) or memory/recall (p=.90). Additional control for cSES and SRH (Model 2) attenuated estimates by 14–25% and CIs widened slightly. The CI for memory/recall among Black adults included the null (β=.064; CI=−.009, .138).

Additional control for adolescent school absences and cognitive scores (Model 3) further attenuated estimates by 16–63% compared to estimates from Model 2. Each additional year of education was associated with higher cognitive composite scores for Black (β=.137; CI=.068, .206) and White respondents (β=.056; CI=.034, .078) with an interaction with race (p=.03). For Black respondents, fully adjusted coefficients were attenuated by 37% compared to the minimally adjusted coefficient; among White respondents, fully adjusted coefficients were attenuated by 60% compared to minimally adjusted coefficients. Most results of the independent cognitive measures remained large enough to be substantively relevant, although two CIs included the null: the fully adjusted association between education and memory/recall among Black adults (β=.036; CI=−.037, .109) and attention among White adults (β=.022; CI=−.002, .046) were non-significant. In fully adjusted models, there were race–education interactions for the composite (p=.03) and attention measures (p<.001) but not verbal fluency (p=.61) or memory/recall (p=.95).

Results from our sensitivity analyses are presented in SDC 4. Main findings are similar, although with the imputed dataset comparing non-White (instead of Black) participants to White respondents, one result became statistically significant (SDC Table 4a): the fully adjusted estimated effect of education on memory/recall among non-White participants (β=.058; CI=.005, .111) was nearly double the coefficient among White participants (β=.035; CI=.012, .058) although the test of interaction indicated that this difference was plausibly due to chance (p=.42).

Associations among the smaller sample of Black and White participants for which there were complete data (n=2,078; SDC 1) were also similar (SDC Table 4b). The coefficients among Black participants were slightly smaller for the composite (β=.107; CI= .030, .183) and attention measures (β=.122; CI=.042, .202) and the race–education interaction for the composite measure was not statistically significant (p=0.18).

DISCUSSION

In a national sample of Black and White older adults followed nearly 60 years after initial assessments, we found that greater educational attainment predicted better overall cognition regardless of race. The association of education and cognition was attenuated slightly more for White than for Black participants when controlling for prospectively measured childhood and adolescent confounders. Contrary to our hypothesis, education was associated with larger increments in scores on late-life attention and composite cognitive measures for Black respondents than for White respondents.

This is the first prospective cohort study to investigate the link between educational attainment and late-life cognition in a national sample of racially diverse adults with prospectively collected information on early-life SES and cognitive ability. Childhood SES and cognitive ability are considered among the most plausible confounders of the link between education and late-life cognitive outcomes. In the US, the Wisconsin Longitudinal Study (WLS) – recruited from the 1957 high-school graduates in Wisconsin – is among the only cohort studies with prospectively collected information on adolescent cognitive skills and late-life cognition. In WLS, each year of education was associated with approximately a .15 standard deviation (SD) higher cognitive composite score.[23] The association in our sample, whose participants were approximately a decade older at cognitive assessment than the WLS sample, was somewhat smaller among White participants (.06 SD) but similar among Black participants (.14 SD). WLS includes individuals who resided in Wisconsin at enrollment and is almost entirely comprised of White respondents with at least a high school diploma.[24] A small proportion of PTAS participants never completed high school. The covariates included in our model were slightly more comprehensive than those in WLS, but the discrepancy for White participants is more likely due to differences in the exposure and outcome measures assessed or potentially the geographic diversity of the sample.

Our findings confirm robust associations between education and late-life cognition among older Black adults, which persist after control for various early-life predictors of ADRD, including SES and cognitive ability. Control for early-life factors attenuated the association between education and late-life cognition to a slightly larger degree among White participants than among Black participants. This may reflect the extreme discrimination faced by Black individuals in these cohorts; race-based discrimination likely precluded many cognitively gifted Black students from pursuing additional schooling.

Prior work on whether education confers the same magnitude of health benefits for Black and White adults is inconsistent. These inconsistencies may relate to the outcomes assessed or to the populations included in the studies or a combination of both. Using the National Longitudinal Survey of Youth 1979 study, Vable and colleagues (2018) demonstrated greater health returns on each additional year of education attained by age 25 for Black women compared to White men at age 50, on the mental component scores of the 12-item short-form survey.[25] However, Eng and colleagues (2020) found that more schooling predicted similar benefits in verbal episodic memory among racially-diverse Californians over age 65 in the Kaiser Healthy Aging and Diverse Life Experiences study.[26] Our study findings are consistent with Jean and colleagues' (2019) reporting that the effect of educational attainment was twice as large for overall cognition among Black compared to White older adults in a sample from the Family Relationships In Late Life Study, and that there was significant race–education interaction for attention.[27] Moreover, in the current study when contrasting Black and White respondents, the difference in magnitude of association between education and overall cognition was largely driven by the attention measure. This growing body of evidence suggests that higher education may indirectly mitigate Black-White gaps in dementia risk via cognitive improvement within specific domains (e.g., attention) masked by composite cognitive measures. Future studies investigating the impact of years of schooling on cognitive functioning should separate out specific domains when examining the extent to which educational benefits vary by racial group. This may help disentangle the relevance of various levels of educational attainment on racial inequities in dementia risk and inform more targeted interventions.

When comparing the effects of education for Black and White adults born in the early 1940s, it is important to consider both educational quality and labor market conditions shaping the potential value of educational credentials. Children in most southern states would have completed much of their schooling in institutions legally segregated by race. Such institutions tend to be under-resourced.[28,29] Black students who pursued high-school or college in racially integrated institutions would likely have encountered both implicit and explicit forms of racially motivated antipathy (e.g., microaggressions, overt hostility, cultural exclusion) and would have been taught almost entirely by White faculty members.

Given that Black students at predominantly White institutions commonly report racial stress and discrimination[6,7,30] race-based educational experiences may influence late-life risk of ADRD through stress-regulation mechanisms. Chronic stress can promote oxidative cellular stress.[31] This oxidative cellular stress is linked to early pathogenesis of ADRD through neuro- and/or vascular-inflammatory pathways.[32] Although stress-related factors might be expected to diminish the returns to education for Black cohort members, we found no evidence of this. Our analyses indicate that the advantage in late-life cognition potentially offered by educational attainment is equal to or greater for Black than White individuals. This finding may indicate that investment into educational opportunities for Black students can narrow disparities in later life cognitive health. Our results may also reflect the comparatively extreme disadvantages faced by Black individuals with less education from these cohorts.

Historical inequalities in access to education may have been a critical mechanism for the racial differences in older adult cognitive outcomes and dementia risk currently observed. Selection processes limiting access to higher education likely exacerbated early childhood inequalities. Likewise, investment in schools that serve Black children and increasing educational opportunities for Black people may offer an opportunity to mitigate future Black-White inequities in dementia risk. Our findings support this possibility by providing convincing evidence that the association between education and late-life cognitive outcomes is robust to controls for early-life confounders for both Black and White respondents, even for confounders measured in adolescence.

Several methodological considerations should be noted. Although our exposure was not randomized, we have detailed prospective measures on the most relevant early-life confounders. Further, our results align with prior quasi-experimental studies showing positive benefits of longer education for later-life cognition, although those studies have mostly been in White individuals. While confounding remains a possibility, evidence for causation is increasingly strong. Internal validity was further strengthened by accounting of early and late-life covariates that contribute to cognitive aging. Follow-up of the original Project Talent sample was hindered by high mortality and low participation rates, especially for Black participants. If education and cognition interacted in their effects on participation, this may have biased effect estimates. Given historical and ongoing Black-White differences in time taken to complete a diploma or degree,[33–36] converting levels of education to years may underestimate the years of exposure to schooling for Black participants. However, a post hoc analysis using dichotomized educational attainment comparing high school or less (n=410) and more than high school (n=1668) showed results consistent with our findings though estimates were larger in magnitude. We did not have sample size sufficient to examine the intersection of race and sex in our analyses, but prior evidence suggests education may have differentially benefited Black women compared to Black men.[25,37] Our cognitive assessments used validated instruments but were not comprehensive and may be subject to measurement error due to the mode of administration. This measurement error may have attenuated effect estimates. For some participants, only one of the two cognitive tests were complete and used to measure verbal fluency (animal or letter "*f*" fluency) and memory/recall (immediate or delayed recall). This could bias estimates since cognitive tests can differ in difficulty. However, a post hoc analysis confirmed that a negligible proportion of participants' scores were measured using the test expected to be less difficult for verbal fluency (<0.1%) and memory/recall (<1.5%).

This study leverages the strengths of one of the most diverse school-based longitudinal studies to provide critical evidence linking education to cognition in US adults, especially for Black participants. Further research using larger nationally representative diverse samples is needed to determine the robustness of our findings, factors that may modify effects, potential causation, and mechanisms. Future research evaluating racial inequities in dementia will require a more nuanced examination of social exposures that uniquely impact Black Americans (e.g., attending predominantly Black schools) beyond established risk factors derived from the general population (e.g., years of schooling).

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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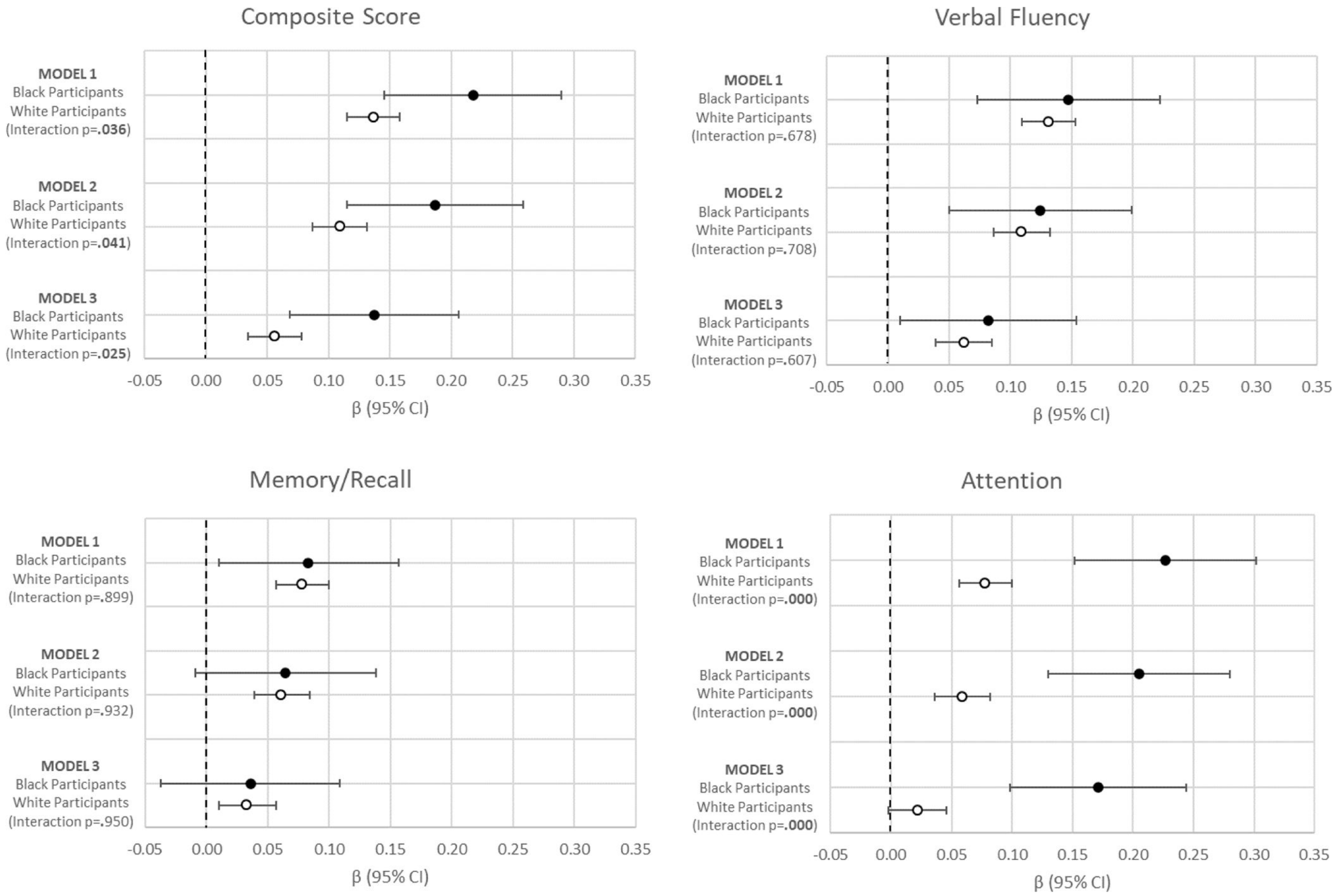

Figure 1.

Linear regression estimates of cognitive outcomes on years of education in the Project Talent Aging Study, comparing coefficients among Black participants versus White participants using multiply imputed data (N=2,343). Indicated along the x-axis, the coefficients estimate the effects of years of education on each cognitive measure. Three models adjusting successively for each of the three covariate sets in Black participants and in White participants are indicated along the y-axis. All models include an education*race/ethnicity interaction term and the interaction p-value tests the null hypothesis that the effect of education on cognition is the same for Black participants and White participants. Model 1 is adjusted for race/ethnicity, age, and sex. Model 2 includes Model 1 plus childhood socioeconomic status and childhood self-reported health status. Model 3 includes Model 2 plus number of adolescent school absences and adolescent cognitive ability. Interactions significant at $p < .05$ in bold on the y-axis.

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Table 1.

Sample characteristic for the Project Talent Aging Study (PTAS) participants, stratified by race.

	Overall Variable	White Participants N=2,343	Black Participants n=1879	Other Race Participants n=243	p-value n=221
	mean (sd)		***mean (sd)***		
Late-life Covariates					
Years of education (range 11–18)	14.08 (1.92)	14.17 (1.98)	13.60 (1.61)	13.86 (1.61)	<0.001
Male sex (%)	1115 (47.6)	916 (48.7)	95 (39.1)	104 (47.1)	0.018
Age (years)	74.80 (1.22)	74.79 (1.20)	74.99 (1.31)	74.71 (1.26)	0.024
Early-life Covariates					
Childhood health status (range 1–6)	5.00 (1.00)	5.06 (0.96)	4.61 (1.15)	4.84 (1.01)	<0.001
Childhood SES status (range 67–126)	98.40 (10.31)	100.08 (9.61)	90.33 (10.44)	93.18 (10.03)	<0.001
Adolescent cognitive score (range 20–79)	176.22 (53.22)	184.82 (49.71)	121.53 (48.10)	164.00 (48.97)	<0.001
Adolescent school absences (range 1–6)	2.57 (1.19)	2.58 (1.17)	2.61 (1.36)	2.39 (1.19)	0.080
Cognitive Outcomes					
Composite cognitive score (range −4.63–2.64)	0.00 (1.00)	0.07 (0.96)	−0.43 (1.12)	−0.15 (1.05)	<0.001
Verbal fluency score (range −3.38–3.64)	0.00 (1.00)	0.05 (1.00)	−0.31 (0.98)	−0.06 (1.00)	<0.001
Memory/recall score (range −3.41–2.12)	0.00 (1.00)	0.03 (0.99)	−0.13 (1.03)	−0.11 (1.03)	0.014
Attention score (range −3.66–0.65)	0.00 (1.00)	0.08 (0.93)	−0.47 (1.28)	−0.14 (1.11)	<0.001

SES=socioeconomic status; sd = standard deviation; p-value tests the null hypothesis that the covariate mean is the same for White, Black, and other race participants.