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Black–White differences on IQ and grades: The mediating role of elementary cognitive tasks

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A Black–White group difference on intelligence test scores has persisted in the literature for over 90 years. Currently, the group IQ mean for Blacks (85) remains about one-standard deviation below the group IQ mean for Whites (100; see, e.g., Neisser et al., 1996; Lynn, 2006; Rushton & Jensen, 2006). Though the difference exists, no consensus as to its cause is likely forthcoming. Some argue that research here is flawed because race-based classifications are invalid (see e.g., Sternberg, Grigorenko, & Kidd, 2005; Tate & Audette, 2001), or because a single, global IQ score cannot adequately represent human intelligence (see, e.g., Gardner 1983). Others argue that Black–White differences are real—due neither to cultural, nor test bias—and at least partly driven by genes (see, e.g., Herrnstein & Murray, 1994; Rushton & Jensen, 2005; Gottfredson, 2005a).

The literature also shows that Blacks, on average, are less likely than Whites to attend college, and those that do have lower standardized test scores, grade point averages (GPAs), and higher dropout rates (Dreary, Strand, Smith, & Fernandes, 2007; Roth et al., 2001; U.S. Department of Education, 2001). Academic achievement and IQ, however, are strongly related. Gottfredson (2005b) summarized data showing a median correlation of .60 between standardized tests of school performance and IQ test scores (.80 when aggregating the different academic tests into a single composite; see also Gottfredson, 2004). Clearly, a large percentage of the variance in academic performance is

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shared by variance in IQ. The direction of causality, however, and whether third variables explain the relationship, remain empirical questions.

One prominent explanation for Black–White differences is Spearman's hypothesis (Spearman, 1927; see also Jensen, 1985), which posits that race differences on IQ test scores reflect race differences on the general factor of intelligence, or *g*. Evidence for Spearman's hypothesis comes from findings that a test's *g* loading strongly correlates with the magnitude of the Black–White difference the test produces (see, e.g., Hartmann, Kruuse, & Nyborg, 2007; Jensen, 1998; Lynn & Owen, 1994; Nyborg & Jensen, 2000; te Nijenhuis & van der Flier, 2003). If the race difference on IQ tests is a *g* difference, then other valid measures of *g* (i.e., beyond traditional paper and pencil IQ tests) should mediate the relationship between race and IQ. Consistent with this prediction, our goal is to explore whether performance on basic measures of information processing, which themselves are highly *g*-loaded, can mediate race differences on IQ.

Information processing ability is inferred by subject performance on so-called elementary cognitive tasks (ECTs). Examples of commonly used ECTs are those that measure processing speed, or reaction time (RT), and those that measure speed of information intake, or inspection time (IT; see Jensen, 1998, for an overview of various ECTs). The literature shows that basic information processing ability, as measured by ECTs, correlates about .50 (after correcting for attenuation) with *g*, as measured by traditional IQ tests (for meta-analytic reviews, see Grudnik & Kranzler, 2001; Kranzler & Jensen, 1989 see also Jensen, 1998). To our knowledge, however, studies exploring the relationship between race and ECT performance have used RT but not IT (for reviews, see Jensen, 1998; Rushton & Jensen, 2005). And, although the relationship between grades, race and IQ is clear (see, e.g., Dreary et al., 2007; Gottfredson, 2004; 2005b), how ECT performance might mediate these relationships is unknown.

The paucity of research in this area is not surprising, given the politically charged environment under which literature on race and intelligence is scrutinized (see, e.g., Gottfredson, 2005c; Reynolds, 2000). Yet, it is now clear that IQ scores have criterion-related validity for many important life outcomes (Hunt, 1995; Neisser et al., 1996). For example, IQ is often the single best predictor of job performance, especially when the job is mentally demanding (Schmidt & Hunter, 1998). Newer research has even shown a link between ECT-like tasks (i.e., "safety suitability" tests, which measure selective- and focused-attention, as well as processing speed) and performance on jobs where the public's safety might be at risk (e.g., fire fighters; see te Nijenhuis & van der Flier, 2004). Given IQ's criterion-related validity, group differences must have significant practical consequences, independent of their cause. And, because race differences on IQ tests have persisted over decades (Lynn 2006; Rushton & Jensen, 2006), it seems unlikely they will go away soon. Hence, the scientific study of race and IQ is both proper and important.

The present study thus explores whether ECT-task performance can mediate Black–White IQ and GPA differences. To the extent that *g* reflects basic information processing ability, ECTs that putatively measure these processes should mediate race differences on IQ test scores, given Spearman's hypothesis. Further, since IQ is strongly correlated with academic success (Gottfredson, 2004; 2005b; Neisser et al., 1996), ECT performance should also at least partially mediate race differences on GPA. Consistent with the extant research on race differences in IQ, GPA, and ECT-task performance, together with Spearman's hypothesis, we predict:

(1) ECT performance will fully mediate the relationship between race and IQ (using the three stage test of mediation proposed by Baron & Kenny, 1986).
(2) ECT performance will at least partially mediate the relationship between race and GPA.

1. Method

1.1. Participants

The participants were 139 White and 40 Black undergraduates enrolled at a large urban university, comprising a diverse student body. We recruited from various sections (all in the same semester) of introductory accounting classes. Students signed consent forms before completing the study, and received extra course credit for participation. Race was self-reported from among the following categories: White, Black, Hispanic, Asian, Indian, and Other. We did not have enough Hispanic ($n=6$), Asian ($n=9$), Indian ($n=4$) or Other-race ($n=3$) participants to conduct statistical analyses, and so we excluded these people from the study. In addition, two older students (age 55 and 70 years) were excluded because they exhibited RTs well above their group means (see, e.g., Salthouse, 2000, for discussion of the strong inverse relationship between age and RT).

Table 1 shows the demographic characteristics of the White and Black samples, which differed by both gender and age. For gender, the Black students

Table 1
Demographic characteristics by participant race: gender, age, Wonderlic IQ score, and grade point average (GPA)

Sample	% Male	Age (SD) [a]	Mean IQ (SD)	Mean GPA (SD)
All students	55%	24.08 (5.3)	22.84 (5.8)	2.97 (.55)
Whites	60%	23.48 (4.7)	23.42 (5.8)	3.06 (.51)
Blacks	40%	26.18 (6.7)	20.80 (5.8)	2.68 (.57)
Difference	20% *	−2.70 *	2.62 *	0.38 *
Effect size [b]	–	0.52	0.45	0.73

[a] Age in years.
[b] Cohen's *d*, using the pooled group standard deviation.
* $p < .05$.

comprised more females (60%), whereas, the White students comprised more males (60%; X^2 (1)=4.88). This difference is consistent with overall enrollment patterns found in our college of business. Our college enrolled 1494 White and Black students this academic year. Of these, 1145 (76.6%) were White, and 349 (23.4%) were Black. Within race groups, 748 (65.4%) of White students were male, while only 151 (43.3%) of the Black students were male. We offer no hypotheses for why gender differs across race in our student body, but we included gender (and age) as a control variable in the mediated regressions reported below. With regard to age, Black students, on average, were 2.70 years older than the White students (t (51)=2.40; we did not have Age×Race enrollment data for our college).

1.2. Materials

All participants completed the Wonderlic Personnel Test (WPT; Form IV, Wonderlic & Associates, 2002). The WPT is a widely used, standardized measure of cognitive ability, with test–retest reliabilities ranging from .82 to .94 (Geisinger, 2001). The test manual reports strong correlations between the WPT and other standardized IQ tests, and produces Black–White differences of just under one-standard deviation (Wonderlic & Associates, 2002; see Table 9, p. 34). In addition, McKelvie (1989) reports validities between .30 and .45 for the WPT predicting grades.

Participants completed the ECTs on desktop Pentium computers. Each computer used 15-inch cathode ray tube (CRT) monitors, with a refresh rate of 75 Hz, and a display resolution of 800 by 680 pixels. The stimuli for the inspection time task appeared centered on the monitors and subtended a visual angle of 2.1° and 2.5°, for the shorter and longer lines of the IT stimulus, respectively. For the choice RT task, the stimuli also appeared centered on the monitors and subtended a visual angle of 0.5°. The inspection time task was modeled after that used by Luciano, Leisser, Wright and Martin (2004). The choice RT task was adapted from a Hick-task script on the E-prime online data base, and can be accessed at http://step.psy.cmu.edu/scripts/HF/Hyman1953.html.

1.3. Procedure

We administered the 12-minute version of the WPT in classrooms which varied in size between 11 and 38 students. Students later completed the ECTs in a computer laboratory. Instructions for the ECTs were presented onscreen. They included an overview of each task, and sample trials illustrating how participants should respond. For the IT task, we emphasized that speed of response was not important. Subjects were told to take as much time as they needed, focusing only on responding accurately. For the RT task, we told subjects to respond as fast as possible while maintaining high accuracy.

On each trial of the IT task, a fixation cross (+) appeared centered on the screen for 1000 ms. The fixation cross was then blanked for 100 ms. Thereafter, the IT stimulus (i.e., two vertical lines of differing length, connected by a smaller horizontal line) appeared. On a random half of trials, the left line of the IT stimulus was longer than the right. For the other half of trials, the opposite was true. The IT stimulus remained onscreen for a varying amount of time, as described below. After the appropriate IT duration had passed, a lightening bolt mask (where both vertical lines were of equal length, see, e.g., Luciano et al., 2004) appeared for 300 ms. The screen then went blank, and subjects responded by pressing "z" if they thought the left line was longer than the right, or by pressing "m" if they thought the right line was longer than the left.

The critical manipulation in the IT task involves varying the duration of the IT stimulus from trial to trial. All durations, however, had to be multiples of the computer monitor's refresh rate (one frame every 13.33 ms, given a refresh rate of 75 Hz). To achieve this, we used an adaptive staircase method which varied the IT duration across trials, as outlined by Luciano et al. (2004). All subjects first completed three practice trials, and then started the experimental trials with the IT duration set at 133 ms. Four correct answers in a row at any IT duration resulted in a "reversal," which caused the IT duration for the next trial to decrease (by four frames for the first two reversals; two frames for the next two reversals, and one frame for every reversal thereafter).

Table 2
Mean and standard deviation inspection times (IT), reaction times (RT), and intra-individual variability in milliseconds by race

	Race			
	White	Black	Difference	Effect size[a]
Inspection time	101 (46)	155 (118)	−54.0 *	0.79
IT variability	28.5 (22)	43.1 (36)	−14.6 *	0.57
Reaction time	460 (53)	483 (73)	−23.0 *	0.40
RT variability	71.4 (18)	85.8 (44)	−14.4 *	0.55

Note. Standard deviations are in parenthesis.
[a] Cohen's d, using the pooled group standard deviation.
* $p<.05$.

The IT duration also increased (by four, two or one frame, depending on the current reversal count) whenever a wrong answer was made. Reversals for wrong answers, though, occurred only if the previous IT duration was longer than the IT duration that forced the mistake. Hence, a long string of wrong answers would result in a constant increase of the IT duration. These would not count as reversals. Wrong-answer reversals only occurred when subjects made mistakes just after the IT duration had been decreased (due to four correct responses in a row on trials using a longer IT duration). The program ran for 96 trials or 15 reversals, whichever came first.

For the RT task, three letters (always two Capital "Ss" and one Capital "A") appeared centered on the screen, and remained until the subject responded. The subject's task was to rapidly indicate in which of the three positions the letter "A" appeared. For example, if the display showed: S A S, the subject would indicate that the letter "A" appeared in position two. Subjects used the number keypad on the keyboard, and responded with their right hand. The first six trials for each subject were practice, and not included in data analyses. Subjects then completed 60 experimental trials (where the target letter, "A," appeared randomly, 20 times in each of the three possible positions).

2. Results

We used $p<.05$ as the level of significance for all analyses. Table 1 shows mean WPT scores and GPAs by race. The WPT has a reported population mean of 22, with a population standard deviation of 7.0 (Wonderlic & Associates, 2002). From Table 1, the range of IQ scores for our participants seems somewhat restricted, as the sample standard deviation of 5.8 is only 83% of the population standard deviation of 7.0. The partial restriction of range might explain why the Black–White IQ difference here ($d=.45$) was smaller than the typical one-standard deviation effect ($d=1.0$) reported in the literature. A larger race difference emerged, however, for GPA where Black students averaged .73 standard deviations lower than the White student mean (this value is similar to those reported by Gottfredson, 2005a,b,c see Table 18.3, p. 536). In sum, significant race differences appeared for both IQ scores and GPAs.

Table 2 shows group means and standard deviations for the IT and RT tasks. We calculated each person's overall IT as his/her average IT duration across all reversals except the first. The column labeled "IT variability" is a measure of intra-individual variability. It represents the mean of the standard deviation of IT durations for subjects by race across all reversals. This measure is not typically reported in the literature. We included it here because it showed significant race differences, and also correlated with various other measures in the study (see Table 3). For the RT task, we calculated median RTs and standard deviations for each subject across the 60 experimental trials, after first excluding error trials and any single trial with an RT

Table 3
Simple correlation matrix of the demographic variables, IQ, GPA, and elementary cognitive task scores

Measure		1	2	3	4	5	6	7	8	9	10
1	Race	–									
2	Age	.21 *	–								
3	Gender	.17 *	.00	–							
4	IQ	−.19 *	.20 *	.04	–						
5	GPA	−.29 *	.01	.04	.30 *	–					
6	IT	.31 *	−.04	.09	−.39 *	−.20 *	–				
7	IT SD	.23 *	−.02	.14	−.30 *	−.05	.68 *	–			
8	RT	.17 *	.21 *	.20 *	−.24*	−.11	.32 *	.21 *	–		
9	RT SD	.22 *	.06	.07	−.29 *	−.19 *	.39 *	.37 *	.35 *	–	
10	ECT	.33 *	.04	.14	−.42 *	−.17 *	.86 *	.86 *	.51*	.60 *	–

Notes. IQ = Wonderlic intelligence score, GPA = grade point average, IT = inspection time, IT SD = inspection time standard deviation, RT = reaction time, RT SD = reaction time standard deviation, ECT = elementary cognitive task factor score.
* $p<.05$.

Table 4
Standardized regression beta weights testing elementary cognitive task performance as a mediator of race differences on Wonderlic IQ scores after controlling for participant age and gender

Equation	*B*	*t*-value
1. Age, gender, and race on ECT:		
Age	−.026	−0.36
Gender	.089	1.23
Race	.324	4.40 *
R, R^2	.35	.12
2. Age, gender, and race on IQ:		
Age	.253	3.45 *
Gender	.085	1.17
Race	−.254	−3.42 *
R, R^2	.32	.10
3. Age, gender, race, and ECT on IQ:		
Age	.243	3.60 *
Gender	.121	1.80
Race	−.124	−1.72
ECT	−.401	−5.70 *
R, R^2	.49	.24

Notes. ECT = elementary cognitive task factor score, IQ = Wonderlic intelligence score.
* $p<.05$.

greater than 1000 ms. Error and excluded trials combined averaged only 2.72 occurrences (SD=5.02, out of 60 possible) per subject. Note that all group differences in Table 2 are significant.

Table 3 shows simple correlations for the demographic variables, IQ, GPA, and the ECT scores. Small but significant effects appeared for race and its correlation with every other variable in the table. The last variable in Table 3 is a factor score derived from a principal components factor analysis conducted on the four ECT-task variables listed in Table 2. We conducted it to avoid multicollinearity in the regression analyses, as all ECT scores were intercorrelated. The analysis revealed a single factor accounting for 55% percent of the variance in the ECT scores. Each of the four ECT-task scores loaded significantly on the factor (loadings ranged from .58 for RT to .84 for IT).

Table 4 shows regression analyses which test whether ECT factor scores mediated the race difference on IQ (Hypothesis 1). For each regression equation in the table, both age and gender were entered as control variables. Baron and Kenny (1986) identified three criteria that must be met for a variable to achieve the status of a mediator. First, the independent variable (race) must correlate with the mediator variable (ECT), as shown in Eq. (1). Second, the independent variable (race) must correlate with the dependent variable (IQ), as shown in Eq. (2). Third, entering both the mediator and the independent variable should result in the latter now being non-significant. From Eq. (3), the standardized beta weight for race, controlling for ECT-task performance, is no longer significant ($B=-.124$, $p=.09$). Complete mediation, in theory, should result in the beta weight dropping to zero, which did not happen here. Nonetheless, ECT-task performance qualifies as a statistical mediator of race and IQ, as controlling for it reduced the relationship between race and IQ from a significant weight of −.254 in Eq. (2), to a non-significant rate of −.124 in Eq. (3) (a 49% decrease). This mediation occurred even after controlling for race differences on both age and gender.

Table 5 reports tests of whether the ECT factor scores mediated the relationship between race and GPA (Hypothesis 2). Again, all equations included age and gender as control variables. In Eq. (1), the independent variable (race) correlated with the mediator (ECT). In Eq. (2), the independent variable correlated with the dependent variable (GPA). However, Eq. (3) shows that race still significantly predicted GPA, even after controlling for ECT-task performance ($B=-.285$). In fact, (1) controlling for ECT-task performance in Eq. (3) only reduced the race/GPA correlation by .03 (10%), relative to Eq. (2), and (2) ECT-task performance itself was not significant in Eq. (3) ($B=-.093$; $p=.23$). Hence, contrary to Hypothesis 2, ECT-task performance failed to mediate the relationship between race and GPA reported here.

Table 5
Standardized regression beta weights testing elementary cognitive task performance as a mediator of race differences on grade point average after controlling for participant age and gender

Equation	*B*	*t*-value
1. Age, gender, and race on ECT:		
Age	−.026	−0.36
Gender	.089	1.23
Race	.324	4.40 *
R, R^2	.35	.12
2. Age, gender, and race on GPA:		
Age	.058	0.79
Gender	.092	1.26
Race	−.315	−4.22 *
R, R^2	.31	.09
3. Age, gender, race, and ECT on GPA:		
Age	.055	0.75
Gender	.100	1.37
Race	−.285	−3.63 *
ECT	−.093	−1.22
R, R^2	.32	.10

Notes. ECT = elementary cognitive task factor score, GPA = grade point average.
* $p<.05$.

3. Discussion

Summarizing key results: (1) Small (relative to the literature) race differences existed on IQ test scores. (2) Large (relative to the IQ difference here) race differences existed on GPA. (3) Race differences also existed on all ECT measures, including the intra-individual variability of IT and RT. (4) A factor score derived from the ECT measures statistically mediated the relationship between race and IQ. (5) The ECT factor scores failed to even partially mediate the relationship between race and GPA. In fact, ECT scores added little in the way of incremental variance explained when race, age and gender were also in the equation predicting grades. The data therefore support our first but not second hypothesis.

Given Spearman's hypothesis, it is perhaps not surprising that cognitive indicators of *g* (i.e., our ECTs) would mediate the relationship between race and psychometric measures of *g* (i.e., the WPT). The variation in both ECT performance and IQ scores seems largely driven by individual and group differences in the general factor. On the other hand, more than *g* contributes to a person's GPA, including variables like motivation, conscientiousness, family environment, work status, etc. (though recent research also points to a genetic cause for within-group differences in academic achievement, see, e.g., Luo, Thompson, & Detterman, 2003; Wainwright, Wright, Geffen, Luciano, & Martin, 2005; Wainwright et al., 2006). Considering just the present data set, however, basic measures of information processing do little to explain the Black–White difference on GPA.

Although consistent with Spearman's hypothesis, our data offer no insights as to possible causes for race differences on the ECTs. Whether these differences might arise from differences in environment, nutritional levels, genes or some other factor is an issue in need of further study. Further limits to the present study include: (1) a relatively small sample size for Black students, though statistical power did not seem to be an issue given the pattern of consistent, significant results was found. (2) A restricted range of participants, as we ran only college students. (3) Use of WPT scores as a proxy for *g* (i.e., we did not derive *g* factorially). Future studies with multiple measures of *g* might show an even clearer picture of the mediation effects reported here. (4) For unknown reasons, both age and gender differed by race. Although we included each as control variables in the mediated regressions, a more random sampling of race in a future study would offer stronger evidence that neither played a role in the data patterns reported here.

We believe the present data illustrate the potential of explaining and understanding group differences on IQ test scores by appeal to group differences on basic information processing tasks. In the present study, controlling for the latter eliminated the former. In addition, ECTs are so simple, that many possible explanations for observed differences (e.g., motivational levels) are reduced if not diminished. More research is needed, both on the criterion-related validity of ECTs, and on the underlying theoretical reasons for Black–White differences on these measures.

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