NOT BY *g* ALONE: THE BENEFITS OF A COLLEGE EDUCATION AMONG INDIVIDUALS WITH LOW LEVELS OF GENERAL COGNITIVE ABILITY

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ABSTRACT

In a longitudinal sample of 2593 individuals, we investigated the frequency individuals with IQs ≤ 90 completed college and whether these individuals experienced the same social and economic benefits higher-IQ college graduates did. Although the majority of individuals with IQs ≤ 90 did not have a college degree, approximately one in three women and one in five men did. The magnitude of the college effect on occupational status, income, financial independence and law abidingness was independent of IQ level, a finding replicated using the longitudinal NLSY97 sample. Additional analyses suggested the association of college with occupational status was causal and that the educational success of individuals with low average IQs may depend on personality factors, family socioeconomic status and genetic endowment. We discuss our finding in the context of the recent expansion in college attainment as well as the dearth of research on individuals with low average IQs.

Key Words: Low average IQ, returns to college, non-ability contributors to educational attainment, general cognitive ability

General cognitive ability (GCA, or often just *g*) is one of psychology's most powerful constructs, its significance deriving principally from the broad array of social and economic outcomes with which it has been linked (Warne, 2020). GCA is correlated cross-sectionally with occupational and educational attainment, income, job performance, health, and economic independence (Deary & Batty, 2007; Fors, Torssander, & Almquist, 2018; Herrnstein & Murray, 1994; Kuncel, Hezlett, & Ones, 2004; Strenze, 2007). Many of these associations also hold prospectively (Fergusson, John Horwood, & Ridder, 2005), supporting the conclusion that GCA influences many important life outcomes. Educational attainment is similarly associated with a broad array of desirable outcomes. College graduates are more likely than non-graduates to be employed, have high-status jobs, earn a high income, and enjoy good health and a long life (Hout, 2012; Lleras-Muney, 2005). As with GCA, research implicates a causal contribution of education in these associations (Hout, 2012).

The high correlation between GCA and educational attainment (Ceci, 1991) as well as the overlapping outcomes with which both have been linked motivate the question of how GCA and educational attainment jointly contribute to life outcomes. There is considerable evidence that GCA influences educational attainment (Strenze, 2007), and conversely that educational attainment can contribute to intellectual growth (Ritchie & Tucker-Drob, 2018). The resulting mutual dependence between GCA and educational attainment has made it difficult to resolve their separate contributions. Regression has been frequently used to investigate their joint effects. While not without limitation (Deary & Johnson, 2010), regression analyses have yielded a consistent set of results: GCA and educational attainment both contribute independently to

the prediction of life outcomes (Becker, Baumert, Tetzner, Maaz, & Koller, 2019; Caspi, Wright, Moffitt, & Silva, 1998; Scullin, Peters, Williams, & Ceci, 2000).

The independent association of GCA and educational attainment with life outcomes suggests there are highly educated individuals who experience social and economic success and yet have low levels of GCA. Unfortunately, we know very little about the frequency of these individuals nor the nature and extent of their achievements. In contrast, the achievements of very high-ability individuals (Lubinski & Benbow, 2021) as well individuals with intellectual disabilities (Blackorby & Wagner, 1996) have long been a focus of psychological research. The lack of research on individuals with low average GCA is even more remarkable given that they constitute a sizable portion of the population. As the 1960s era Newsom report concluded, individuals with average or low average GCA are "politically, socially and economically . . . vital to our national life" (p. xiv, Ministry of Education, 1963).

The current study seeks to address this gap by investigating:

1. How often individuals with low GCA achieve high educational standing as reflected by completing college.
2. Whether college-educated individuals with low GCA experience the same social and economic benefits that high ability college graduates do.
3. Whether the social and economic benefits associated with college appear to be caused by college.
4. The factors that in addition to GCA appear to contribute to the academic success of individuals with low GCA.

METHOD

Primary Sample: The Minnesota Twin Family Study (MTFS)

Our primary sample was derived from the longitudinal MTFS and was used previously by McGue et al. (2020) to explore the nature of intergenerational social mobility. The original MTFS sample consisted of 1382 pairs of like-sex twins, born in Minnesota between 1972 and 1984 and initially assessed between 1990 and 1996 at a target age of either 11 or 17 years (Iacono & McGue, 2002). The 11-year-old (younger) cohort was subsequently assessed at target ages of 14, 17, 20, 24 and 29; the 17-year-old (older) cohort was subsequently assessed at target ages of 20, 24 and 29. The last complete follow-up assessments were completed in 2002-2014; ongoing assessments in midlife were not used in the present analysis.

Of the 2764 twins who completed an intake assessment, 2593 (93.8%) were included in the current study because they had completed an IQ assessment at intake and reported educational attainment at either the age-29 (N=2486) or, for those who did not complete that assessment, the age-24 (N=107) assessment. Among the 171 intake twins not included in our analyses, 141 were excluded because they did not complete either follow-up, 25 were excluded for unknown educational attainment, and 5 were excluded for missing IQ. The mean (SD) intake IQ score was 99.8 (14.0) for the 2593 included twins versus 95.7 (14.4) for the 164 excluded twins with IQ data, suggesting some selection favoring higher GCA. Consistent with the demographics for the Minnesota birth years sampled, 93% of the sample was of European ancestry (Miller et al., 2012)

MTFS Measures

Educational attainment: Was based on participant-reported highest degree at their age-29, or if missing, their age-24 assessment coded as: 1 = Less than High School, 2 = High School or GED, 3

= Some College, 4 = 4-year College, 5 = Graduate or Professional (e.g., M.A., Ph.D., M.D.). Codes 4 and 5 were considered to have completed college.

General Cognitive Ability (GCA): Was assessed at intake using an abbreviated form of either the Weschler Adult Intelligence Scale-Revised (WAIS-R, Wechsler, 1981) in the older cohort or the Weschler Intelligence Scale for Children-Revised (WISC-R, Wechsler, 1974) in the younger cohort. In both cases, the abbreviated test consisted of two performance (Block Design and Picture Arrangement) and two verbal (Vocabulary and Information) subtests. Prorated IQs, derived from the four subtests following standard procedures, have been shown to correlate .90 with IQs based on all Weschler subtests (Kaufman, 1990). Mean GCA was significantly greater (χ^2 (1df) = 37.8, $p < .001$) in the younger cohort (104.2, SD=13.9, N=1387) than the older cohort (99.8, SD=14.1, N=1206), with a standardized mean difference, *d* (95% CI), of .31 (.21, .41). Because this difference could reflect a Flynn effect (the WISC-R was normed 7 years before the WAIS-R), IQ scores were adjusted by subtracting the average difference of 4.4 points from the IQ scores of younger cohort participants.

Social outcomes: Four social outcomes were assessed at either the age-29 or, if unavailable, the age-24 assessment. For those working full-time, occupational status was coded on a reflected 7-point Hollingshead scale (Hollingshead, 1957) so that higher scores corresponded to higher perceived status. Scores on the reflected scale ranged from 1 = unskilled labor to 7 = professional positions. Annual gross income was reported for those who had a job. Because of the marked skewness in the income data, incomes were winsorized at an annual income of $200,000 (eight incomes exceeded this limit, less than 1% of the sample) and log-transformed prior to statistical analysis. An Independence scale was constructed by summing five

dichotomous indicators of financial independence (the first four being reflected): 1) government assistance as an adult, 2) unemployment that lasted at least 6 months, 3) living with parents, 4) receiving financial support from parents, and 5) being engaged full-time (i.e., either in a job, or being a full-time student or parent). Finally, a Legal Problems scale was constructed by summing four dichotomous items all reported since the participant's previous assessment: having problems with drugs, police contact, going to court, jailed.

Predictors: Three additional variables were used to investigate potential mechanisms by which individuals with low GCA achieve high educational standing. The first two were assessed when the twins were in adolescence: 1) a composite of five non-ability personality scales and 2) a composite of three indicators of family socioeconomic status (SES). The personality composite was based on our earlier research (McGue et al., 2020) and consisted of self-report scales measuring a willingness to inhibit behavior, delay reward and work hard along with the belief that doing so would be personally beneficial. Four of the components were scales from the Multidimensional Personality Questionnaire (MPQ, Tellegen & Waller, 2008) and the fifth was a measure of behavioral disinhibition (Hicks, Schalet, Malone, Iacono, & McGue, 2011); all were completed at the age-17 assessment. The MPQ scales included: Social Potency (being decisive), Achievement (ambitious, hard-working), Alienation (feeling exploited, unlucky), and Control (being careful, reflective). The Behavioral Disinhibition scale consisted of aggregated symptoms of antisocial behavior and substance abuse obtained by clinical interview. The Personality composite was formed by taking the mean of the five (or when no more than one was missing, four) standardized components after reflecting the Alienation and Behavioral Disinhibition scores.

Rearing SES was a composite of three indicators reported by parents at the twins' intake assessment: parent education, parent occupation, and family income. Parent education and occupation were assessed as the midparent average using the same scales as used with offspring. Family income was rated on a 1 (less than $10,000/year) to 13 (more than $80,000/year) scale by parents at the intake assessment, completed between 1990 and 1996. The Rearing SES composite was formed by taking the mean of these three standardized indicators (or the mean of two in cases where one was missing). Both the Personality composite and the Rearing SES composite were standardized in the total sample.

Finally, the MTFS sample has been genotyped on over 500,000 single nucleotide polymorphisms (SNPS, Miller et al., 2012), allowing us to compute an educational attainment polygenic score (PGS) using results from the Social Science Genetics Association Consortium's most recent GWAS of educational attainment (Lee et al., 2018). PGS were computed using the LDpred software with a prior probability of 1.0 (Vilhjálmsson et al., 2015). Because genetic prediction varies by ancestral background (Martin et al., 2017), PGS was calculated only for the 93% of the sample determined to have European ancestry (Miller et al., 2012).

Analysis of MTFS Sample

Group Classification: The 2x3 (College by GCA) design used in the current study involved crossing 4-year college degree completion with GCA level (Low=IQ of 90 or less, Medium=IQ between 90 and 110, and High=IQ of 110 or more). The GCA classification was selected to approximate IQs at the extremes of the educational attainment distribution (Figure 1). Specifically, in the MTFS sample the mean IQ (95% CI) was 90.2 (87.1, 93.3) for the 41

individuals who did not complete a high school or GED degree and 108.3 (106.9, 109.7) for the 442 individuals with a graduate or professional degree.

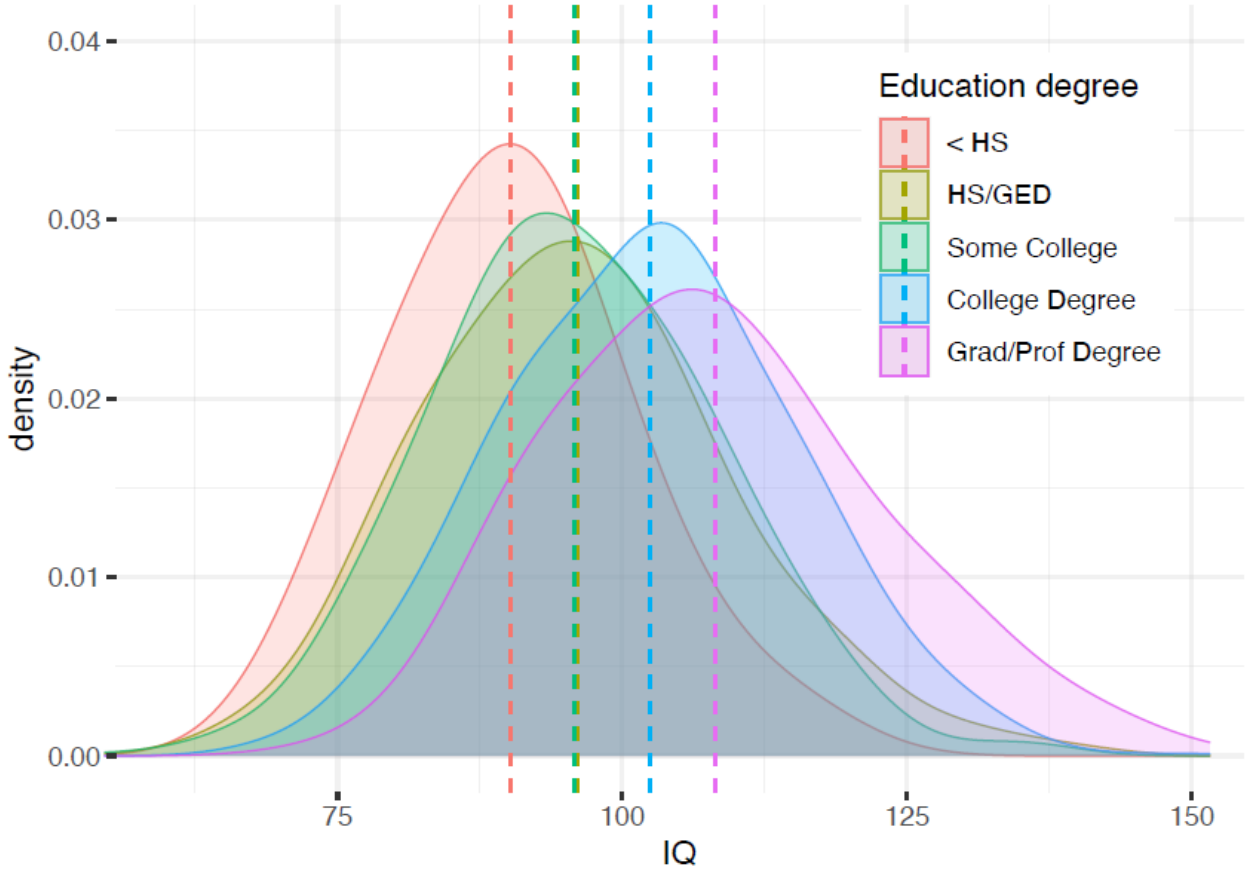


Figure 1: Distribution of IQs as a function of highest degree completed in MTFS sample (N=2593). Dashed lines give group mean IQ.

The effects of GCA and College were evaluated using a generalized linear model with generalized estimating equations (GEE) to account for the clustering of the data by twin pair (Hanley, Negassa, Edwardes, & Forrester, 2003). Our main analysis involved fitting a three-factor (Sex by GCA by College) analysis of variance (ANOVA) model separately for each of the

four social outcome scales. Occupation and Log Income were fit assuming a normal distribution with identity link function; Independence (reflected) and Legal Problems were fit using a negative binomial distribution and log link function. ANOVA models were fit to the social outcomes both without and with adjustment for the Personality and Rearing SES composites. In all analyses, age at assessment and ethnicity (limited to white versus non-white given the structure of the sample) were included as covariates and dependent variables were standardized to facilitate interpretation. We report Type III test of effects and estimates of standardized group differences (*d*) along with confidence intervals. All MTFS participants that met study inclusion criteria were included in the analyses. Because of the large number of statistical tests reported, we both used a significance level of $p < .005$ (Benjamin et al., 2018) to minimize false positive reports and emphasized effect size rather than statistical significance. Power calculations are complex in a multi-objective study with clustered sampling. We conservatively assessed power based on number of families and in two-group comparisons we have power of .80 or greater to detect mean differences .20SD or smaller at $p < .005$ (two-tailed).

Cotwin Control (CTC) Analysis: CTC analyses sought to determine whether associations between college completion and the four social and occupational outcomes were consistent with a causal effect of college by determining whether associations held within monozygotic (MZ) twin pairs discordant for college completion (McGue, Osler, & Christensen, 2010). CTC analysis followed the procedures described by Saunders et al. (2019).

Description and Analysis of the Secondary Sample: National Longitudinal Survey of Youth, 1997 (NLSY97)

The NLSY97 sample (Bureau of Labor Statistics, 2019) was used to assess robustness of key findings from the MTFS. Although there is no sample that perfectly duplicates the MTFS twin structure and assessments, the NLSY97 has the advantage of being a U.S. longitudinal study that spans adolescence through early adulthood and includes birth cohorts that overlap those in the MTFS. The NLSY97 included individuals born between 1980 and 1984 who were first assessed in 1997 and followed annually through 2011 and biannually thereafter. To approximate the MTFS sample, we made use only of what is known as the cross-sectional NLSY97 sample (i.e., the sample selected to be representative of the U.S.), which numbered 6748 at the initial assessment. The ethnic distribution of this sample was 16% Black, 14% Hispanic, 69% Non-Hispanic White and 1% mixed.

The specific variables used from the NLSY97 along with their variable codes are listed in Table S1 (Supplemental Online Material, SOM). Education was coded as highest degree completed on the same 5-point scale used in the MTFS. The NLSY97 did not administer an IQ test but did administer an ASVAB Verbal-Math composite in 1999. These composite scores were converted to IQ equivalents (i.e., mean of 100 and standard deviation of 15). Occupation was based on the 4-digit census code derived in 2015, and log Income was based on the 2011 report. We also computed an Assistance scale by summing ever receiving unemployment benefits and ever receiving government assistance; and a Legal Problems scale by summing ever arrested, use of marijuana, and use of other illicit drugs from the 2011 and 2015 assessments, respectively.

RESULTS

Initial Analysis of the MTFS sample

GCA, the four social outcomes (Occupation, Income, Independence, Legal Problems) and three predictors (Personality, SES, PGS) were all monotonically related to highest educational degree with the single exception of those not graduating high school having a higher mean income than those with a high school degree, perhaps because they have been in the workforce longer (Table S2, SOM). There was marked variability in GCA within each degree group (Figure 1), such that some with a college degree had relatively low GCA. Table 1 gives the sample size and descriptive statistics for study variables as a function of the College by GCA grouping, separately for women and men. Of note is that 147 (10.8%) of women but only 45 (3.7%) of men were in the low GCA-College group. Given the expansion of educational opportunity that occurred during the 20th century, it is informative to compare rates of college completion in the offspring sample with that of their parents. Among offspring, 53.0% (N=1365) of women and 40.2% of men (N=1228) completed college; 25.3% (N=1365) of their mothers and 27.8% (N=1188) of their fathers had a college degree. While all GCA groups saw an increase in college completion between the parent and offspring generations, the largest proportional increase was in the low GCA group as only 10 (0.7%) of the moms and 5 (0.4%) of the dads would be classified in a low GCA-College group.

Table 1. Descriptive data on study variables by group membership separately by sex in MTFS sample.

		Women (Total N=1365)						Men (Total N=1228)					
		NO COLLEGE			COLLEGE			NO COLLEGE			COLLEGE		
		Low GCA	Med GCA	High GCA	Low GCA	Med GCA	High GCA	Low GCA	Med GCA	High GCA	Low GCA	Med GCA	High GCA
N	%	279 20.4%	311 22.8%	52 3.8%	147 10.8%	378 27.7%	198 14.5%	203 16.5%	406 33.1%	124 10.1%	45 3.7%	261 21.3%	189 15.4%
IQ	Mean (SD)	81.4 (6.3)	98.7 (5.3)	117.2 (5.2)	84.6 (5.1)	100.9 (5.5)	119.3 (7.7)	83.6 (6.2)	99.5 (5.5)	118.3 (7.5)	85.1 (4.4)	100.9 (5.5)	120.9 (8.4)
Demographics:													
Age	Mean (SD)	29.2 (1.2)	29.2 (0.9)	29.2 (0.9)	29.2 (0.9)	29.2 (0.9)	29.1 (0.9)	29.3 (1.2)	29.2 (1.2)	29.3 (1.3)	29.5 (0.7)	29.4 (0.9)	29.5 (0.8)
Married %		57.8%	57.5%	64.7%	68.8%	63.6%	54.5%	47.1%	50.4%	50.0%	60.0%	59.5%	49.5%
European Ancestry %		93.8%	91.5%	94.2%	87.7%	97.0%	94.9%	90.1%	93.8%	88.6%	100.0%	93.4%	93.0%
Social Outcomes:													
Occupation	Mean (SD)	3.66 (1.34)	3.96 (1.37)	4.32 (1.29)	5.06 (1.28)	5.33 (1.06)	5.59 (1.04)	3.20 (1.49)	3.56 (1.52)	3.90 (1.54)	5.48 (0.94)	5.29 (1.28)	5.59 (1.21)
Income	Mean (SD)	29.4 (17.8)	31.7 (16.4)	36.7 (25.4)	42.2 (20.3)	44.6 (21.1)	45.7 (25.6)	49.0 (33.3)	46.1 (22.7)	45.3 (22.1)	57.5 (35.6)	61.5 (34.5)	57.1 (35.3)
Independ	Mean (SD)	4.20 (0.98)	4.29 (0.89)	4.39 (0.87)	4.65 (0.77)	4.72 (0.59)	4.53 (0.77)	4.26 (0.96)	4.34 (1.00)	4.46 (0.80)	4.62 (0.72)	4.71 (0.63)	4.70 (0.64)
Legal Problems	Mean (SD)	0.36 (0.80)	0.29 (0.77)	0.08 (0.27)	0.11 (0.47)	0.08 (0.28)	0.08 (0.38)	0.68 (1.20)	0.50 (1.04)	0.53 (1.07)	0.22 (0.67)	0.31 (0.85)	0.22 (0.73)
Predictors:													
Personality Composite	Mean (SD)	-.47 (0.95)	-.34 (1.05)	.00 (1.03)	.28 (0.89)	.39 (0.94)	.56 (0.89)	-.39 (0.85)	-.31 (0.96)	-.32 (0.94)	.26 (0.80)	0.27 (0.80)	.33 (0.91)
Rearing SES	Mean (SD)	-.54 (0.72)	-.31 (0.87)	-.01 (0.98)	.15 (0.90)	.34 (0.96)	.76 (1.02)	-.48 (0.86)	-.39 (0.83)	-.03 (0.90)	.13 (0.87)	.34 (0.93)	.68 (1.04)
PGS	Mean (SD)	-.48 (0.93)	-.13 (0.94)	-.05 (0.86)	-.26 (1.01)	.24 (0.94)	0.60 (0.93)	-.33 (1.01)	-.13 (0.96)	0.04 (0.97)	0.01 (1.07)	0.22 (0.94)	0.54 (0.88)

Note: GCA = General Cognitive Ability; SES = Socioeconomic Status; PGS = Educational Attainment Polygenic Score

Correlations among study variables are reported in Table S3 (SOM). Both GCA and educational attainment were moderately correlated with all outcomes, with correlations for the latter being consistently greater than those for the former. Descriptive statistics are given in Table S4 (SOM) for the individual components comprising the Independence and Legal Problems scales and in Table S5 (SOM) for components of the Personality and Rearing SES composites.

GCA group status was based on observed IQ, which could lead to selection on measurement error, especially at the extremes (e.g., IQ $\leq$ 90 for the Low GCA group). Of the 2593 individuals in the sample, 1683 (65%) completed a second IQ assessment (based on the same four WAIS-R subtests used at the initial assessment) on average 6.6 years (SD=0.7) after the first (complete results in Table S6 and Figure S1, SOM). Those retested had a slightly higher mean IQ at initial testing (mean=101.0, SD=13.9, N=1683) than those not retested (mean =97.5, SD=13.8, N=910), with the correlation between the two assessments being .79 (95% CI =.77, .81). As expected, the 122 individuals in the Low GCA-College group with two IQ assessments scored lower at the initial assessment used to form the GCA groups (mean=85.1, SD=4.7) than at retest (mean=91.8, SD=9.1) and the 119 individuals in the High GCA-No College group with two IQ assessments scored higher at initial assessment (mean=117.9, SD=6.8) than retest (mean=115.1, SD=12.3). Although the mean IQs for the low GCA and high GCA groups are likely somewhat biased due to selection, both groups are extreme on the IQ distribution.

Association of GCA and College Completion with Social Outcomes in Young Adulthood in the MTFS

ANOVA results for the four social outcomes are summarized in Table 2. Looking first at the results unadjusted for the predictors, in only one case was there a statistically significant two-way or three-way interaction (a Sex by College interaction for Occupation, where the College effect was greater in men than women). Notably, there was no evidence that the College effect varied by GCA level, indicating that the magnitude of the College effect was statistically as great for those with low GCA as with those with medium or high GCA. We consequently focus on the main effects for College and GCA (note that the effect for each factor is net the contribution of the other factor). College was significantly associated with all four outcomes at $p < .001$; GCA was significantly associated with Occupation only. Standardized mean differences between those completing college and those not both overall and by GCA level are plotted in Figure 2A. College was associated with markedly higher occupational status (d = 1.07, 95% CI=1.00, 1.14), and moderately higher income (d = .49, 95% CI=.40, .57) and independence (d = .46, 95% CI=.37, .54) and lower legal problems (d = -.46, 95% CI=-.54, -.37).

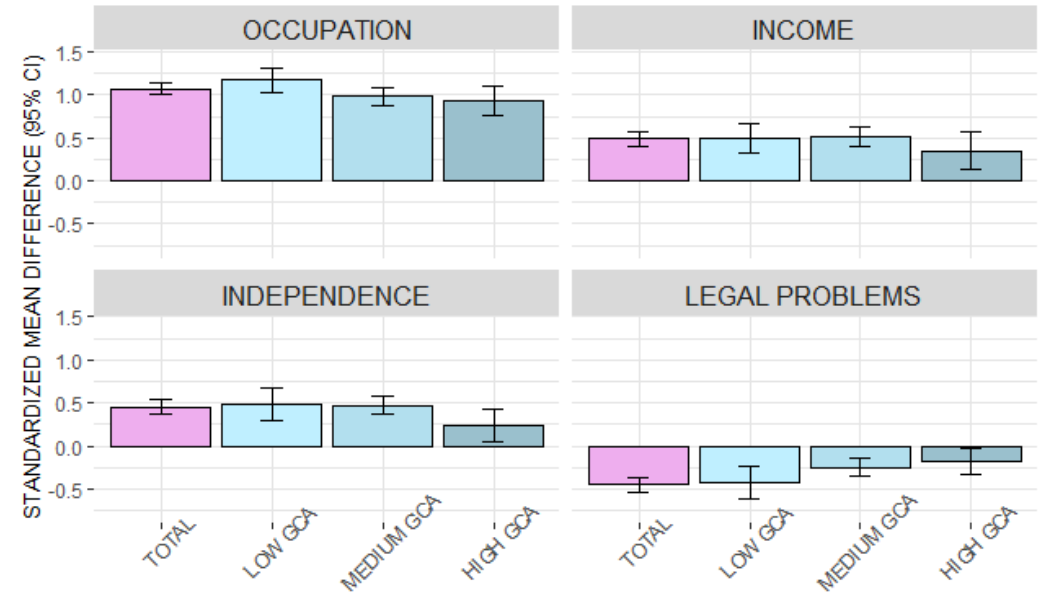
Table 2. Regression Results for Social Outcomes and Predictors in MTFS sample.

Effect (test statistic df)	Occupation		Log Income		Independence		Legal Problems	
	Base χ^2 p	Adjusted χ^2 p	Base χ^2 p	Adjusted χ^2 P	Base χ^2 p	Adjusted χ^2 p	Base χ^2 p	Adjusted χ^2 p
Age (1df)	4.05 p=.04	2.32 p=.13	1.60 p=.21	0.61 p=.44	5.59 p=.02	6.59 p<.01	1.35 p=.25	.10 p=.75
Sex (1df)	5.96 p=.02	2.63 p=.11	103.1 p<.001	106.6 <.001	0.88 p=.35	1.17 p=.19	37.5 p<.001	26.0 p<.001
Ethnicity (1df)	0.31 p=.58	1.30 p=.25	0.00 p=.98	0.04 p=.84	2.58 p=.11	2.64 p=.11	3.43 p=.08	2.49 p=.11
GCA Group (2df)	30.1 p<.001	17.3 p<.001	1.83 p=.40	1.98 p=.37	2.91 p=.23	2.33 p=.31	5.70 p=.06	2.14 p=.34
College (1df)	585.3 p<.001	354.3 p<.001	72.5 p<.001	35.2 p<.001	59.6 p<.001	29.0 p<.001	37.3 p<.001	11.8 p=.001
GCA x College (2df)	5.86 p=.053	5.79 p=.055	1.59 p=.45	1.32 p=.52	4.71 p=.10	2.85 p=.24	4.10 p=.13	1.48 p=.48
Sex x College (1df)	15.5 p<.001	13.2 p<.001	4.04 p=.045	4.60 p=.32	0.01 p=.91	.02 p=.89	4.80 p=.29	2.88 p=.90
Sex x GCA (2df)	2.35 p=.31	0.63 p=.73	2.71 p=.26	94 p=.63	2.09 p=.35	2.21 p=.33	.54 p=.76	0.40 p=.82
Sex x College x GCA (2df)	3.29 p=.19	3.84 p=.15	1.39 p=.50	3.10 p=.21	1.89 p=.39	2.88 p=.24	4.10 p=.13	3.72 p=.16
Personality (1df)	NA	77.0 p<.001	NA	23.3 p<.001	NA	13.1 p<.001	NA	19.7 p<.001
Rearing SES (1df)	NA	10.0 p=.002	NA	1.68 p=.20	NA	3.43 p=.06	NA	2.67 p=.10

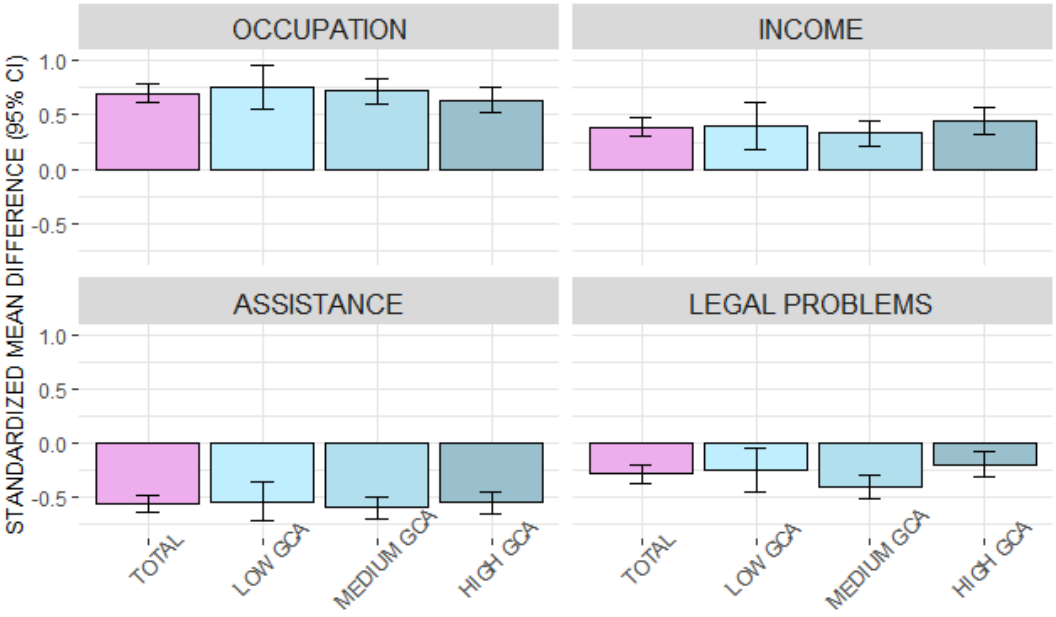
NA: Base model did not include Personality and Rearing SES composites as covariates while Adjusted model did. Adjusted model not fit with the three predictors: Personality, SES and PGS.

Table 2. continued

Effect (test statistic df)	Personality Base χ^2 p	SES Base χ^2 p	PGS Base χ^2 p
Age (1df)	1.69 p=.19	1.94 p=.16	0.90 p=.34
Sex (1df)	4.17 p=.04	0.12 p=.73	0.87 p=.35
Ethnicity (1df)	0.00 p=.95	0.02 P=.89	NA
GCA Group (2df)	9.60 P=.018	51.9 p<.001	45.2 p<.001
College (1df)	169.2 p<.001	175.7 p<.001	51.6 p<.001
GCA x College (2df)	0.52 p=.77	0.29 p=.86	4.02 p=.13
Sex x College (1df)	0.41 P=.52	0.01 p=.92	0.00 p=.96
Sex x GCA (2df)	5.57 p=.06	0.27 p=.88	3.69 p=.16
Sex x College x GCA (2df)	1.08 p=.58	0.99 p=.61	1.07 p=.59
Personality (1df)	NA	NA	NA
Rearing SES (1df)	NA	NA	NA



A. STANDARDIZED COLLEGE EFFECT IN MTFS SAMPLE



B. STANDARDIZED COLLEGE EFFECT IN NLSY97 SAMPLE

Figure 2: Effect of college completion on social outcomes in the MTFS (A) and NLSY97 (B) samples. Total gives marginal standardized mean college effect; others give standardized mean college effect as a function of GCA group. Error bars represent 95% confidence intervals.

Table 2 also gives ANOVA results for the Personality and Rearing SES composites as well as for the social outcomes adjusted for these predictors. None of the interactions were statistically significant, and we focus on the main effects of College and GCA. College was significantly and similarly associated with both Personality (*d*=.65, 95% CI=.55, .75) and Rearing SES (*d*=.64, 95% CI=.59, .80). GCA was significantly associated with Rearing SES (difference between High and Low GCA groups, *d*=.59, 95% CI=.38, .67) but not with Personality (High versus Low *d*=.21, 95% CI=.08, .35). Adjusting for the two composites minimally reduced the magnitude of the College effect on the four social outcomes (Figure 3).

Figure 3: Standardized mean difference (95% CI) between College and Non-College samples in the MTFS. Total gives mean difference adjusted only for the demographic factors of Age, Sex and Ethnicity. Marginal is the estimate averaged across General Cognitive Ability groups, and so further adjusts for that variable. Adjusted gives the fully adjusted estimate from the model that also included the Personality and Family SES composites as covariates. W/I MZ is the mean difference within monozygotic twin pairs discordant for college completion.

Genetically Informed Analysis of the MTFS Sample

Consistent with previous research (Branigan, McCallum, & Freese, 2013), MZ twins were more similar in college attainment (tetrachoric r = .83, 95% CI = .79, .87) than DZ twins (r = .51, 95% CI = .39, .63). CTC analysis sought to determine whether associations of college with outcomes were consistent with a causal college effect (McGue et al., 2010). MZ twins discordant for college attainment are perfectly matched on their genomes and rearing environment. Consequently, if college contributes causally to social and economic outcomes, we expect the college educated twin to score higher on these outcomes than their non-college educated cotwin. The sample included 818 pairs of MZ twins, 347 concordant for not having a college degree, 319 concordant for college and 152 discordant. Results of the CTC analyses are summarized in Figure 3 and Table S7 (SOM). College-completing MZ twins had higher means on all four outcomes than their non-college completing cotwins, although this difference was generally modest in magnitude (d < .25) and non-significant except for occupational status (χ^2 (1df) = 33.6, p < .001, d=.54, 95% CI= .36, .72). The college-completing twin also scored on average higher on GCA (mean difference of 1.8 IQ points, 95% CI = 0.4, 3.2) and the Personality composite (d=.49, 95% CI = .32, .67), although adjusting within-pair differences on social outcomes for these potential confounders had minimal effect on estimates (Table S7).

Analysis of the educational attainment PGS scores sought to determine whether genetic factors contributed to the educational achievement of individuals with low levels of GCA. PGS means by group are given in Table 1 and analyses are summarized in Table 2. Only the main effects of GCA and College were significant, both at p < .001. The marginal mean difference was

moderate both for the college effect (*d*=.41, 95% CI=.30, .53) and when comparing the two extreme GCA groups (*d*=.55, 95% CI=.39, .71).

Analyses of the NLSY97

Analysis of the NLSY97 sought to replicate our MTFS finding that individuals low in GCA who complete college experience many of the social and economic benefits associated with college. Means and SDs of the NLSY97 sample, grouped by GCA-College group, are given in Table S8. Although the NLSY97 included individuals with low GCA (i.e., an IQ $\leq$ 90) who completed a college degree, their proportionate representation was less than what we observed in the MTFS. Among women, 3.3% completed college and had an IQ $\leq$ 90 (mean=85.3, SD=3.6, N=87); the comparable rate for men was 2.1% (mean IQ = 84.5, SD=4.1, N=57).

The ANOVA results for the four social outcomes in the NLSY97 sample are summarized in Table S9 and closely paralleled those from the MTFS. College and GCA group were significantly associated with all four outcomes with no evidence of an interaction between the two factors. Estimates of the marginal standardized difference between the college and non-college group are plotted in Figure 2A, both overall and as a function of GCA group level.

DISCUSSION

We investigated social and economic outcomes in 2593 MTFS participants, cross classified by college completion and GCA level (IQ $\leq$ 90, 90 < IQ < 110, and IQ $\geq$110). We found: 1) a non-trivial proportion of men and even more women with IQs $\leq$ 90 completed a 4-year college degree; 2) the social and economic benefits associated with completing college did not vary by GCA group; 3) outcomes associated with college may not always be a consequence of

college, and 4) personality characteristics, family SES and genetic endowment may all contribute to the educational success of individuals with low GCA. A secondary analysis of NLSY97 data confirmed the first two findings but did not have data relevant to the last two findings. We, consequently, focus our discussion on the MTFS results.

Individuals with IQs between 80 and 90 are typically labelled as low average (Sattler, 2020). Although they constitute a sizable segment of the population, they have received little empirical attention. As expected, we found that most individuals with IQs $\leq$ 90 did not have a college degree. Nonetheless, in the MTFS roughly one in three women and one in five men with IQs in this range did. To determine whether individuals low in GCA experienced the same benefits as higher-IQ individuals who completed college, we analyzed four outcomes: occupational status, income, financial independence, and absence of legal problems. The magnitude of the college effect on these outcomes did not vary significantly by GCA level; college was neither the great equalizer (i.e., it did not reduce GCA differences, Torche, 2011) nor a producer of a Matthew effect (i.e., it did not expand differences, Damian, Su, Shanahan, Trautwein, & Roberts, 2015).

An association of college with outcome may owe to a causal effect of college; it may also be due to confounding. The CTC method seeks to strengthen causal inference by determining whether an association between exposure and outcome exists within MZ twins discordant on exposure (McGue et al., 2010). Because MZ twins effectively have the same genomes and rearing environments, within-MZ comparisons control for confounding due to these factors even though they are not explicitly assessed. Among MZ twins discordant for college, we found that the college educated twin scored higher on all four outcomes, although

the difference was small and not statistically significant except for occupational status (*d* =.54, 95%CI=.36, 72). Our results are, consequently, consistent with a causal effect of college on occupational attainment, but equivocal for the other three outcomes. There are two major hypotheses for how college might influence social outcomes like occupation (Caplan, 2018). The human capital hypothesis posits that college fosters the development of skills that contribute to occupational success. The alternative, signaling, hypothesis posits that completing college signals to prospective employers that an individual must have possessed the skills needed to gain admission to and ultimately complete college, but that college does not necessarily foster the development of those skills. Although not resolved here, determining whether college exerts its effects through skill building or credentialling has important implications.

Our findings are consistent with a growing literature suggesting a range of factors in addition to GCA can contribute to social success (Roberts, Kuncel, Shiner, Caspi, & Goldberg, 2007). We found support for three: 1) personality factors related to self-control, the delay of gratification and willingness to work hard (McGue, Rustichini, & Iacono, 2017); 2) rearing SES (Anderson, Saunders, Willoughby, Iacono, & McGue, 2021); and 3) genetic endowment (Lee et al., 2018). Although we found each of these to be associated with college attainment independently of GCA, they did not in aggregate account fully for the social and economic benefits we observed to be associated with college. Other factors, including social capital (Portes, 1998), peer norms (Ryan, 2000) and a broader array of personality factors than we assessed (Smithers et al., 2018), may all play a role in the academic success of individuals low in GCA. The role of grade inflation should also be considered. There is concern that grade inflation at the high school level has resulted in increasing numbers of poorly prepared students being

admitted to college (Gershenson, 2018), while grade inflation at the college level has resulted in some students completing a college education without acquiring academic skills (Denning, Eide, Mumford, Patterson, & Warnick, 2021). If these concerns are valid, college may ultimately lose its signaling function and may even compromise its human capital formation function.

Our results do not imply that GCA is irrelevant for academic success nor that colleges should admit individuals without regard to their level of cognitive ability. There is ample evidence of the importance of GCA to educational attainment (Strenze, 2007). Moreover, previous attempts to relax cognitive screens, such as the Vietnam-era Project 100,000 where individuals scoring below the 10th percentile on the Armed Forces Qualifying Test were recruited into the military (Laurence & Ramsberger, 1991), have sometimes ended poorly. Our results show that individuals with low average IQs can succeed in college, but their success likely depended on non-ability skills and social supports that not everyone with IQs in this range share. Our results are also not a repudiation of researchers who have emphasized the importance of *g*. Indeed, the most prominent among these (Gottfredson, 1997; Herrnstein & Murray, 1994) have argued that while critical, *g* is not the sole determinant of life success.

There are other limitations to our study worth noting. Our primary sample, while representative of Minnesota for the birth years sampled, is predominantly of European ancestry. The relevance of our findings for other populations remains to be determined. The social and economic outcomes we investigated might be considered a low bar for assessing the benefits of higher education. We believe it likely that our results would have been different had our focus been on the extremes of intellectual achievement (e.g., patents, scientific publications) shown in previous research to be associated with very high GCA (Park, Lubinski, &

Benbow, 2008). Our results may also look quite different in ten years, when the sample reaches their prime career years. Nonetheless, the outcomes we investigated – holding a good job, earning a livable income, financial independence, and being a good citizen – are all outcomes valued by society and by the individuals that comprise it.

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