ONLINE SUPPLEMENT FOR:

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

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MTFS = Minnesota Twin Family Study

Table S1. Variables used from the National Longitudinal Study of Youth 1997 (NLSY97) sample

NLSY97 Reference Number	Assessment Year	Variable Description
E80331.00	XRND	TOTAL NUMBER OF ARRESTS
R00001.00	1997	PUBID - YOUTH CASE IDENTIFICATION CODE
R05363.00	1997	KEY!SEX - RS GENDER (SYMBOL)
R05364.01	1997	KEY!BDATE - RS BIRTHDATE MONTH/YEAR (SYMBOL)
R05364.02	1997	KEY!BDATE - RS BIRTHDATE MONTH/YEAR (SYMBOL)
R12358.00	1997	SAMPLE TYPE - CROSS-SECTIONAL OR OVERSAMPLE
R14826.00	1997	KEY!RACE_ETHNICITY - COMBINED RACE AND ETHNICITY (SYMBOL)
R98296.00	1999	ASVAB MATH_VERBAL SCORE PERCENT
T75456.00	2011	TOTAL INCOME FROM WAGES AND SALARY IN PAST YEAR
T76397.00	2011	HAS R USED MARIJUANA SINCE DLI?
T76400.00	2011	HAS R USED COCAINE/HARD DRUGS SINCE DLI?
U11271.00	2015	YEMP - OCCUPATION/JOB CODE (2002 CENSUS 4-DIGIT) 01 (ROS ITEM)
U10322.00	2015	HAS R USED MARIJUANA SINCE DLI?
U10325.00	2015	HAS R USED COCAINE/HARD DRUGS SINCE DLI?
Z90750.00	XRND	# MONTHS R EVER RECEIVED UNEMPLOYMENT
Z90794.00	XRND	MONTHS RECEIVE AID FROM GOVERNMENT PROGRAM
Z90839.00	XRND	HIGHEST DEGREE RECEIVED

Table S2. Mean (SD) of GCA, social outcomes and predictors as a function of highest educational degree in MTFS sample.

Education Degree	GCA	Occupation	Income	Independ	Legal Problems	Personality Composite	SES Composite	PGS
Women: N	1365	1142	1140	1305	1309	1276	1365	1263
< High School	86.2	3.43	27.0	3.36	0.42	-.83	-.71	-.74
	(8.8)	(1.40)	(14.8)	(0.81)	(0.90)	(0.84)	(0.85)	(1.09)
High School	92.8	3.72	29.3	4.21	0.37	-.48	-.46	-.31
	(13.0)	(1.39)	(17.9)	(0.95)	(0.84)	(1.06)	(0.85)	(1.00)
Some College	92.9	4.01	32.9	4.34	0.22	-.23	-.29	-.22
	(11.9)	(1.33)	(18.0)	(0.89)	(0.65)	(0.95)	(0.80)	(0.88)
College	100.6	5.09	42.1	4.62	0.10	.28	.31	.12
	(12.8)	(1.10)	(20.0)	(0.74)	(0.41)	(0.91)	(0.94)	(0.96)
Grad/Prof	106.2	5.77	48.2	4.71	0.05	.66	.59	.46
	(13.9)	(1.00)	(25.2)	(0.58)	(0.23)	(0.88)	(1.06)	(1.02)
Men: N	1228	1075	1067	1173	1174	1097	1224	1127
< High School	92.0	2.29	50.7	3.96	0.96	-.25	-.75	-.32
	(10.5)	(1.31)	(40.5)	(1.34)	(1.45)	(1.04)	(0.80)	(0.98)
High School	98.5	3.41	45.6	4.28	0.61	-.35	-.34	-.24
	(13.1)	(1.57)	(27.4)	(0.99)	(1.15)	(0.96)	(0.90)	(1.03)
Some College	98.7	3.76	47.9	4.45	0.43	-.31	-.33	-.13
	(12.6)	(1.43)	(22.6)	(0.85)	(0.95)	(0.87)	(0.81)	(0.92)
College	105.0	5.24	59.6	4.69	0.32	.25	0.32	0.24
	(12.3)	(1.22)	(31.8)	(0.69)	(0.85)	(0.80)	(1.00)	(0.95)
Grad/Prof	111.2	5.75	59.2	4.71	0.18	.36	0.70	0.46
	(14.6)	(1.19)	(40.1)	(0.56)	(0.66)	(0.93)	(0.91)	(0.93)
Total: N	2593	2217	2207	2478	2483	2373	2589	2390
< High School	90.2	2.57	44.8	3.78	0.79	-.45	-.74	-.45
	(10.2)	(1.40)	(37.1)	(1.23)	(1.32)	(1.00)	(0.80)	(1.02)
High School	96.0	3.54	38.7	4.25	0.51	-.41	-.40	-.27
	(13.3)	(1.50)	(25.2)	(0.97)	(1.03)	(1.01)	(0.88)	(1.01)
Some College	95.7	3.88	40.4	4.40	0.32	-.27	-.31	-.18
	(12.6)	(1.39)	(21.7)	(0.87)	(0.82)	(0.91)	(0.81)	(0.90)
College	102.4	5.15	49.6	4.65	0.19	.27	0.31	0.17
	(12.8)	(1.15)	(27.1)	(0.72)	(0.64)	(0.87)	(0.96)	(0.96)
Grad/Prof	108.2	5.76	52.6	4.71	0.10	0.53	0.63	0.46
	(14.3)	(1.08)	(32.5)	(0.57)	(0.46)	(0.91)	(1.01)	(0.98)

GCA = General Cognitive Ability; Grad/Prof = Graduate/Professional degree; SES = Rearing socioeconomic status; PGS = Education polygenic score.

Table S3. Descriptive statistics and intercorrelations (sample size) for study variables in MTFS sample.

	1	2	3	4	5	6	7	8	9	10	11
1. AGE	1.0										
2. SEX	-.07 (N=2593)	1.0									
3. EDUCATION	.03 (N=2593)	.14 (N=2593)	1.0								
4. GCA	.04 (N=2593)	-.14 (N=2593)	.32 (N=2593)	1.0							
5. OCCUPATION	.01 (N=2217)	.11 (N=2217)	.55 (N=2217)	.29 (N=2217)	1.0						
6. LOG INCOME	.06 (N=2207)	-.26 (N=2207)	.20 (N=2207)	.12 (N=2207)	.37 (N=2200)	1.0					
7. INDEPENDENCE	.06 (N=2478)	-.01 (N=2478)	.23 (N=2478)	.13 (N=2478)	.25 (N=2217)	.32 (N=2207)	1.0				
8. LEGAL PROBLEMS	.05 (N=2483)	-.15 (N=2483)	-.20 (N=2483)	-.09 (N=2483)	-.17 (N=2217)	-.05 (N=2207)	-.20 (N=2478)	1.0			
9. PERSONALITY COMPOSITE	.04 (N=2373)	.06 (N=2373)	.36 (N=2373)	.18 (N=2373)	.34 (N=2034)	.18 (N=2024)	.16 (N=2271)	-.15 (N=2276)	1.0		
10. REARING SES COMPOSITE	-.01 (N=2589)	.03 (N=2589)	.40 (N=2589)	.31 (N=2589)	.28 (N=2214)	.13 (N=2474)	.13 (N=2204)	-.10 (N=2479)	.18 (N=2369)	1.0	
11. PGS	.03 (N=2390)	-.01 (N=2390)	.27 (N=2390)	.29 (N=2390)	.21 (N=2071)	.09 (N=2062)	.07 (N=2307)	-.08 (N=2312)	.12 (N=2194)	.24 (N=2386)	1.0
SAMPLE MEAN (SD)	29.3 (1.0) N=2593	1.53 (0.50) N=2593	3.33 (1.11) N=2593	99.8 (14.0) N=2593	4.51 (1.58) N=2217	3.67 (0.60) N=2207	4.48 (0.84) N=2478	0.30 (0.81) N=2483	0.00 (1.00) N=2373	0.01 (1.00) N=2589	0.01 (1.00) N=2390

Note: For comparative purposes, the standard error for an estimated correlation is no greater than .02 in a sample of 2000 and .03 in a sample of 1000. Sex was coded as 1=male and 2=female; Education was coded as 1=less than high school, 2=high school or GED, 3= some college, 4=completed college and 5=graduate or professional degree; and Occupation was reverse-coded on the 1-7 Hollingshead scale for those having a job. GCA = General Cognitive Ability assessed on an IQ scale. SES = Socioeconomic status. PGS = polygenic score (for educational attainment).

Table S4. Descriptive data for individual components used to form the Independence and Legal Problems scales in MTFS sample.

| | | Women (Total N=1365) | | | | | | | Men (Total N=1228) | | | | | |
| | | No College | | | College | | | | No College | | | College | | |
	N	Low GCA	Med GCA	High GCA	Low GCA	Med GCA	High GCA	N	Low GCA	Med GCA	High GCA	Low GCA	Med GCA	High GCA
Government Assistance [a] %	1309	32.8%	34.4%	21.6%	9.9%	10.7%	14.1%	1168	30.4%	28.6%	28.4%	15.6%	10.0%	10.8%
Live with Parents [a] %	1304	9.8%	9.6%	5.9%	5.0%	5.2%	7.9%	1173	9.4%	9.1%	3.4%	4.4%	3.6%	3.2%
Financial Support [a] %	1299	7.8%	8.7%	7.8%	7.8%	4.4%	8.4%	1165	10.5%	5.8%	3.4%	4.5%	4.0%	3.2%
Unemployed [a] %	1309	14.3%	4.6%	9.8%	8.5%	2.5%	3.1%	1172	10.4%	8.9%	8.7%	2.3%	6.3%	2.7%
Engaged Fulltime %	1307	84.9%	87.0%	84.3%	95.7%	94.8%	87.4%	1173	87.4%	87.5%	90.5%	93.3%	96.4%	91.4%
Independence Mean (SD)	1305	4.20 (0.98)	4.29 (0.89)	4.39 (0.87)	4.65 (0.77)	4.72 (0.59)	4.53 (0.77)	1173	4.26 (0.96)	4.34 (1.00)	4.46 (0.80)	4.62 (0.72)	4.71 (0.63)	4.70 (0.64)
Drug Problems %	1309	4.4%	5.6%	0.0%	1.4%	1.1%	1.6%	1174	15.1%	12.0%	13.8%	6.7%	6.7%	4.8%
Police Contact %	1309	6.2%	5.0%	0.0%	1.4%	0.0%	1.0%	1173	14.1%	9.7%	7.8%	4.4%	6.8%	3.2%
Court %	1309	21.6%	15.6%	7.8%	7.1%	6.6%	5.2%	1174	26.6%	21.4%	21.6%	8.9%	14.7%	10.8%
Jail %	1304	2.3%	3.0%	0.0%	0.7%	0.0%	0.0%	1172	12.0%	6.8%	9.5%	2.2%	3.2%	2.7%
Legal Problems Mean (SD)	1309	0.36 (0.80)	0.29 (0.77)	0.08 (0.27)	0.11 (0.47)	0.08 (0.28)	0.08 (0.38)	1174	0.68 (1.20)	0.50 (1.04)	0.53 (1.07)	0.22 (0.67)	0.31 (0.85)	0.22 (0.73)

a. Component weighted negatively in relevant composite. GCA = General cognitive ability

Table S5. Mean (SD) for individual components and Personality and Rearing SES composites by group membership for women and men in MTFS sample

		Women (Total N=1365)							Men (Total N=1228)					
		No College			College				No College			College		
	N	Low GCA	Med GCA	High GCA	Low GCA	Med GCA	High GCA	N	Low GCA	Med GCA	High GCA	Low GCA	Med GCA	High GCA
Social Potency	1274	-.28 (0.90)	-.14 (1.06)	0.00 (1.05)	-.09 (0.93)	0.08 (1.10	0.11 (0.95)	1097	-.09 (0.87)	-.04 (0.98)	0.01 (1.09)	0.00 (0.97)	0.30 (0.96)	0.15 (0.95)
Achievement	1274	-.46 (0.89)	-.32 (1.01)	-.19 (1.07)	-.04 (0.88)	0.11 (1.01)	0.29 (0.96)	1094	0.00 (0.95)	0.07 (1.06)	0.06 (0.98)	0.11 (0.80)	0.20 (0.96)	0.26 (0.89)
Alienation[a]	1276	.29 (1.07)	.18 (1.07)	-.11 (1.13)	-.25 (1.03)	-.25 (0.91)	-.41 (0.89)	1097	0.35 (0.97)	0.21 (1.00)	0.07 (0.98)	-.16 (1.02)	-.09 (0.82)	-.16 (0.88)
Control	1274	-.15 (0.93)	-.20 (0.98)	0.01 (1.14)	0.30 (0.99)	0.31 (1.05)	0.26 (1.06)	1096	-.24 (0.84)	-.21 (0.95)	-.44 (1.03)	.16 (0.86)	0.11 (0.86)	0.10 (1.01)
Disinhibition[a]	1295	0.13 (0.95)	0.07 (0.94)	-.14 (0.71)	-.41 (0.63)	-.36 (0.79)	-.52 (0.75)	1108	0.50 (1.09)	0.52 (1.20)	0.44 (1.12)	-.32 (0.68)	-.08 (0.90)	-.29 (0.80)
Personality Composite	1276	-.47 (0.95)	-.34 (1.05)	0.00 (1.03)	0.28 (0.89)	0.39 (0.94)	0.56 (0.89)	1097	-.39 (0.85)	-.31 (0.96)	-.32 (0.94)	0.26 (0.80)	0.27 (0.80)	0.33 (0.91)
Parent Education	1365	2.2 (0.5)	2.3 (0.7)	2.7 (1.0)	2.7 (0.9)	2.9 (0.9)	3.4 (1.01)	1224	2.3 (0.6)	2.3 (0.7)	2.6 (0.9)	2.6 (0.80)	2.9 (0.97)	3.3 (1.02)
Parent Occupation	1323	3.6 (1.3)	4.0 (1.6)	4.4 (1.6)	4.5 (1.6)	4.7 (1.5)	5.2 (1.5)	1186	3.8 (1.5)	3.9 (1.4)	4.2 (1.4)	4.5 (1.3)	4.8 (1.4)	5.2 (1.5)
Family Income	1363	7.8 (3.1)	8.3 (2.9)	8.5 (3.0)	9.2 (2.6)	9.7 (2.9)	10.0 (2.9)	1204	7.5 (3.3)	7.8 (3.1)	8.9 (2.6)	9.4 (2.9)	9.4 (2.9)	9.9 (2.8)
Rearing SES Composite	1365	-.54 (0.72)	-.31 (0.87)	-.01 (0.98)	0.15 (0.90)	0.34 (0.96)	0.76 (1.02)	1224	-.48 (0.86)	-.39 (0.83)	-.03 (0.90)	0.13 (0.87)	0.34 (0.93)	0.68 (1.04)

a. Component weighted negatively in relevant composite.

Note: Family Income was reported by parents at twins' intake assessment between 1990 and 1996 on a 1 (less than $10,000/year) to 13 (greater than $80,000/year) scale. Parent Education is mean of two parents highest degree on a 1 (< high school) to 5 (professional/graduate) scale and Parent Occupation is mean of two parents occupation on the reversed 1 to 7 Hollingshead scale.

Table S6. Validation of the IQ classifications used to form the GCA groups in the MTFS sample.

| | NO COLLEGE | | | COLLEGE | | |
	LOW GCA (IQ < 90)	MED GCA (90 < IQ < 110)	HIGH GCA (IQ > 110)	LOW GCA (IQ < 90)	MED GCA (90 < IQ < 110)	HIGH GCA (IQ > 110)
IQ_1	82.3 (6.3) N=482	99.2 (5.4) N=717	118.0 (6.9) N=176	84.7 (4.9) N=192	100.9 (5.5) N=689	120.1 (8.1) N=387
IQ_1*	82.5 (6.5) N=266	99.6 (5.4) N-459	117.9 (6.8) N=119	85.1 (4.7) N=122	101.3 (5.5) N=431	120.0 (8.4) N=286
IQ_2	86.4 (8.4) N=266	99.2 (10.1) N=459	115.1 (12.3) N=119	91.8 (9.1) N=122	103.9 (10.8) N=431	120.3 (11.8) N=286

IQ_1 = First IQ assessment in total sample. IQ_1* = First IQ assessment for sample that also completed a second IQ assessment. IQ_2 = Second IQ assessment completed on average 6.6 years (SD=0.7) after the first.

Table S7. Discordant monozygotic (MZ) twin analysis in the MTFS sample

	# Pairs	Non-college Graduate Mean (SD)	College Graduate Mean (SD)	Correlation	Unadjusted for Predictors		Adjusted for Predictors	
					d (95% CI)	χ^2 (1df) p	d (95% CI)	χ^2 (1df) p
OUTCOMES:								
Occupation	86	-.13 (0.94)	.40 (0.75)	.22	.54 (.36, .72)	33.6 p < .001	.48 (.30, .67)	25.2 p < .001
Log Income	86	-.07 (1.07)	.16 (0.82)	.20	.20 (-.01, .40)	3.45 p = .06	.08 (-.12, .29)	0.65 p = .42
Independence	103	.02 (0.98)	.25 (0.68)	.06	.22 (.03, .41)	5.18 p = .02	.27 (.06, .47)	6.66 p = .01
Legal Problems	103	-.01 (0.92)	-.13 (0.73)	.22	-.12 (-.31, .07)	1.53 p = .22	-.09 (-.29, .12)	0.71 p = .40
PREDICTORS:								
GCA	109	100.4 (15.0)	101.6 (15.2)	.89	1.77 (0.37, 3.18)	6.11 p = .013	NA	NA
Personality	99	-.12 (0.94)	.27 (0.91)	.50	.49 (.32, .67)	29.8 p < .001	NA	NA

Note: All variables have been standardized to a mean of 0 and an SD of 1.0 in the total sample except GCA, which was left on the IQ metric. d is the College – Non-College mean difference, it was estimated covarying sex and age in the unadjusted model and for sex, age, GCA and personality in the adjusted model. Correlation gives the correlation of the college graduate twin's score with the score for the non-college graduate in the discordant MZ sample.

Table S8. Descriptive data on study variables by group membership separately by sex in the NLSY97 sample.

| | Women (Total N=2656) | | | | | | 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	665	707	267	87	374	556	858	754	372	57	238	478
%	25.0%	(26.6%)	(10.0%)	(3.3%)	(14.1%)	(20.9%)	31.1%	27.3%	13.5%	2.1%	8.6%	17.3%
GCA Mean	81.8	99.4	117.0	85.3	101.8	118.1	81.7	99.4	116.5	84.5	101.9	119.3
(SD)	(4.6)	(5.6)	(4.4)	(3.6)	(5.5)	(4.6)	(4.6)	(5.8)	(4.3)	(4.1)	(5.6)	(4.5)
Social Outcomes:												
Occupation Mean	4615	4288	3927	3013	2813	2672	6075	5357	4538	3759	3028	2464
(SD)	(1904)	(2079)	(1931)	(2263)	(1814)	(1862)	(2609)	(2705)	(2877)	(2761)	(2340)	(2332)
Income Mean	19 353	24 365	26 946	31 341	39 656	44 233	30 751	39 418	39 083	35 836	44 659	52 662
(SD)	(14296)	(17559)	(19170)	(22309)	(22860)	(29786)	(21278)	(27072)	(30716)	(25656)	(27531)	(35835)
Assistance Mean	1.09	0.88	0.72	0.63	0.38	0.29	0.78	0.68	0.60	0.46	0.33	0.24
(SD)	(0.65)	(0.74)	(0.73)	(0.68)	(0.58)	(0.52)	(0.70)	(0.71)	(0.70)	(0.57)	(0.52)	(0.45)
Legal Mean	0.60	0.70	0.73	0.46	0.38	0.51	0.93	1.10	1.10	0.57	0.56	0.91
Problems (SD)	(0.89)	(1.02)	(1.04)	(0.94)	(0.73)	(0.88)	(0.93)	(1.10)	(1.23)	(0.85)	(0.95)	(1.22)

Note: GCA = General Cognitive Ability

Table S9. Regression Results for Social Outcomes in the NLSY97 Sample

Effect (test statistic df)	Occupation χ^2 p	Log Income χ^2 p	Assistance χ^2 p	Legal Problems χ^2 p
Birth Year (1df)	0.74 p=.39	20.9 p<.001	6.87 p=.009	3.50 p=.06
Sex (1df)	30.2 p<.001	31.9 p<.001	11.7 p=.001	32.4 p<.001
Ethnicity (1df)	1.97 p=.16	1.5 p=.22	10.2 p=.001	0.30 p=.59
GCA Group (2df)	45.1 p<.001	19.8 p<.001	27.6 p<.001	12.1 p=.002
College (1df)	253.0 p<.001	70.9 p<.001	126.8 p<.001	35.8 p<.001
GCA x College (2df)	1.36 p=.51	1.8 p=.41	4.32 p=.12	7.80 p=.02
Sex x College (1df)	12.0 p=.001	10.2 p=.001	0.13 p=.72	0.10 p=.76
Sex x GCA (2df)	9.08 p=.011	2.98 p=.23	0.62 p=.74	0.91 p=.63
Sex x College x GCA (2df)	0.08 p=.96	1.62 p=.45	0.13 p=.94	1.31 p=.52

Marginal Effect Size Estimates (95% CI)

College Effect	.701 (.615, .788)	.391 (.300, .482)	-.559 (-.633, -.484)	-.284 (-.369, -.199)
High versus Low GCA	.387 (.267, .508)	.272 (.145, .399)	-.332 (-.435, -.229)	-.177 (-.295, -.058)

Note: The magnitude of the college effect was found to vary significantly by sex for both Occupation and Log Income. For Occupation, the standardized effect size, d (95% CI), for college was .854 (.728, .981) for men and .548 (.431, .666) for women. The direction of effect was reversed for Log Income where d was .539 (.415, .663) for women and .242 (.109, .375) for men.

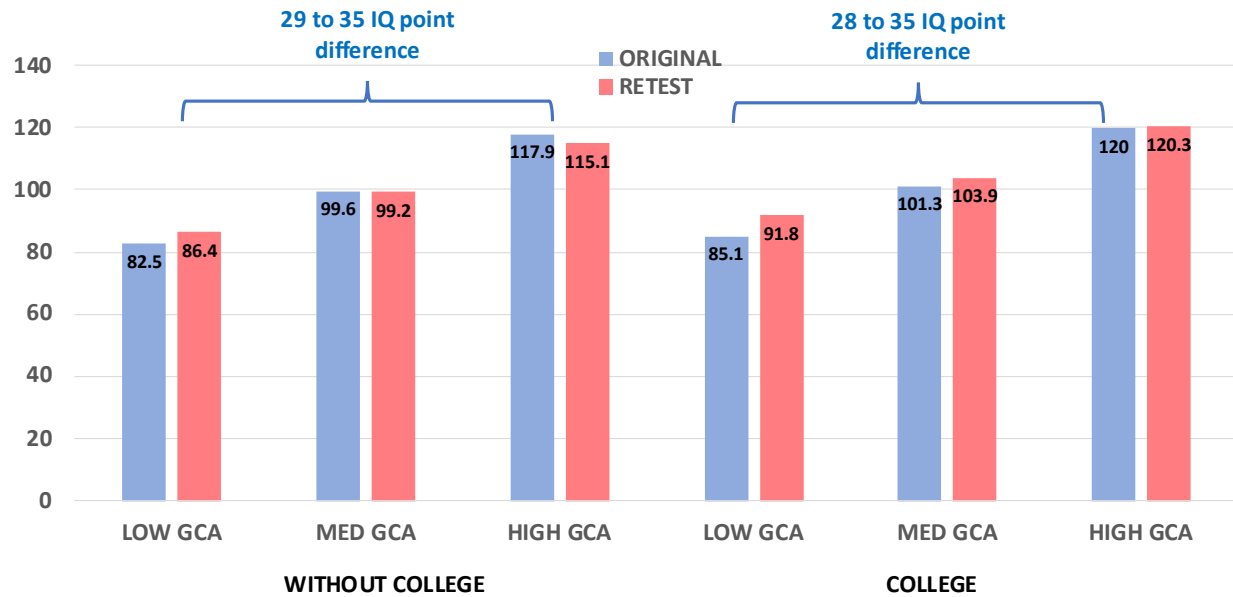# Confirmation of group differences in GCA

Figure S.1. Mean IQs by group membership in MTFS sample that completed both initial and retest IQ assessment.