

SUPPLEMENTARY ONLINE MATERIAL FOR:

THE CONTRIBUTION OF COGNITIVE AND NON-COGNITIVE SKILLS TO INTERGENERATIONAL SOCIAL MOBILITY

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Participants

Participants were drawn from the longitudinal Minnesota Twin Family Study (MTFS). The MTFS sampling unit is a nuclear family, consisting of a pair of like-sex twins and their parents. Twin families were identified and recruited through state of Minnesota birth records and so are broadly representative of the population of Minnesota for the birth years sampled, including for ethnicity with greater than 98% of participants being of European ancestry. Initial offspring assessments were targeted either for age 11 years (younger cohort, total N of 1512 twins, 756 twin pairs, 50.3% female, born 1977-1984) or 17 years (older cohort, total N of 1252, 626 twin pairs, 53.8% female, born 1972-1979). The younger cohort was subsequently assessed at target ages of 14, 17, 20, 24 and 29, while the older cohort was subsequently assessed at target ages of 20, 24 and 29. There was some variability about the target age at each assessment. Data from ongoing assessments of the two cohorts (i.e., past the target age of 29) is not used here as these data are not yet available.

Offspring predictor variables were derived from the age-17 assessment except for general cognitive ability (GCA), which was assessed at the intake assessment of each cohort. This ensured that the predictor variables in the offspring sample were assessed prior to completion of education or attainment of occupation. For 2489 offspring, outcome variables (educational level and occupational level) were based on their age-29 assessment. For an additional 105 offspring who did not complete an age-29 assessment, we obtained outcome data from their age-24 assessment. The offspring sample consisted of the 1229 males (92.4% of the 1330 males who completed an intake MTFS assessment) and 1365 females (95.2% of 1434) for whom we had outcome data. Outcome data was available for a slightly higher percentage of

the older (1207/1252 = 96.4%) than the younger (1387/1512=91.7%) cohort. The 2594 offspring participants in the current study are clustered in 1321 families (with data analyzed from both members of twin pairs from 1273 families and from one member in the other 48 families.)

Mothers in 1321 (100%) and fathers in 1209 (91.5%) of the 1321 families completed an intake assessment. The vast majority of parents completed just a single assessment (the exception being that for purposes of consent one parent was required to participate in the age-14 and age-17 assessments of the younger cohort), so that for parents, assessment of cognitive and non-cognitive skills did not take place prior to their education completion or occupation attainment.

MEASURES

A description of all key measures is given in Table S1.

Assessment of Social Outcome

Two social achievement outcomes were assessed. Educational level was coded on a 5-point scale of highest attained level of education: 1 = Less than High School, 2 = High School or GED, 3 = Some College, 4 = 4-year College Degree, 5 = Professional Degree (e.g., M.A., Ph.D., M.D.). Occupation was coded on a 7-point scale according to the Hollingshead system (Hollingshead, 1957). The original Hollingshead scale was reflected so that higher scores indicated higher occupational prestige and educational requirement. On this scale, 1 = unskilled workers, 2 = machine operators and semi-skilled workers, 3 = skilled manual laborers, 4 = clerical and sales worker, 5 = administrative personnel, small business owner, 6 = manager, medium-sized business owner, and 7 = professional, executive, owner of large business. Occupation was coded only for those who were working full-time; students, homemakers and

the unemployed were coded as missing. MTFS staff have been continuously updating occupational codes over the 30 years of the study to account for the evolving nature of work. Parent and offspring jobs were coded independently based on responses made to open-ended interview questions about the individual's current job title and responsibilities. Education and occupation was based on self-report except for a small number of fathers who did not participate in the intake assessment whose education (N=106) or occupation (N=76) was reported by the participating mother.

Because twin offspring were born 1972-1984, which may have affected their social opportunities, in preliminary analyses we determined whether birth year was associated with either educational or occupational attainment in the offspring sample. Specifically, we regressed education or occupation on sex, age at which social attainment was determined and year of birth (standardized to facilitate interpretation of odds ratios [ORs]). Year of birth was not significantly associated with either educational (OR=1.02; 95% CI = .99, 1.05, χ^2 (1df) = 2.35, $p = .13$) or occupational (OR=.99; 95% CI = .96, 1.02, χ^2 (1df) = 0.23, $p = .63$) level. We consequently did not use birth year as a covariate in our analyses.

Skills Assessment

General Cognitive Ability (GCA): GCA was assessed in both offspring cohorts at intake with an abbreviated form of the Weschler Adult Intelligence Scale-Revised (WAIS-R) (Wechsler, 1981) for offspring age 16 years and older (i.e., the older cohort) and the Weschler Intelligence Scale for Children-Revised (WISC-R) (Wechsler, 1974) for those 15 and younger (i.e., the older cohort). Parents were all administered the abbreviated WAIS-R. For both cohorts and generations, the abbreviated form of the Weschler consisted of two verbal (Vocabulary and

Information) and two performance (Block Design and Picture Arrangement) sub-scales.

Prorated IQ scores based on these four sub-scales have been found to correlate .90 with overall IQ when all subtests are administered (Kaufman, 1990). Prorated IQ scores were standardized to a mean of 0 and a standard deviation of 1 separately in the male and female samples and separately by cohort in the offspring sample (to account for any differences between the WISC-R and the WAIS-R).

Non-Cognitive Composite: There is growing recognition that, in addition to cognitive ability, an array of non-cognitive skills contributes to social success (Almlund, Duckworth, Heckman, & Kautz, 2011; Ferguson, Heckman, & Corr, 2011). Much of the literature relating personality to social success is organized around the Big Five Model of personality (Goldberg, 1993), implicating Conscientiousness as the Big Five trait most consistently related to educational and occupational achievement (Barrick & Mount, 1991; Poropat, 2009). Nonetheless, the personality correlates of social success are multidimensional and extend beyond the Big Five (Humphries & Kosse, 2017). Although there likely is no current consensus on the full range of relevant non-cognitive contributors to social achievement, a core set of psychological constructs has been implicated including: a willingness to work hard and have confidence that advancement can be achieved through hard work (Almlund et al., 2011; Heckman & Kautz, 2012); the capacity to delay gratification and persevere in the face of adversity (Duckworth & Seligman, 2005); and the ability to control impulse and emotion (de Ridder, Lensvelt-Mulders, Finkenauer, Stok, & Baumeister, 2012).

To create a non-cognitive composite, we restricted our selection of individual components to personality and behavioral variables shown previously to be related to either

educational or occupational success and that had been assessed in the same way in both the parent and offspring samples. We do not claim that the five components we selected cover the full range of relevant non-cognitive skills. Four of the components were primary scales from the Multidimensional Personality Questionnaire (MPQ) (Tellegen & Waller, 2008). The MPQ includes 11 primary scales organized according to three higher-order factors: Positive Emotionality, Negative Emotionality, and Constraint. Parents completed the MPQ at their intake assessment, offspring from both cohorts completed the MPQ for the first time at their age-17 assessment. The four primary scales used were: 1) Achievement, ambitious and willingness to work hard; 2) Control, careful and reflective; 3) Social Potency, decisive; and 4) Alienation, feels others are undermining efforts. The first two scales were selected because they are the MPQ scales that correlate most highly with Conscientiousness ($r=.48$ and $.56$ for Achievement and Control, respectively) (Church, 1994), the Big Five factor most consistently linked with social success. The second two MPQ scales, Social Potency and Alienation, were selected because self-confidence and self-efficacy have been consistently found to predict social outcomes (Heckman, Stixrud, & Urzua, 2006; Tolor & Leblanc, 1971).

The fifth non-cognitive component was Behavioral Disinhibition, which was based on an aggregate score of symptoms of externalizing psychopathology, including substance abuse and antisocial behavior, assessed by interview in offspring at their age-17 assessment and in parents as adults (Hicks, Schalet, Malone, Iacono, & McGue, 2011). There is a substantial research literature linking child and adolescent externalizing psychopathology with academic and occupational success (Fergusson & Horwood, 1998; Heckman & Kautz, 2012; Masten et al., 2005). These associations may arise because students high on behavioral disinhibition are likely

to be disruptive and prone to conflict with their teachers and classmates, impeding their opportunity to learn (Stipek & Miles, 2008; Stormshak, Bierman, & Conduct Problems Prevention Res, 1998). Alternatively, externalizing behavior is an indicator of poor impulse control (Heckman & Kautz, 2012; Moffitt et al., 2011).

Polygenic Scores (PGS)

Polygenic scores (PGS) are weighted combinations of individual genotype scores, where weights are defined in order to maximize correlation with a specific phenotype. PGS are increasingly used in genomic-level studies to address limitations that are a consequence of the very small effect associated with any specific genetic variant (Dudbridge, 2016). MTFS participants were genotyped on more than 500K single nucleotide polymorphisms (SNPs) using Illumina's Human 660W-Quad array. Data cleaning and imputation followed standard procedures as described in Miller et al. (2012). SNP weights used in generating the PGS were taken from the most recent genomewide association study (GWAS) of educational attainment, which involved more than one million participants (Lee et al., 2018). Because the MTFS parent sample was included in this GWAS, weights used to generate PGS were recomputed in a GWAS after the MTFS (as well as the 23andMe) sample had been removed. PGS were computed using the LDpred software with a prior probability of 1.0 (Vilhjálmsón et al., 2015).

In the parent sample, PGS were only used for genetic parents of participating offspring. This eliminated 41 step-fathers and 3 step-mothers with genetic data from the PGS analysis. Also, GWAS weights will result in biased prediction when there is an ancestry mismatch between the GWAS and application sample (Martin et al., 2017). Since both the educational attainment GWAS and MTFS samples were predominantly of European ancestry, we restricted

our analysis to individuals of European ancestry as determined for the MTF5 sample by Miller et al. (2012). This resulted in the elimination of 21 biological fathers, 26 biological mothers and 69 twin offspring, leaving a sample of 2394 offspring and 2114 parents for PGS analysis. Finally, because restriction to a single ancestral group does not necessarily eliminate all possibility of genetic stratification effects (Patterson, Price, & Reich, 2006), we computed the first 10 principal components (PCs) from the genetic covariance matrix among individuals and used these as covariates in all regression analyses involving the PGS.

Combining Mother and Father Variables

For both skill predictors and social outcomes, a single parent score was derived by combining the mother and father scores. For education and occupation, we took the maximum of the two parent scores when there was education or occupation data for both parents or just the single score when there was data for only one parent. For education, in 1312 (99.3%) of 1321 families we had information on education level for both parents. We had occupation level for both parents in 689 (52.2%) families, the lower level in comparison to education reflecting that in many families only one of the two parents had a full-time job at the time of assessment. Our rationale for using the maximum educational and occupational levels of the parents was that it established an achievement target for each family. That is, we did not want to conclude offspring had moved up socially unless they had achieved more than both their parents had achieved. This does, however, have as a consequence that offspring were considered to be downwardly mobile when they achieved more than one but not both of their parents.

For the skill measures, mother and father scores were combined by taking the average parent score, so that the resulting parent score reflected the skills of both parents. Although

using the mid-parent average for the independent variables and the highest parent score for the dependent variables may appear to be quite different approaches to combining parent data, in fact the two methods generated very similar scores. The mid-parent/max-parent correlation was .94 for both education and occupation; the same correlation ranged from .84 to .93 for the individual non-cognitive components and equaled .90, .93 and .89 for the Non-Cognitive Composite, General Cognitive Ability, and the PGS, respectively (Table S4, includes confidence intervals).

Extreme Offspring-Parent Differences in Education and Occupation

We observed offspring-parent difference scores throughout the full possible range for both education (maximum difference of 4) and occupation (maximum difference of 6). There were, however, a relatively small number of observations at the extremes and so we winsorized both difference scores in order to provide stable estimates for reporting descriptive statistics associated with extreme scores. For education, differences were winsorized to ± 3 , which affected one score each at +4 (offspring higher than parent) and -4 (parent higher than offspring). For occupation, differences were winsorized to ± 4 , which affected one score at +6, 13 scores at +5, 28 scores at -5 and five scores at -6. As a result, the range of both difference scores was symmetric and had at least 25 observations (minimum was 36) at every level.

Confidence interval estimates for correlations

Confidence intervals for correlations were computed using the number of independent clusters (i.e., families) as the sample size rather than the number of (correlated) individuals.

Table S1. Description of measures used in assessment

Variable	Description	When Assessed in Offspring
Outcome Measures:		
Education Level	Coded on 5-point scale: 1= < High School; 2 = High School; 3 = Some College; 4 = College; 5 = Professional Degree	Either the age-24 or age-29 assessment
Occupation Level	Coded on a 1 (=Unskilled Labor) to 7 (=Professional Class) Hollingshead scale. Only coded for individuals holding a full-time job	Either the age-24 or age-29 assessment
Non-Cognitive Measures:		
Social Potency (SP)	18-item MPQ self-report with high scorers characterized as being decisive and persuasive	Age-17 assessment
Achievement (AC)	18-item MPQ self-report with high scorers characterized as hard-working and ambitious	Age-17 assessment
Alienation (AL)	18-item MPQ self-report with high scorers characterized as feeling exploited and unlucky	Age-17 assessment
Control (CON)	18-item MPQ self-report with high scorers characterized as careful and reflective	Age-17 assessment
Behavioral Disinhibition (BD)	Composite of symptoms of antisocial behavior and substance abuse	Age-17 assessment
Non-Cognitive Composite	Average of the five personality components (AL and EXT were reflected) after these components had been standardized to a mean of 0 and standard deviation of 1	Age-17 assessment
Cognitive Measure:		
General Cognitive Ability (GCA)	IQ based on four subscales (Vocabulary, Information, Block Design and Picture Arrangement) from either the Weschler Intelligence Scale for Children-Revised (younger cohort) (Wechsler, 1974) or Weschler Adult Intelligence Scale-Revised (older cohort) (Wechsler, 1981)	At intake assessment of the younger and older cohorts
Polygenic Score (PGS):	Polygenic score based on GWAS of educational attainment	Not relevant

Note: Variables were assessed identically in the offspring and parent samples.

MPQ = Multidimensional Personality Questionnaire (Tellegen & Waller, 2008).

Table S2. Descriptive statistics by gender in parent and offspring samples (entries are mean (SD))

	Offspring		χ^2 (1df) p	Parents		χ^2 (1df) (p)
	Sons	Daughters		Fathers	Mothers	
Age	29.4 (1.10) N=1229	29.2 (0.97) N=1365	8.9 p = .003	44.2 (5.84) N=1209	41.7 (5.29) N=1321	574.7 p < .001
Education Level	3.17 (1.11) N=1229	3.47 (1.08) N=1365	32.3 p < .001	2.68 (1.12) N=1315	2.62 (0.97) N=1318	0.0 p = .98
Occupation Level	4.33 (1.69) N=1078	4.68 (1.44) N=1142	17.6 p < .001	4.25 (1.77) N=1211	4.45 (1.49) N=756	11.0 p = .001
Social Potency	.07 (0.97) N=1097	-.06 (1.02) N=1274	6.3 p = .01	.20 (0.97) N=1085	-.18 (0.99) N=1225	101.9 p < .001
Achievement	.12 (0.98) N=1094	-.10 (1.00) N=1274	20.3 p < .001	.11 (1.01) N=1086	-.10 (0.98) N=1226	27.3 p < .001
Alienation	.08 (0.96) N=1097	-.07 (1.03) N=1276	9.9 p < .01	.09 (1.01) N=1086	-.08 (0.98) N=1225	26.2 p < .001
Control	-.10 (0.95) N=1096	.08 (1.03) N=1274	16.4 p < .001	-.10 (1.04) N=1086	.09 (0.95) N=1225	24.1 p < .001
Behavioral Disinhibition	.22 (1.09) N=1109	-.19 (0.88) N=1295	56.4 p < .001	.47 (1.03) N=1014	-.40 (0.78) N=1183	956.4 p < .001
Non-cognitive Composite	-.07 (0.95) N=1097	.06 (1.04) N=1276	7.1 p = .01	-.11 (1.07) N=1086	.10 (0.93) N=1226	39.5 p < .001
General Cognitive Ability	.15 (0.98) N=1224	-.13 (1.00) N=1365	31.2 p < .001	.16 (1.03) N=1147	-.13 (0.95) N=1313	39.0 p < .001
PGS	.01 (1.00) N=1131	.00 (1.01) N=1263	0.02 p = .89	.03 (0.97) N=975	-.02 (1.02) N=1139	1.6 p = .21

PGS = polygenic score based on GWAS of educational attainment. Except for Age, Education level and Occupation level, all variables have been standardized to a mean of 0 and a standard deviation of 1, separately in the offspring and parent samples. Chi-square statistic tests the hypothesis of equal male and female means within offspring or parent samples. Age was included as a covariate in these models.

Table S3. Correlations (95% confidence intervals) of skill variables with educational and occupational outcomes in offspring and parent samples.

	Sons	Offspring Daughters	Total	Fathers	Parents Mothers	Total
Education as outcome:						
Social Potency	.12 (.04, .20)	.14 (.06, .21)	.12 (.06, .17)	.19 (.13, .25)	.17 (.12, .22)	.19 (.14, .24)
Achievement	.06 (-.02, .14)	.27* (.20, .34)	.16 (.11, .21)	.00 (-.06, .06)	.08 (-.07, .07)	.05 (-.01, .10)
Alienation	-.16 (-.24, -.08)	-.26 (-.33, -.19)	-.22 (-.27, -.17)	-.22 (-.28, -.16)	-.13 (-.18, -.07)	-.17 (-.22, -.12)
Control	.17 (.09, .25)	.23 (.16, .30)	.21 (.16, .26)	.13 (.07, .19)	.03 (-.03, .09)	.08 (.02, .13)
Behavioral Disinhibition	-.33 (-.40, -.26)	-.30 (-.37, -.23)	-.33 (-.38, -.28)	-.23 (-.29, -.17)	-.18 (-.23, -.12)	-.16 (-.21, -.10)
Non-Cognitive Composite	.30 (.22, .37)	.40 (.33, .46)	.36 (.31, .41)	.28 (.22, .33)	.23 (.18, .28)	.25 (.20, .30)
General Cognitive Ability	.33 (.26, .40)	.37 (.30, .43)	.32 (.27, .37)	.51 (.47, .55)	.47 (.43, .51)	.50 (.46, .54)
PGS	.26 (.18, .33)	.28 (.21, .35)	.27 (.22, .32)	.32 (.26, .38)	.27 (.22, .32)	.29 (.24, .34)
Occupation as outcome:						
Social Potency	.21 (.13, .29)	.17 (.09, .24)	.18 (.12, .23)	.27 (.21, .33)	.23 (.16, .30)	.24 (.19, .29)
Achievement	.14 (.06, .22)	.24 (.17, .31)	.17 (.11, .22)	.06 (.00, .12)	.17 (.10, .24)	.10 (.04, .16)
Alienation	-.19 (-.27, -.11)	-.18 (-.25, -.10)	-.19 (-.24, -.13)	-.22 (-.28, -.16)	-.12 (-.19, -.05)	-.19 (-.24, -.14)
Control	.18 (.10, .26)	.17 (.09, .24)	.18 (.12, .23)	.12 (.06, .18)	.01 (-.06, .08)	.08 (.02, .14)
Behavioral Disinhibition	-.26 (-.34, -.18)	-.23 (-.30, -.15)	-.26 (-.31, -.21)	-.19 (-.26, -.14)	-.10 (-.17, -.03)	-.16 (-.21, -.10)
Non-Cognitive Composite	.36 (.29, .43)	.33 (.26, .40)	.35 (.30, .40)	.31 (.25, .36)	.24 (.17, .31)	.29 (.24, .34)
General Cognitive Ability	.30 (.22, .37)	.32 (.25, .39)	.29 (.24, .34)	.43 (.38, .48)	.37 (.31, .43)	.40 (.35, .45)
PGS	.19 (.11, .27)	.24 (.16, .31)	.21 (.15, .26)	.22 (.16, .28)	.23 (.16, .30)	.22 (.16, .27)

PGS = polygenic score;

* correlation significantly different in male and female samples at $p < .01$ (two-tailed); significance of individual correlations not computed, for context a correlation of .09 is significant at $p < .01$ (two-tailed) in a sample of 1000.

Table S4. Mid-Parent/Offspring, Mother-Father, and Mid-Parent/Max-Parent correlations (95% confidence intervals) for variables used in the study

	Mid- Parent/Offspring	Mother-Father	Mid-Parent/Max- Parent
Social Outcomes:			
Education Level	.39 (.36, .42)	.52 (.48, .56)	.94 (.93, .95)
Occupation Level	.23 (.19, .27)	.38 (.31, .44)	.94 (.93, .95)
Skill Predictors:			
Social Potency	.23 (.19, .27)	.08 (.02, .14)	.87 (.86, .88)
Achievement	.16 (.12, .20)	.07 (.01, .13)	.87 (.86, .88)
Alienation	.17 (.13, .21)	.22 (.16, .28)	.92 (.91, .93)
Control	.11 (.07, .15)	.02 (-.04, .08)	.84 (.82, .86)
Behavioral Disinhibition	.27 (.23, .31)	.53 (.48, .57)	.93 (.92, .94)
Non-Cognitive Composite	.23 (.19, .27)	.22 (.16, .28)	.90 (.89, .91)
General Cognitive Ability	.48 (.45, .51)	.37 (.32, .42)	.93 (.92, .94)
PGS	.68 (.66, .70)	.15 (.09, .21)	.89 (.88, .90)

PGS = Polygenic score

Table S.5. Association of individual non-cognitive components and overall skills with education and occupation level from ordinal regression model fit separately in offspring and parent samples

	Offspring				Parents			
	Univariate		Multivariate		Univariate		Multivariate	
	OR (95% CI)	χ^2 (1df) p	OR (95% CI)	χ^2 (1df) p	OR (95% CI)	χ^2 (1df) P	OR (95% CI)	χ^2 (1df) p
Education as Outcome								
Non-Cognitive Component:								
Social Potency	1.27 (1.17, 1.38)	32.2 p < .001	1.33 (1.21, 1.47)	34.5 p < .001	1.48 (1.36, 1.62)	76.0 p < .001	1.54 (1.39, 1.70)	67.4 p < .001
Achievement	1.40 (1.29, 1.52)	65.7 p < .001	1.16 (1.05, 1.27)	8.8 p = .003	1.09 (1.01, 1.19)	4.3 p = .04	0.94 (0.85, 1.04)	1.42 p = .23
Alienation ^R	1.48 (1.37, 1.61)	93.9 p < .001	1.29 (1.18, 1.40)	34.8 p < .001	1.46 (1.33, 1.60)	61.6	1.41 (1.28, 1.57)	43.3 p < .001
Control	1.45 (1.34, 1.57)	85.0 p < .001	1.09 (0.99, 1.20)	3.3 p = .07	1.18 (1.08, 1.28)	14.2 p < .001	1.06 (0.96, 1.17)	1.39 p = .24
Behavioral Disinhibition ^R	1.88 (1.70, 2.07)	159.3 p < .001	1.80 (1.61, 2.00)	109.8 p < .001	1.56 (1.40, 1.74)	63.7	1.56 (1.39, 1.76)	54.8 p < .001
Overall Predictors:								
Non-Cognitive Composite	2.03 (1.86, 2.21)	250.6 p < .001	1.83 (1.67, 2.01)	160.1 p < .001	1.70 (1.56, 1.86)	142.4 p < .001	1.52 (1.38, 1.68)	65.5 p < .001
General Cognitive Ability	2.00 (1.83, 2.18)	242.0 p < .001	1.71 (1.55, 1.88)	115.4 p < .001	3.08 (2.79, 3.40)	498.5 p < .001	2.98 (2.67, 3.34)	363.9 p < .001
PGS	1.69 (1.54, 1.85)	124.0 p < .001	1.43 (1.30, 1.57)	52.1 p < .001	1.83 (1.66, 2.01)	158.5 p < .001	1.50 (1.35, 1.67)	57.0 p < .001

Table S.5. continued

	Offspring				Parents			
	Univariate		Multivariate		Univariate		Multivariate	
	OR (95% CI)	χ^2 (1df) p	OR (95% CI)	χ^2 (1df) p	OR (95% CI)	χ^2 (1df) P	OR (95% CI)	χ^2 (1df) p
Occupation as Outcome								
Non-Cognitive Component:								
Social Potency	1.41 (1.30, 1.54)	65.5 p < .001	1.47 (1.33, 1.61)	63.5 p < .001	1.63 (1.49, 1.78)	110.5 p < .001	1.63 (1.47, 1.80)	88.2 p < .001
Achievement	1.44 (1.32, 1.56)	72.1 p < .001	1.17 (1.06, 1.29)	9.8 p = .002	1.21 (1.10, 1.31)	17.6 p < .001	1.05 (0.95, 1.17)	0.87 p = .35
Alienation ^R	1.40 (1.29, 1.53)	60.6 p < .001	1.24 (1.14, 1.36)	22.7 p < .001	1.40 (1.28, 1.52)	58.9 p < .001	1.37 (1.25, 1.50)	45.7 p < .001
Control	1.37 (1.26, 1.49)	55.1 p < .001	1.08 (0.98, 1.20)	2.7 p = .10	1.14 (1.05, 1.24)	10.2 p = .001	1.05 (0.95, 1.15)	0.95 p = .33
Behavioral Disinhibition ^R	1.60 (1.46, 1.75)	103.2 p < .001	1.57 (1.42, 1.74)	73.0 p < .001	1.35 (1.22, 1.49)	34.0 p < .001	1.31 (1.18, 1.46)	23.8 p < .001
Overall Predictors:								
Non-Cognitive Composite	1.96 (1.80, 2.14)	235.3 p < .001	1.81 (1.66, 1.98)	166.1 p < .001	1.67 (1.54, 1.82)	141.8 p < .001	1.63 (1.48, 1.79)	95.8 p < .001
General Cognitive Ability	1.81 (1.66, 1.97)	184.4 p < .001	1.53 (1.39, 1.68)	80.7 p < .001	2.22 (2.03, 2.44)	286.1 p < .001	2.13 (1.92, 2.37)	200.8 p < .001
PGS	1.50 (1.38, 1.63)	88.0 p < .001	1.32 (1.21, 1.44)	36.5 p < .001	1.49 (1.35, 1.63)	68.5 p < .001	1.18 (1.06, 1.30)	10.1 p = .001

^R – Scale has been reflected so that it has a positive association with social outcomes and to facilitate comparison to results for other components. All analyses based on an ordinal regression, included sex and age as covariates and corrected for family clustering. Univariate columns give estimates and test statistics when education or occupation was regressed on that component as well as sex and age at last assessment; analysis with the PGS also included as covariates the 10 genomic principal components. For the non-cognitive components, multivariate columns give results when all five non-cognitive components as well as sex and age were simultaneously included in the regression. For the overall predictors, multivariate results are for the model in which the three overall predictors and age and sex were included in the analyses. All independent variables, but not education and occupation, were standardized to facilitate comparisons across components.

OR = Odds ratio; PGS = Polygenic score

Table S.6. Correlations (95% confidence intervals) among the non-cognitive components as well as between the non-cognitive components and the Non-Cognitive Composite, General Cognitive Ability (GCA) and the polygenic score (PGS) in the offspring and parent samples.

	Social Potency	Achievement	Alienation ^R	Control	Behavioral Disinhibition ^R	Non-Cognitive Composite	GCA	PGS
Social Potency		.32 (.27, .37)	.07 (.01, .13)	-.09 (-.14, -.03)	-.18 (-.23, -.12)	.41 (.36, .46)	.09 (.03, .14)	.02 (-.04, .08)
Achievement	.33 (.28, .38)		.11 (.05, .16)	.34 (.29, .39)	.11 (.05, .17)	.67 (.64, .70)	.14 (.09, .19)	.08 (.02, .14)
Alienation ^R	.00 (-.06, .06)	-.06 (-.11, .00)		.21 (.16, .26)	.19 (.13, .24)	.56 (.52, .60)	.13 (.08, .18)	.08 (.02, .14)
Control	-.12 (-.17, -.07)	.18 (.13, .23)	.19 (.14, .24)		.39 (.34, .44)	.66 (.63, .69)	.04 (-.02, .10)	.04 (-.02, .10)
Behavioral Disinhibition ^R	-.16 (-.22, -.10)	-.02 (-.08, .04)	.09 (.03, .15)	.24 (.19, .29)		.54 (.50, .58)	.11 (.05, .16)	.12 (.06, .18)
Non-Cognitive Composite	.44 (.39, .48)	.58 (.54, .62)	.48 (.44, .52)	.59 (.55, .62)	.45 (.40, .49)		.18 (.13, .23)	.12 (.06, .18)
GCA	.15 (.10, .20)	.01 (-.05, .07)	.22 (.17, .27)	.05 (-.01, .10)	.02 (-.04, .08)	.17 (.12, .22)		.29 (.24, .34)
PGS	.04 (-.02, .10)	.00 (-.06, .06)	.12 (.06, .18)	.03 (-.03, .09)	.14 (.08, .19)	.12 (.06, .18)	.28 (.23, .33)	

^R – Scale reflected to facilitate comparison with correlations for other components.

Correlations for offspring sample given above the diagonal and for parent sample below the diagonal. The Non-Cognitive Composite is computed by adding the standard scores for the five individual components.

Table S7. Test for an interactive effect of social background and social mobility on general cognitive ability, the non-cognitive composite and the polygenic score (PGS)

	Offspring-Parent Education Difference		Parent Education		Interaction	
	b (95% CI)	χ^2 (1df) p	b (95% CI)	χ^2 (1df) p	b (95% CI)	χ^2 (1df) p
General Cognitive Ability	.248 (.149, .348)	23.9 p < .001	.434 (.385, .483)	304.2 p < .001	-.001 (-.034, .031)	0.01 p = .94
Non-Cognitive Composite	.269 (.161, .377)	24.0 p < .001	.331 (.285, .378)	193.4 p < .001	.017 (-.018, .051)	0.9 p = .34
PGS	.244 (.126, .363)	16.3 p < .001	.324 (.271, .377)	144.3 p < .001	-.016 (-.053, .020)	0.8 p = .37
	Offspring-Parent Occupation Difference		Parent Occupation		Interaction	
	b (95% CI)	χ^2 (1df) p	b (95% CI)	χ^2 (1df) p	b (95% CI)	χ^2 (1df) p
General Cognitive Ability	.199 (.127, .271)	29.2 p < .001	.266 (.227, .305)	179.5 p < .001	-.007 (-.021, .008)	0.8 p = .38
Non-Cognitive Composite	.237 (.170, .304)	48.5 p < .001	.230 (.195, .265)	159.0 p < .001	-.007 (-.021, .006)	1.11 p = .29
PGS	.110 (.035, .185)	8.3 p = .004	.189 (.147, .232)	76.9 p < .001	.002 (-.013, .016)	.06 p = .81

Note: Results are from a regression that in addition to the two main effects and interaction included gender and age at last assessment. Analysis of PGS also include 10 genomic principal components as covariates. b = regression coefficient, CI = confidence interval.

Table S8. Intercorrelations (95% Confidence Interval) among offspring-parent difference scores

	General Cognitive Ability	Non- Cognitive Composite	PGS	Educational Level	Occupational Level
General Cognitive Ability	---				
Non-Cognitive Composite	.16 (.10, .21)	---			
PGS	.16 (.10, .22)	.03 (-.03, .09)	---		
Education Level	.25 (.20, .30)	.19 (.14, .24)	.12 (.06, .18)	---	
Occupation Level	.24 (.19, .29)	.21 (.15, .27)	.12 (.06, .18)	.45 (.40, .49)	---

PGS = Polygenic score

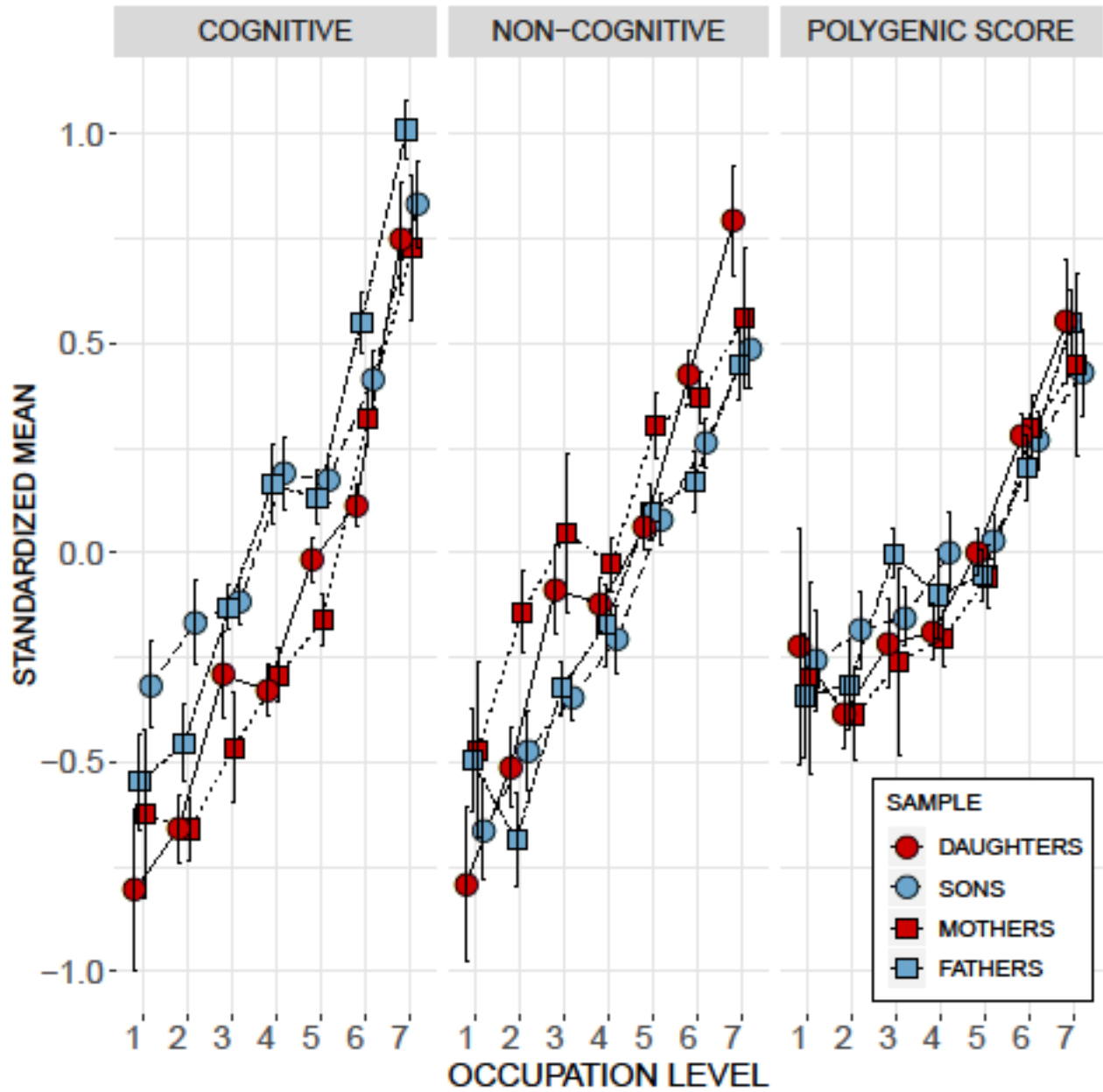


Figure S1: Standardized mean general cognitive ability (GCA), non-cognitive composite and polygenic score (PGS) as a function of attained occupation level in parent and offspring samples by gender. Occupation is coded on the 7-point (reflected) Hollingshead scale with 1 = unskilled labor and 7 = professional class.

Figure S2A

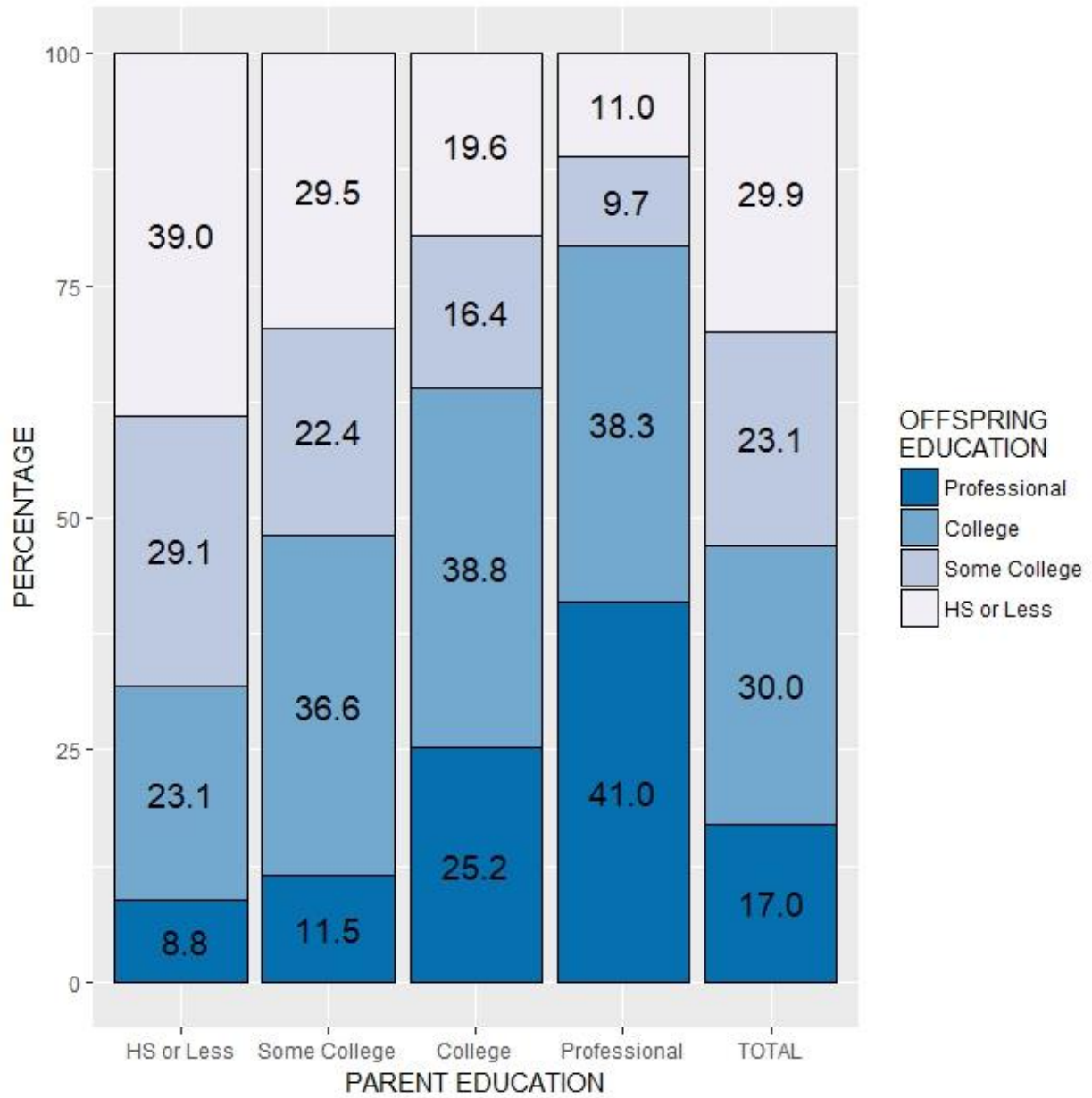


Figure S2B

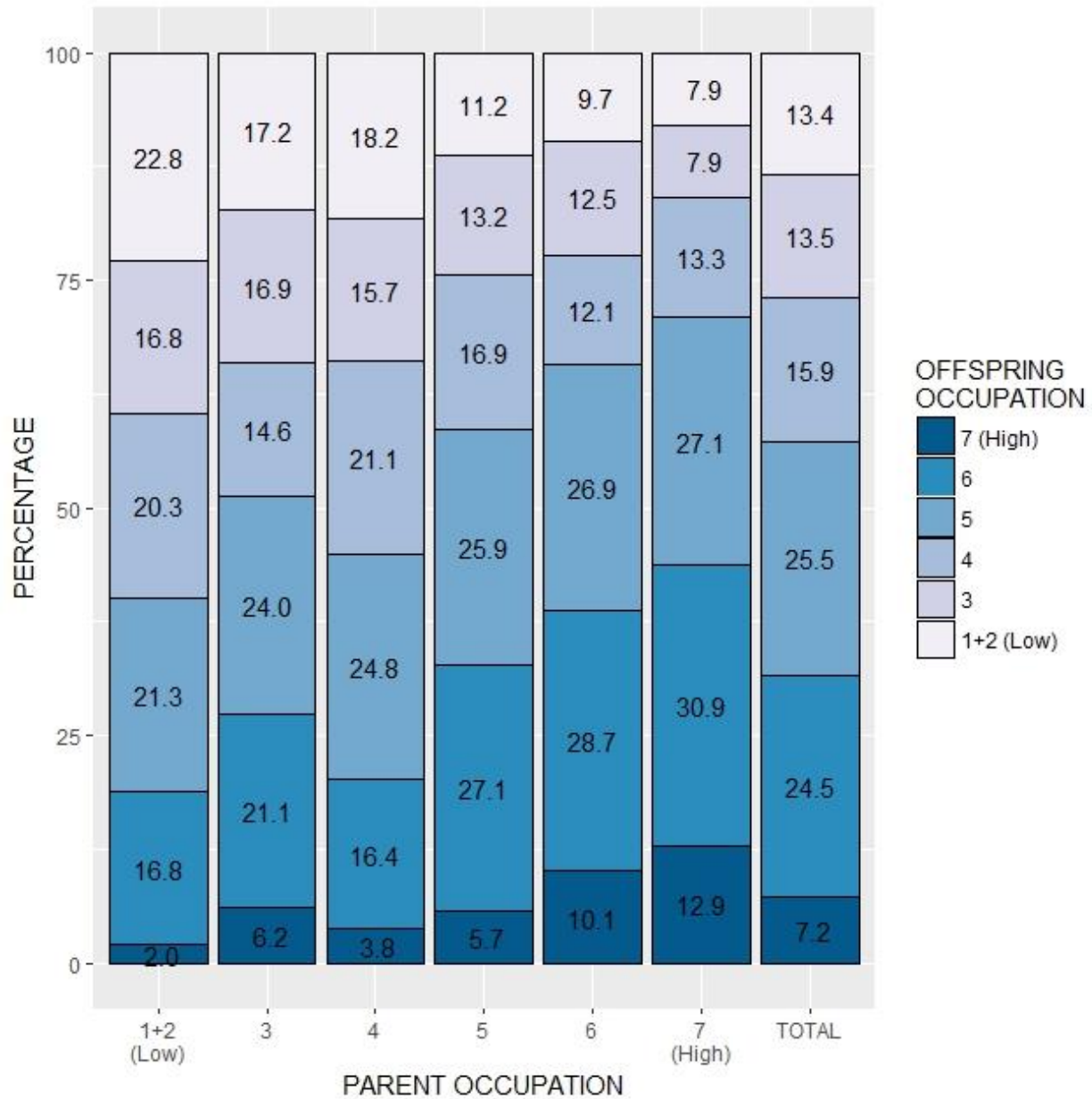


Figure S2: Percentage offspring who achieve the same or different education (A) or occupation (B) level as the maximum level of their parents. For the five columns for parent education, the number of offspring were 1426, 183, 685, 300 and 2594, respectively. For the seven columns of parent occupation, the number of offspring were 199, 336, 320, 509, 464, 319 and 2147, respectively. Occupation only coded for individuals with a full-time position. The lowest two categories were combined for both education and occupation because of small sample size.

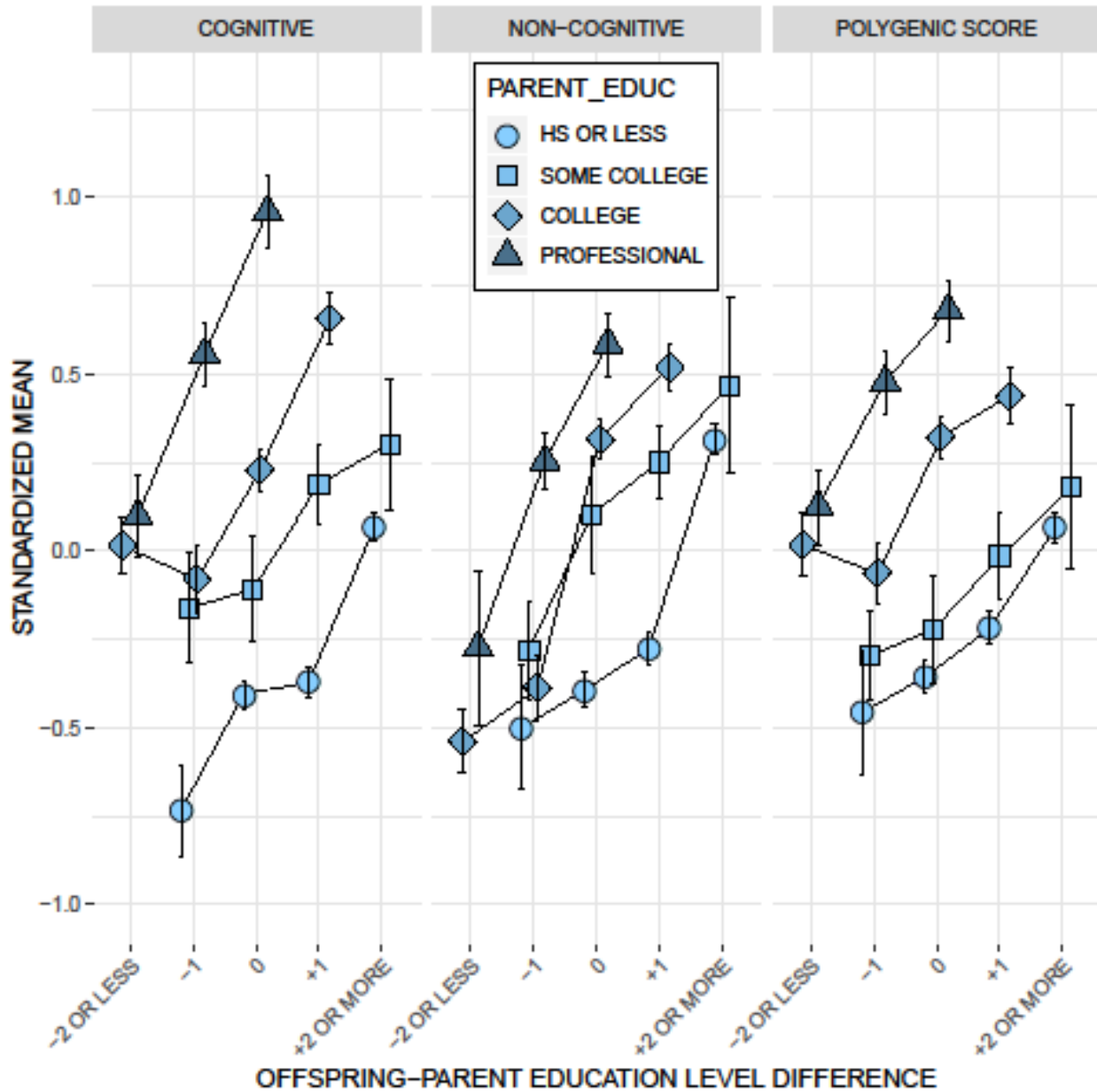


Figure S3. Relationship of mean standardized predictor variables with educational mobility as a function of parent educational level. The figure illustrates that the relationship between each of the predictors and educational mobility is similar across levels of parental education. Statistical analysis given in Table S8. Note that data do not exist for certain combinations (e.g., children of professionally degreed parents cannot move up educationally) and small-N cells at the extremes have been combined (e.g., high school combined with less than high school), although in statistical analysis original levels were analyzed.

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