Paternal Antisocial Behavior and Sons' Cognitive Ability: A Population-Based Quasiexperimental Study

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Abstract

Parents' antisocial behavior is associated with developmental risks for their offspring, but its effects on their children's cognitive ability are unknown. We used linked Swedish register data for a large sample of adolescent men ($N = 1,177,173$) and their parents to estimate associations between fathers' criminal-conviction status and sons' cognitive ability assessed at compulsory military conscription. Mechanisms behind the association were tested in children-of-siblings models across three types of sibling fathers with increasing genetic relatedness (half-siblings, full siblings, and monozygotic twins) and in quantitative genetic models. Sons whose fathers had a criminal conviction had lower cognitive ability than sons whose fathers had no conviction (any crime: Cohen's $d = -0.28$; violent crime: Cohen's $d = -0.49$). As models adjusted for more genetic factors, the association was gradually reduced and eventually eliminated. Nuclear-family environmental factors did not contribute to the association. Our results suggest that the association between men's antisocial behavior and their children's cognitive ability is not causal but is due mostly to underlying genetic factors.

Keywords

Antisocial behavior is a major societal, public-health, and safety concern and is associated with substantial hardships for families. Intergenerational research indicates that children of antisocial parents are at elevated risk for negative outcomes, including conduct disturbance (Hicks, Foster, Iacono, & McGue, 2013; Thornberry, Freeman-Gallant, Lizotte, Krohn, & Smith, 2003), criminality (Frisell, Lichtenstein, & Långström, 2011), psychiatric disorders (Herndon & Iacono, 2005), substance use, and low academic achievement (Murray, Loeber, & Pardini, 2012). Despite this literature and the large number of families affected by parental antisocial behavior, surprisingly little is known about how parents' antisocial behaviors are associated with psychological and cognitive development in offspring. Cognitive ability predicts socioeconomic success, health, and mortality (Calvin et al., 2011; Strenze, 2007) and is also one of the best-replicated individual contributors to the risk for antisocial

behavior (Portnoy, Chen, & Raine, 2013). Assessing the link between parents' antisocial behavior and their children's cognitive ability is thus important for understanding the intergenerational continuity of antisocial behavior and related risks.

Children of antisocial parents may experience various adversities that could compromise their cognitive development. Such factors include unstable rearing environments, poor parenting practices, limited cognitive stimulation, interparental conflict and violence, and even victimization from parental abuse or neglect (Eaves, Prom, & Silberg, 2010; Hanscombe, Haworth, Davis, Jaffee, & Plomin, 2011; Koenen, Moffitt, Caspi, Taylor, &

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Purcell, 2003; Perkins & Graham-Bermann, 2012; Schwartz & Beaver, 2013). Such adversities might influence cognitive development directly, or their effects could be mediated via other factors, such as the biological effects of chronic stress. For example, it has been suggested that exposure to violence—a factor potentially linked to parents' antisocial behaviors and criminality—can cause neurocognitive problems in children via neurological changes that result directly from the exposure or via problems in interpersonal communication between parents and children (Perkins & Graham-Bermann, 2012). Moreover, it has been speculated that parental involvement in the criminal-justice system might itself also have adverse effects on children's development (Murray et al., 2012).

However, antisocial behavior is not randomly distributed in the population. Antisocial parents are likely to differ from parents who have no tendency toward antisocial behavior in many important additional aspects that could influence the cognitive development of their children. Antisocial behaviors have increased incidence among parents with low levels of education and low socioeconomic status, both of which are associated with poor cognitive development in offspring (Lawlor et al., 2005; Neiss & Rowe, 2000). As a result, any association between parents' antisocial traits and cognitive development of their children could be noncausal and merely reflect confounding by factors such as parental cognitive abilities or genetic influences. Antisocial behaviors and cognitive abilities are well known to be significantly heritable; genetic factors explain 40% to 70% of their variation in the population (Burt, 2009; Frisell, Pawitan, Långström, & Lichtenstein, 2012; Haworth et al., 2010; Rhee & Waldman, 2002). Antisocial traits and cognitive abilities are also systematically negatively correlated (Frisell, Pawitan, & Långström, 2012; Isen, 2010), and twin studies have suggested that this correlation is due in part to common genetic influences (Koenen, Caspi, Moffitt, Rijsdijk, & Taylor, 2006). However, a meta-analysis of large-scale twin studies of cognitive ability confirmed that in addition to genetic influences, environmental factors shared by twins reared together explain a significant proportion of variation in cognitive development until young adulthood (Haworth et al., 2010). Thus, an association between parents' antisocial behavior and cognitive outcomes in their offspring might arise because of genetic confounding or because of a true causal influence of parental behavior.

Common observational research designs that use data collected from unrelated individuals and their parents can show an association between traits of parents and their offspring but are unable to clarify the mechanisms behind an intergenerational association. In contrast, family-based quasiexperimental study designs, such as sibling-comparison and children-of-siblings designs, can be used to rigorously test for causal effects of the family environment and parental characteristics (D'Onofrio, Lahey, Turkheimer, & Lichtenstein, 2013; Rutter, Pickles, Murray, & Eaves, 2001). Such family-based, quasiexperimental designs compare biologically related individuals who differ with regard to the presence of a particular risk factor, such as parental antisocial behavior, and are thus able to partly control for unmeasured genetic and environmental factors shared by family members. The potential of quasiexperimental methods for testing causal hypotheses has been emphasized in the literature; so far, however, they have only rarely been applied to testing environmental influences on traits such as cognitive ability (D'Onofrio et al., 2014; Ellingson, Goodnight, Van Hulle, Waldman, & D'Onofrio, 2014; Lundberg et al., 2010).

To our knowledge, two previous quasiexperimental studies on the effects of parents' antisocial traits on their children's behavioral characteristics have been published (D'Onofrio et al., 2007; Silberg, Maes, & Eaves, 2012). Both studies used the children-of-twins design. In these studies, researchers analyzed children who have a parent who is a monozygotic (MZ) or dizygotic (DZ) twin and who has antisocial traits, but the parent's sibling does not (i.e., one sibling has an antisocial trait and the other does not). D'Onofrio et al. (2007) focused on the intergenerational transmission of childhood conduct problems and found evidence for environmentally mediated, and possibly causal, transmission to male offspring; genetic risk explained the intergenerational association for female offspring. Silberg et al. (2012) used an extended children-of-twins design and found that the links between parents' antisocial behavior and three separate behavioral outcomes among their children (hyperactivity, conduct disturbance, and depression) were explained by different combinations of genetic and family environmental factors. However, neither of these studies examined cognitive ability of offspring.

Using a large, population-based data set that included Swedish men born over a 40-year period and their parents, we estimated associations between fathers' antisocial behavior and their sons' cognitive ability. To test for potential genetic confounding, we examined this association in fathers with and without criminal convictions and of three sibling types with different degrees of genetic relatedness (i.e., half-siblings, full siblings, and MZ twins). We refer to these as sibling-father pairs. Sources of familial confounding were further investigated with quantitative genetic structural equation modeling in extended families. The study was approved by the institutional review board of the Karolinska Institutet.

Method

Databases

We performed a national cohort study by linking several Swedish longitudinal population-based registries maintained by governmental agencies. The link between the registries was the unique personal identification numbers given to all Swedish citizens at birth and to immigrants on arrival to Sweden. Data from cognitive-ability testing of males born in Sweden from 1952 until 1991 were obtained from the Conscript Register. Although registration was mandatory, and more than 95% of men generally attended the conscription testing, exemptions were allowed for somatic disorders, handicaps, or mental retardation (Carlstedt, 2000). No data were available after 2009 because conscription at age 18 was no longer mandatory for Swedish men.

The Multi-Generation Register (MGR; Statistics Sweden, 2010) identifies biological and adoptive parents of each individual born since 1932 and living in Sweden at any time since 1961. The personal identification numbers in the MGR were used to link to data in other government records. Parents' antisocial behavior was indexed by data on criminal convictions obtained from the Crime Register, which documents all convictions in lower courts for individuals ages 15 (age of criminal responsibility) and older from 1973 onward. The register includes detailed information about the timing, nature, and number of offenses leading to court convictions. The MGR was used to identify biological parents of conscripted men and to construct extended families for the children-of-siblings analyses (by identifying paternal grandparents). The Swedish Twin Register was used to identify pairs of fathers who were MZ or DZ twins.

The Total Population Register provided information about the parents' country of birth. Death or departure (i.e., emigration) dates for parents were obtained from the Cause of Death Register and the Migration Register, respectively. Data on parents' highest levels of education were available from the National Census in 1970 and from the Education Register since 1985. Information on parents' hospitalization for psychiatric disorders was obtained from the Hospital Discharge Register, which contains details of all individual episodes of hospitalization in Sweden since 1973. Data on socioeconomic status (SES) during childhood were available from National Censuses undertaken in 1960, 1970, 1980, 1985, and 1990.

Study population

We identified 2,207,631 men born in Sweden between 1952 and 1991. We excluded men for whom any of the following information was missing: conscription information (n = 385,964), cognitive-ability measure (n = 88,924),

or biological father's or mother's identity (n = 24,586). We also excluded all offspring who had been adopted (n = 13,257). To make the samples used in population analyses and within-family analyses (see Statistical Analysis) consistent, we excluded people whose parents were born before 1932 (n = 502,834) and whose grandparents could thus not be identified via the MGR. Offspring whose parents died or emigrated from Sweden before the start of the Crime Register in 1973 were also excluded (n = 14,893). After exclusions, the population analyses included 1,177,173 men for whom cognitive-ability data were available. For the within-family analyses, 111,784 extended families with paternal cousins were identified, and we randomly selected one son per nuclear family. There were 102,133 pairs of full-sibling fathers (i.e., full brothers or DZ twins; n = 1,003), 8,977 pairs of half-sibling fathers, and 674 pairs of MZ-twin fathers. For the quantitative genetic structural equation modeling, data from all families were used; we selected a maximum of two brothers per nuclear family (n = 867,439).

Measures

Parental criminal convictions were classified into subtypes: violent (nonsexual), sexual, drug-related, property-related, and traffic-related crimes. *Violent crimes* included murder, manslaughter, assault, kidnapping, illegal restraint, illegal coercion or threats, robbery, threats or violence against an officer, arson, gross violation of a person's integrity, and harassment. *Sexual crimes* included rape, sexual coercion, child molestation, sexual intercourse with a child, child-pornography offenses, pimping, and sexual harassment. *Drug-related crimes* were possession of controlled substances for personal use, consumption, or sale; possession of substances used in the manufacture of illegal drugs; and crimes committed while driving under the influence of alcohol or other intoxicants. *Property-related crimes* included theft, larceny, burglary, embezzlement, and vandalism. *Traffic-related crimes* included, for example, reckless driving and unlawful driving of a vehicle, but excluded speeding fines issued by a police officer. We recorded criminal-conviction status (i.e., whether each parent had a conviction) along with a specific conviction subtype. Attempted and aggravated forms of the offenses were considered as well.

General cognitive ability was assessed with the Swedish Enlistment Battery (SEB), which is administered as part of the military-conscription testing. Three different versions of the SEB were used during the 40-year period for which cognitive data were available: the SEB67, used from 1970 to 1979; the SEB80, used from 1980 to 1993; and the computer-aided testing (CAT) SEB, used from 1994 to 2009 (Carlstedt, 2000). The SEB67 and

SEB80 were paper-and-pencil tests with four subtests assessing verbal, visuospatial, technical, and inductive abilities; scores on all subtests were summed to derive a measure of general cognitive ability. High internal consistency has been reported for the SEB80 (coefficient α = .79–.91; Carlstedt & Mårdberg, 1993). As a result of theoretical and methodological developments in intelligence research and the advent of the personal computer, CAT-SEB was launched in 1994. The CAT-SEB was based on a three-level hierarchical model of cognitive abilities and included 12 tests, 10 of which were used to form a latent factor for general cognitive ability and secondary factors for crystallized intelligence and general visualization. The reliability of the CAT-SEB tests is also good (coefficient α = .70–.85; Mårdberg & Carlstedt, 1998). The general cognitive-ability data, available from the Conscription Register and based on these versions of the SEB, is provided as a normally distributed variable divided into nine categories (i.e., a stanine scale; $M = 5$, $SD = 2$). The scale was standardized separately for each conscription year, which resulted in a constant distribution across the study period.

Parental factors that were potential confounds were included as covariates: birth year, immigrant status, highest educational level, and history of hospitalization for any psychiatric disorder (ICD8 code range 290–315; ICD9 code range 290–319; and ICD10 code range F00–F99). Immigration was coded as a dichotomous variable denoting whether the parent was born outside of Sweden. Educational level was assessed with an ordinal variable with seven categories, ranging from less than the 9 years' compulsory schooling to postgraduate education. Fathers' cognitive ability was included as a covariate in analyses on a subsample of sons whose fathers were born in 1952 or later and had cognitive-ability data available from the Conscription Register ($n = 287,966$).

Offspring covariates included birth year and family SES before age 10 years. The SES variable was derived from the censuses; the occupation of each head of household (usually the father) was coded as belonging to one of three classes: low (skilled and unskilled workers across all fields), medium (low- and intermediate-rank white-collar workers), and high (high-rank white-collar workers and self-employed professionals and entrepreneurs). For the cohort of sons born in 1991 ($n = 16,595$), the SES variable denoted household SES during the year preceding the son's birth.

Statistical analysis

Because of the significantly higher prevalence of crime among men compared with women, we focused on fathers' criminality, but we included mothers' criminal-conviction status as a covariate. Associations between fathers' criminal-conviction status and sons' cognitive ability were first studied in the full population sample using linear regression models and a robust sandwich estimator to adjust standard errors for the nonindependence of brothers in the offspring generation. Four different models were fitted: Model 1 predicted sons' cognitive ability from fathers' criminal-conviction status without any covariates. Model 2 adjusted for fathers' and sons' birth years, family SES, and fathers' educational levels. Model 3 added mothers' birth years, criminal-conviction status, and educational levels as covariates. Model 4 further adjusted for parents' existing psychiatric disorder and immigration status. We conducted a separate population regression model for each crime subtype as well as for crime of any subtype. To account for confounding by fathers' cognitive ability, we conducted separate analyses for the subset of sons whose fathers had cognitive-ability data available. In these models, fathers' cognitive ability was used instead of educational level.

Using the *xtreg* modeling command with the fixed effects (*fe*) option in Stata (Version 12; StataCorp, 2011), we fitted conditional linear regression models (i.e., fixed-effects regression models; Gunasekara, Richardson, Carter, & Blakely, 2014) to study the association between fathers' criminal-conviction status and sons' cognitive ability within sibling-father pairs. These models use a within-family estimator to compare the cognitive-ability scores of cousins whose fathers' criminality data were discordant (i.e., one cousin's father had committed crimes but the other one's father had not) and thus adjust for all unmeasured factors shared by cousins. A separate model was fitted to the data for each type of sibling father: half-siblings, who share, on average, 25% of their segregating genes; full siblings and DZ twins, who share, on average, 50% of their genetic makeup; and MZ twins, who share 100% of their genes. In this order, these within-family analyses increasingly controlled for genetic confounding in the association between fathers' criminality and sons' cognitive ability. If genetic factors confounded the association, the regression coefficient would be reduced as the control for genetic factors increased (i.e., coefficient in the population > coefficient for offspring of half-siblings > coefficient for offspring of full siblings > coefficient for offspring of MZ twins). In contrast, a causal effect of fathers' criminality would be supported if the observed association with son's cognitive ability was equal across the population-based and within-family models.

To complement the within-family regression analyses, we conducted quantitative genetic structural equation modeling (Kuja-Halkola, D'Onofrio, Larsson, & Lichtenstein, 2014) for the data from the extended families to estimate the magnitudes of genetic and environmental sources of familial confounding. The model we

used is an extension of the standard model used in twin research, which decomposes variance into genetic influences (*A*), shared environmental influences (*C*), and non-shared environmental influences (*E*). In contrast to the standard twin model, the model estimated an intergenerational bivariate association between fathers' crime and sons' cognitive ability and decomposed the shared environmental variance into environmental influences assumed to be shared by members of an extended family (i.e., fathers who are full siblings, MZ twins, or maternal half-siblings and their sons; *C*) and environmental influences shared only by members of a nuclear family (i.e., father and his son or sons; *F*). The model partitioned the association between paternal crime and cognitive ability of offspring into the *A*, *C*, and *F* factors and estimated the proportion of the correlation explained by each factor. This model has been described in detail elsewhere (Kuja-Halkola et al., 2014) and is also described in the Supplemental Method available online. The OpenMx package (Version 1.2.0; Boker et al., 2011) was used for modeling in the R software environment (Version 3.0.2; R Development Core Team, 2012).

Several sensitivity analyses were conducted to rule out possible alternative explanations for our results. First, to rule out the possibility that the results were due to the likelihood of having convictions in the Crime Register varying with the birth year of the father (i.e., left truncation), we studied the association after stratifying the sample into quartiles based on fathers' birth years. Second, to inspect potential effects of the differences between the CAT-SEB and the earlier paper-and-pencil cognitive batteries (SEB67 and SEB80), we estimated the association separately for men assessed with each of these two methods. Third, any conviction, regardless of timing, was considered in the main analysis. However, we conducted a sensitivity analysis in which we considered only paternal convictions that took place between the son's birth and his conscription. Finally, to further evaluate the plausibility of possible genetic confounding in the intergenerational association between fathers' criminal behavior and their sons' cognitive ability, we conducted within-family analyses in which we switched the variables for fathers and sons—that is, we tested the association between fathers' cognitive ability and sons' criminal-conviction status in the population and across different types of sibling pairs in the fathers' generation.

Results

As shown in Table 1, men whose fathers had any criminal convictions had lower cognitive-ability scores than men whose fathers had no criminal convictions (4.70, 95% confidence interval, or CI = [4.69, 4.70], vs. 5.22, 95% CI = [5.22, 5.23], Cohen's *d* = −0.28). Of the subtypes of

paternal convictions, violent and sexual crimes were associated with the lowest cognitive ability among sons (4.28, 95% CI = [4.26, 4.30], Cohen's *d* = −0.49, and 4.32, 95% CI = [4.27, 4.38], Cohen's *d* = −0.47, respectively); traffic crimes were associated with the highest cognitive ability among sons (4.73, 95% CI = [4.72, 4.74], Cohen's *d* = −0.26). Similar mean differences were observed for paternal cognitive ability among the subset of fathers for whom cognitive-ability data were available (*n* = 223,433 fathers). Fathers' criminality was also associated with lower parental education, higher prevalence of parental psychiatric morbidity, parental immigration to Sweden, lower SES when the son was younger than 10, and mothers' criminal-conviction status (Table 1).

Results from regression models predicting sons' cognitive ability using fathers' criminal-conviction status are presented in Table 2. In unadjusted models, fathers' criminal convictions predicted a reduction of 0.43 to 0.86 stanine units in sons' cognitive-ability scores. For all crime types, adjustment for cohort effects, family SES, and paternal education significantly reduced the association (by between 41% and 47%; Model 2). Adjustments for maternal characteristics (Model 3) and for parental immigrant status and psychiatric morbidity further reduced the associations (by between 59% and 63% in total; Model 4) but did not completely eliminate them. Table 2 also presents results for the subsample of fathers with cognitive-ability data; the results paralleled those found in the whole population.

To investigate the mechanisms linking fathers' criminal-conviction status and sons' cognitive ability, we compared the association in the population and across fathers who were half-siblings, full siblings, and MZ twins. As shown in Table 3, the association in Model 1 was gradually reduced with increasing adjustment for unmeasured genetic factors—population: *b* = −0.53, 95% CI = [−0.54, −0.52]; sons of half-siblings, *b* = −0.38, 95% CI = [−0.46, −0.29]; sons of full siblings, *b* = −0.22, 95% CI = [−0.25, −0.19]; and sons of MZ twins, *b* = 0.14, 95% CI = [−0.18, 0.46]. The pattern of associations remained similar in models adjusting for measured parental covariates (Models 2–4).

We observed overlapping confidence intervals for regression coefficients in offspring of half-siblings with estimates from the population and offspring of full siblings, potentially because statistical power for estimation was lower after adjustments among offspring of half-siblings than among offspring of other sibling groups. However, the estimates for sons of full siblings and sons of MZ twins were smaller than the population estimates (Table 3). Models adjusting for father's cognitive ability instead of education had reduced power because of limited sample sizes but provided similar results; although the associations among sons of half-sibling pairs and

Table 1. Cognitive Ability and Parental Characteristics Among Swedish Men Born in 1952 Through 1991 (*N* = 1,177,173)

	Fathers' criminal convictions						
Variable	None (*n* = 891,220)	Any (*n* = 285,953)	Violent (*n* = 61,966)	Sexual (*n* = 5,719)	Drug (*n* = 107,317)	Property (*n* = 80,879)	Traffic (*n* = 174,994)
Cognitive ability in offspring (mean)[a]	5.22 [5.22, 5.23]	4.70 [4.69, 4.70]	4.28 [4.26, 4.30]	4.32 [4.27, 4.38]	4.51 [4.50, 4.53]	4.44 [4.42, 4.45]	4.73 [4.72, 4.74]
Fathers' education (mean)[b]	3.35 [3.35, 3.36]	3.04 [3.03, 3.04]	2.77 [2.76, 2.78]	2.77 [2.73, 2.81]	2.85 [2.84, 2.86]	2.92 [2.91, 2.93]	3.06 [3.05, 3.07]
Mothers' education (mean)[b]	3.47 [3.47, 3.48]	3.31 [3.30, 3.32]	3.13 [3.11, 3.14]	3.12 [3.08, 3.16]	3.17 [3.16, 3.18]	3.24 [3.23, 3.25]	3.34 [3.33, 3.35]
Fathers' cognitive ability (mean)[c]	5.38 [5.37, 5.39]	4.66 [4.65, 4.68]	4.11 [4.08, 4.13]	4.06 [3.95, 4.17]	4.39 [4.37, 4.41]	4.34 [4.32, 4.37]	4.66 [4.65, 4.68]
Mothers' criminal-conviction status (% with convictions)	5.33	12.3	18.9	15.6	15.7	18.0	12.7
Fathers' prevalence of psychiatric disorders (%)	8.64	25.3	40.9	40.6	41.9	34.6	23.1
Mothers' prevalence of psychiatric disorders (%)	11.1	16.9	22.8	22.8	20.1	20.7	16.5
Father's immigrant status (%)	7.10	13.4	18.1	17.7	12.6	16.4	12.7
Mother's immigrant status (%)	7.27	11.1	13.5	12.9	10.6	12.8	10.6
Socioeconomic status (%)							
Low	37.5	44.8	51.0	51.0	47.8	49.6	43.5
Medium	36.6	28.7	22.8	22.9	26.8	25.0	28.2
High	20.8	16.4	11.5	10.5	12.8	11.8	18.0
Missing	5.1	10.1	14.7	15.5	12.7	13.7	10.3

Note: The *n*s for fathers' criminal convictions denote numbers of sons whose fathers had a conviction of the specified type. Percentages were calculated for 844,940 fathers and 844,940 mothers. Values in brackets are 95% confidence intervals.
[a]The confidence intervals for this variable have been adjusted for clustering of brothers. [b]Education values (range: 1–7) were available for 831,258 fathers and 839,308 mothers. Means are reported for descriptive purposes, but categorical values were used in the analyses. [c]Data were available for 223,433 fathers.

sons of MZ twins could not be differentiated from those among other groups, the associations among sons of full siblings were consistently smaller than the population estimates (Table S1 in the Supplemental Tables). We found a similar pattern of associations indicating genetic confounding of the association between paternal criminality and sons' cognitive ability for the different subtypes of crimes in the full sample (Table S2 in the Supplemental Tables).

Results of the quantitative genetic model strongly supported the children-of-siblings regressions (Tables S3–S5 in the Supplemental Tables). Genetic factors explained 80% of the intergenerational association between fathers' criminal-conviction status and sons' cognitive ability. The rest of the association was due to environmental factors shared by all members of an extended family (*C*); nuclear-family environmental influences (*F*) did not contribute to the association.

Sensitivity analyses indicated that the association between fathers' conviction for any crime and sons' cognitive ability was similar across quartiles of fathers' birth-year distribution, though the association was slightly reduced in the oldest cohorts—fathers born before 1940:

b = −0.46, 95% CI = [−0.48, −0.44]; fathers born from 1940 to 1945: b = −0.52, 95% CI = [−0.54, −0.50]; fathers born from 1946 to 1951: b = −0.52, 95% CI = [−0.53, −0.50]; and fathers born after 1951: b = −0.51, 95% CI = [−0.53, −0.49]. The association was also similar among men whose cognitive ability had been assessed with a paper-and-pencil test and men who had taken the newer computerized test—SEB67 and SEB80: b = −0.51, 95% CI = [−0.53, −0.50]; CAT-SEB: b = −0.54, 95% CI = [−0.55, −0.53]. Restricting the analyses to paternal convictions that took place between the sons' birth and conscription suggested that the association with sons' cognitive ability was somewhat stronger (b = −0.62, 95% CI = [−0.63, −0.61]) than in the main analysis; as in the main analysis, the association observed for the whole population was reduced in within-family comparisons (Supplemental Table S6).

Finally, to test the robustness of the finding that adjusting for more genetic factors reduced the association between fathers' criminality and sons' cognitive ability, we conducted analyses on the association between paternal cognitive ability and sons' criminal-conviction status. The rationale for this approach was that if genetic factors

Table 2. Regression Results: Coefficients for Fathers' Criminal-Conviction Status (by Subtype of Crime) as a Predictor of Sons' Cognitive Ability

	Subtype of crime				
Sample and model	Violent	Sexual	Drug	Property	Traffic
Full sample (*N* = 1,177,173)					
Model 1: unadjusted association	−0.86	−0.78	−0.64	−0.71	−0.43
	[−0.88, −0.84]	[−0.83, −0.72]	[−0.65, −0.63]	[−0.72, −0.69]	[−0.44, −0.42]
Model 2: adjusted for fathers' and sons' birth years, family SES, and fathers' education levels	−0.50	−0.46	−0.36	−0.40	−0.23
	[−0.52, −0.48]	[−0.51, −0.41]	[−0.37, −0.35]	[−0.41, −0.38]	[−0.24, −0.22]
Model 3: further adjusted for mothers' birth years, criminal-conviction status, and education levels	−0.43	−0.41	−0.31	−0.34	−0.19
	[−0.44, −0.41]	[−0.46, −0.36]	[−0.33, −0.30]	[−0.35, −0.32]	[−0.20, −0.18]
Model 4: further adjusted for fathers' and mothers' existing psychiatric disorders and immigration status	−0.35	−0.32	−0.24	−0.27	−0.16
	[−0.36, −0.33]	[−0.37, −0.27]	[−0.25, −0.23]	[−0.28, −0.25]	[−0.17, −0.15]
Subsample (fathers for whom cognitive-ability data were available; *n* = 287,966)					
Model 1: unadjusted association	−0.75	−0.75	−0.61	−0.61	−0.41
	[−0.78, −0.73]	[−0.83, −0.72]	[−0.63, −0.58]	[−0.63, −0.58]	[−0.43, −0.39]
Model 2: adjusted for fathers' and sons' birth years, family SES, and fathers' cognitive ability	−0.30	−0.29	−0.25	−0.22	−0.16
	[−0.32, −0.26]	[−0.38, −0.20]	[−0.27, −0.22]	[−0.24, −0.20]	[−0.17, −0.14]
Model 3: further adjusted for mothers' birth years, criminal-conviction status, and education levels	−0.23	−0.23	−0.19	−0.17	−0.11
	[−0.25, −0.20]	[−0.32, −0.14]	[−0.21, −0.17]	[−0.19, −0.15]	[−0.13, −0.10]
Model 4: further adjusted for fathers' and mothers' existing psychiatric disorders and immigration status	−0.20	−0.19	−0.16	−0.14	−0.10
	[−0.22, −0.17]	[−0.28, −0.10]	[−0.18, −0.14]	[−0.17, −0.12]	[−0.12, −0.08]

Note: The table presents unstandardized regression coefficients (with 95% confidence intervals in brackets). In all models, standard errors were adjusted for the clustering of brothers. All the coefficients in the table were significant, $p < .001$.

play a role in the intergenerational association between criminality and cognitive ability, a similar pattern of results should be seen when predicting sons' criminality using their fathers' cognitive functioning. The results were compatible with this hypothesis. Conditional logistic regression analyses of the population data, adjusting for

Table 3. Regression Results: Coefficients for Fathers' Criminal-Conviction Status (Any Crime) as a Predictor of Sons' Cognitive Ability in the Full Sample and in Within-Family Models

		Within-family models		
Model	Population model: full sample (*N* = 1,177,173)	Sons of half-siblings (*n* = 17,954)	Sons of full siblings (*n* = 204,226)	Sons of MZ twins (*n* = 1,348)
Model 1: unadjusted association	−0.53	−0.38	−0.22	0.14
	[−0.54, −0.52]	[−0.46, −0.29]	[−0.25, −0.19]	[−0.18, 0.46]
Model 2: adjusted for fathers' and sons' birth years, family SES, and fathers' education levels	−0.31	−0.26	−0.17	0.21
	[−0.31, −0.30]	[−0.34, −0.18]	[−0.20, −0.14]	[−0.11, 0.53]
Model 3: further adjusted for mothers' birth years, criminal-conviction status, and education levels	−0.27	−0.23	−0.16	0.17
	[−0.27, −0.26]	[−0.32, −0.15]	[−0.18, −0.13]	[−0.15, 0.49]
Model 4: further adjusted for fathers' and mothers' existing psychiatric disorders and immigration status	−0.22	−0.19	−0.13	0.14
	[−0.23, −0.21]	[−0.27, −0.10]	[−0.16, −0.10]	[−0.18, 0.46]

Note: The table presents unstandardized regression coefficients (with 95% confidence intervals in brackets). Those from the population model are from linear regression models of sons' cognitive ability regressed on fathers' criminal-conviction status and covariates, with standard errors adjusted for the clustering of brothers. Values for the within-family models are from conditional linear regression models (fixed-effects regression). All coefficients in the table were significant at the .001 level, except those for sons of MZ twins (*p*s > .05).

fathers' criminal-conviction status, revealed that each 1-stanine-unit increase in paternal cognitive ability was associated with a 13% reduction in the likelihood of the sons' having any criminal convictions (odds ratio, OR = 0.87, 95% CI = [0.87, 0.88]). In contrast, in children-of-siblings analyses, the association was gradually reduced when genetic factors were controlled for more extensively (sons of half-siblings: OR = 0.86, 95% CI = [0.80, 0.92]; sons of full siblings: OR = 0.93, 95% CI = [0.90, 0.96]; sons of MZ twins: OR = 1.12, 95% CI = [0.70, 1.79]).

Discussion

In a nationwide population-based sample of more than 1 million adolescent men, we found a robust association between paternal antisocial behavior and sons' cognitive ability. Adolescents whose fathers had criminal convictions performed more poorly in cognitive testing during compulsory military conscription than did those whose fathers had never been convicted. This finding suggests that in addition to the risks related to adverse behavioral (Hicks et al., 2013; Thornberry et al., 2003) and psychiatric (Herndon & Iacono, 2005) outcomes, there is a risk of poor cognitive development in offspring of antisocial parents. The association was observed for all crime types, but it was strongest for violent crimes (Cohen's $d = -0.49$) and weakest for traffic-related crimes (Cohen's $d = -0.26$).

To explicitly test whether genetic factors were important for the observed association, we conducted children-of-siblings analyses across three types of sibling-father pairs differing in the degree of control for genetic confounding. These within-family analyses showed that as more genetic factors were controlled for, the association between fathers' criminality and sons' cognitive ability gradually diminished. When genetic factors confounding the association were completely adjusted for, in sons of MZ twin brothers, no association between fathers' criminal-conviction status and sons' cognitive ability was observed. This analysis was followed up with quantitative genetic modeling using the extended-family data, the results of which supported the main analysis: Genetic influences explained most of the association. Extended-family environmental factors also contributed to the association, but nuclear-family environmental factors shared only between fathers and sons did not. Our findings, therefore, do not support a causal effect but rather suggest that genetic effects and nongenetic factors shared by members of extended families and, potentially, reflecting wider socioeconomic differences are sufficient to explain the intergenerational link between parents' antisocial behavior and lower cognitive ability in their offspring.

Previous research on parents' antisocial behavior and cognitive ability of their offspring is scarce. A study of 3,000 urban American children found that paternal incarceration was associated with lower verbal ability in children at age 5, but adjustment for a range of paternal and maternal covariates, including cognitive ability and educational level, completely eliminated the association (Geller, Cooper, Garfinkel, Schwartz-Soicher, & Mincy, 2012). Our findings are compatible with previous twin and family studies suggesting that the link between antisocial traits and lower cognitive ability is explained in part by genetic factors (Frisell, Pawitan, & Långström, 2012; Koenen et al., 2006). Our results thus indicate that despite the adversities related to parental criminality, having a father who has been convicted of crime is unlikely to influence cognitive development in the offspring when the effects of other factors associated with parental antisocial behavior, including genetic risks, are taken into account. To confirm this finding, we investigated whether genetic factors also explained the association between fathers' cognitive ability and sons' criminal-conviction status. This analysis provided additional support for genetic confounding in the intergenerational association between antisocial behavior and cognitive ability.

To gain a comprehensive view of the association of parental antisocial behavior with cognitive ability of offspring, we investigated five crime subtypes. Violence is the most severe form of antisocial behavior, and cognitive ability among both sons and fathers was lowest when the fathers had been convicted of violent crimes. This result is compatible with earlier studies suggesting that verbal cognitive ability is lower among violent compared with nonviolent antisocial individuals (Barker et al., 2007; Kennedy, Burnett, & Edmonds, 2011). Our results suggest that the intergenerational association between antisocial behavior and cognitive ability is stronger for crimes of greater severity than for those of lesser severity, such as traffic offenses. However, similar evidence for genetic confounding emerged regardless of the subtype of the father's crime, which suggests that the genetic overlap with cognitive ability is not crime-specific but instead related to criminal behavior in general.

Several methodological considerations are relevant for the interpretation of these results. First, because representative cognitive data were available only for men, our findings do not necessarily generalize to women. Second, official records of criminal convictions were used to index parental antisocial behavior, which may have biased the results. Although the differential-detection hypothesis holds that criminals with lower cognitive ability are more likely to be arrested and convicted and do not represent the population of all criminals, there is some evidence that commission of officially recorded crimes and commission of self-reported crimes are similarly associated with lower cognitive ability (Moffitt & Silva, 1988). Our register-based data did not include self-reported

criminality, but adjustment for fathers' cognitive ability did not eliminate the association between fathers' criminal-conviction status and sons' cognitive ability, which suggests that differential detection of fathers with lower cognitive ability does not explain our results.

Third, because of left truncation of the information in the criminal register, parent cohorts differed in their likelihood of having registered convictions. To overcome this bias, our analyses adjusted for both parents' birth years, and further analyses stratified the sample by fathers' birth years. Fourth, like all research results involving cognitive-ability tests, our results may have been affected by differences in noncognitive factors affecting performance, such as test motivation and effort (Duckworth, Quinn, Lynam, Loeber, & Stouthamer-Loeber, 2011). However, in contrast to performance in low-stakes research settings, performance in conscription testing has clear and tangible consequences for the test takers, which is likely to reduce confounding by test motivation. Available evidence suggests that the association between cognitive-ability test scores and antisocial behavior may be inflated but is not completely explained by differences in motivation (Duckworth et al., 2011; Lynam, Moffitt, & Stouthamer-Loeber, 1993).

Finally, it should be noted that the children-of-siblings design, like any nonexperimental research design, cannot conclusively prove or rule out a causal association. Each quasiexperimental design is based on assumptions that need to be carefully considered when interpreting the results (D'Onofrio et al., 2013). Among the assumptions of the children-of-siblings analyses are that there are no carryover effects, meaning that the exposure of one cousin has no effect on the outcome of the other cousin and that the results generalize to extended families with no cousins. Note, however, that the results of our children-of-siblings analyses were supported by compatible findings from quantitative genetic structural equation modeling in which data from all families were used.

In conclusion, our findings from a large and representative nationwide cohort of men suggest that parental antisocial behaviors are associated with lower cognitive ability in offspring. However, children-of-siblings analyses and quantitative genetic modeling indicated that the association between fathers' antisocial behavior and sons' cognitive ability is unlikely to be causal and instead reflects confounding by genetic and extended-family influences. Our results suggest that poor cognitive ability is one of the factors associated with the inherited risk for antisocial behavior.

Author Contributions

All authors contributed to planning the study and interpreting the results. A. Latvala performed the main analyses and drafted the manuscript. R. Kuja-Halkola managed the creation of extended families and conducted structural equation modeling. All authors contributed to revising the manuscript and have accepted the final version.

Supplemental Material

Additional supporting information can be found at http://pss .sagepub.com/content/by/supplemental-data

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Paternal antisocial behavior and sons' cognitive ability: A population-based quasi-experimental study

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Paternal Antisocial Behavior and Sons' Cognitive Ability: A Population-Based Quasiexperimental Study

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Abstract

Parents' antisocial behavior is associated with developmental risks for their offspring, but its effects on their children's cognitive ability are unknown. We used linked Swedish register data for a large sample of adolescent men ($N = 1,177,173$) and their parents to estimate associations between fathers' criminal-conviction status and sons' cognitive ability assessed at compulsory military conscription. Mechanisms behind the association were tested in children-of-siblings models across three types of sibling fathers with increasing genetic relatedness (half-siblings, full siblings, and monozygotic twins) and in quantitative genetic models. Sons whose fathers had a criminal conviction had lower cognitive ability than sons whose fathers had no conviction (any crime: Cohen's $d = -0.28$; violent crime: Cohen's $d = -0.49$). As models adjusted for more genetic factors, the association was gradually reduced and eventually eliminated. Nuclear-family environmental factors did not contribute to the association. Our results suggest that the association between men's antisocial behavior and their children's cognitive ability is not causal but is due mostly to underlying genetic factors.

Keywords

antisocial behavior, cognitive ability, parents, offspring, quasiexperimental designs, genetic confounding

Intelligence and antisocial behavior

Antisocial traits are associated with lower cognitive ability in childhood, adolescence, and adulthood[1-4]

> *Correlations typically -0.2 to -0.3*

Association with violence in a population-based sample of 700,000 men[5]

Low cognitive ability seen as "one of the best-replicated correlates of antisocial behavior"[6]

[1] Koenen et al. 2006, *J Abnorm Psychol*
[2] Fergusson et al. 2005, *J Child Psychol Psychiatry*
[3] Lynam et al. 1993, *J Abnorm Psychol*
[4] Moffitt 1993, *Dev Psychopathol*
[5] Frisell et al. 2012, *PLos ONE*
[6] Portnoy et al. 2013, *J Crim Justice*

Intergenerational link?

Children of antisocial parents are at risk for conduct disturbance, criminality, psychiatric disorders, substance use, and low academic achievement[1-5]

How about *cognitive* development?

Meta-analysis of twin studies: Shared environmental factors influence cognitive ability until early adulthood [6]

Family environmental adversities related to parents' antisocial behavior could causally influence cognitive development in the offspring

Or the association could be due to genetic correlation[7]

[1] Hicks et al. 2013, *JAMA Psychiatry*
[2] Thornberry et al., 2003, *J Abnorm Child Psychol*
[3] Frisell et al. 2011, *Psychol Med*
[4] Herndon & Iacono 2005, *Psychol Med*
[5] Murray et al. 2012, *Criminology*
[6] Haworth et al. 2010, *Mol Psychiatry*
[7] Koenen et al. 2006, *J Abnorm Psychol*

Quasi-experimental family designs

Data: Family relationships differing in environmental exposure and genetic closeness

Basic idea: What happens to an association between exposure (risk factor) and outcome when unobserved familial factors are increasingly controlled for

D'Onofrio et al. 2013

Main types:

1. **Sibling comparisons** (incl. co-twin control)
2. **Cousin comparisons** (incl. children of twins)
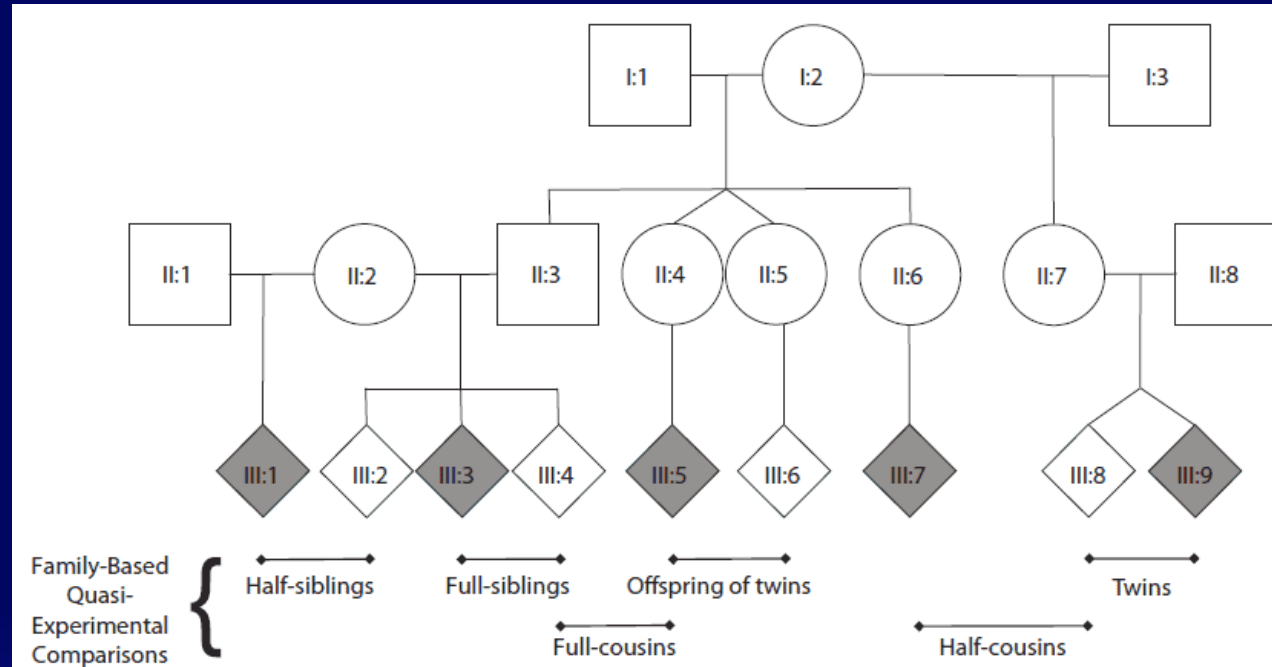
Aims of the study

1. To estimate the association between fathers' antisocial behavior (indexed by criminal convictions) and their sons' cognitive ability in the general population

2. To test for potential genetic confounding of the association using children-of-siblings analyses (cousin comparisons) and quantitative genetic structural equation modeling

Data

Population analyses

Men born in Sweden 1952-1991, with parental & grandparental information via the Multi-Generation Register[1] and cognitive data from the Conscription Register

→ **N = 1,177,173**

Within-family analyses

Extended families with paternal cousins (1 son / nuclear family)

→ **111,784** families

102,133 pairs of full brother fathers (incl. 1,003 pairs of DZ twin fathers)

8,977 pairs of half-brother fathers

674 pairs of MZ twin fathers
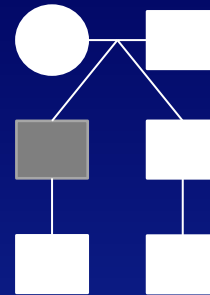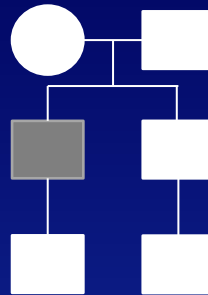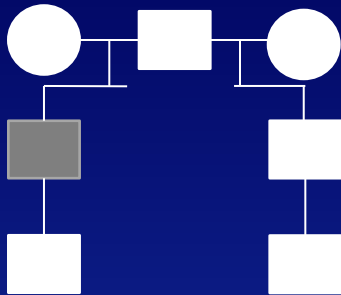
Measures

- ✓ Swedish Crime Register 1973-2009

  Violent, sexual, drug, property, traffic crimes

  Register start at age 15

- ✓ Cognitive ability: measured at conscription tests for the Swedish Armed Forces (Conscription Register)[1,2]

  Conscription was mandatory until 2009, over 95% coverage

  3 different versions of the Swedish Enlistment Battery between 1970-2009 (2 paper-and-pencil, 1 computer-aided)

  Stanine score: range 1-9, mean=5, sd=2

  Coefficient α = .70-.91

- ✓ Parental covariates: birth year, immigrant status, education, psychiatric disorders, mother's criminal convictions

- ✓ Offspring covariates: birth year, childhood SES

- ✓ A subsample of **N = 287,966** had father's cognitive ability data available

[1] Carlstedt & Mårdberg 1993, *Scand J Psychol*
[2] Mårdberg & Carlstedt 1998, *Int J Select Assess*

Statistical methods

Population analyses: linear regression with adjustment of standard errors for the non-independence of brothers in the offspring generation

Within-family analyses: conditional linear regression (fixed-effects regression) within sibling father pairs

*Equal effects across sibling types would be compatible with a causal association*
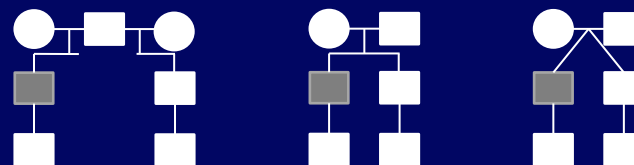
Quantitative genetic model: variance and covariance due to additive genetic influences (A), environmental influences shared by all members of an extended family (C), and environmental influences only shared by members of a nuclear family (F)[1]
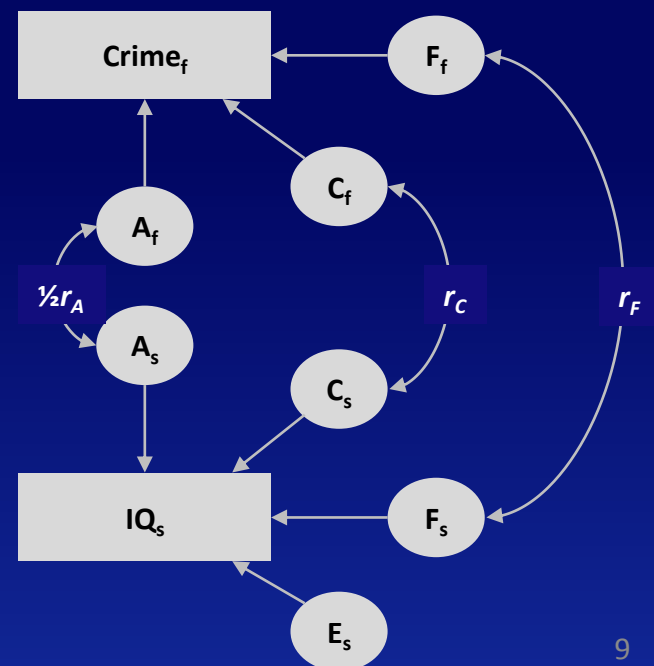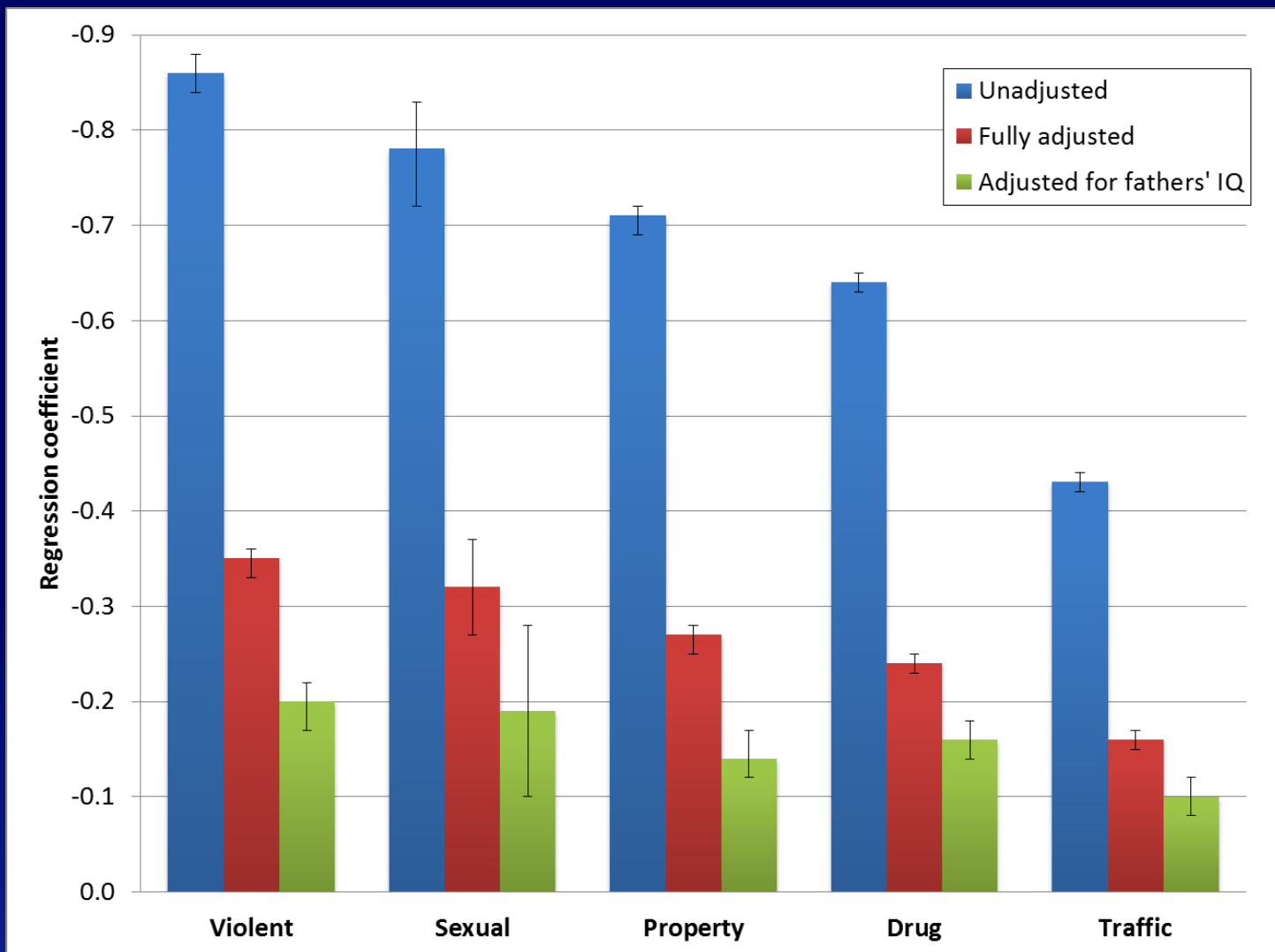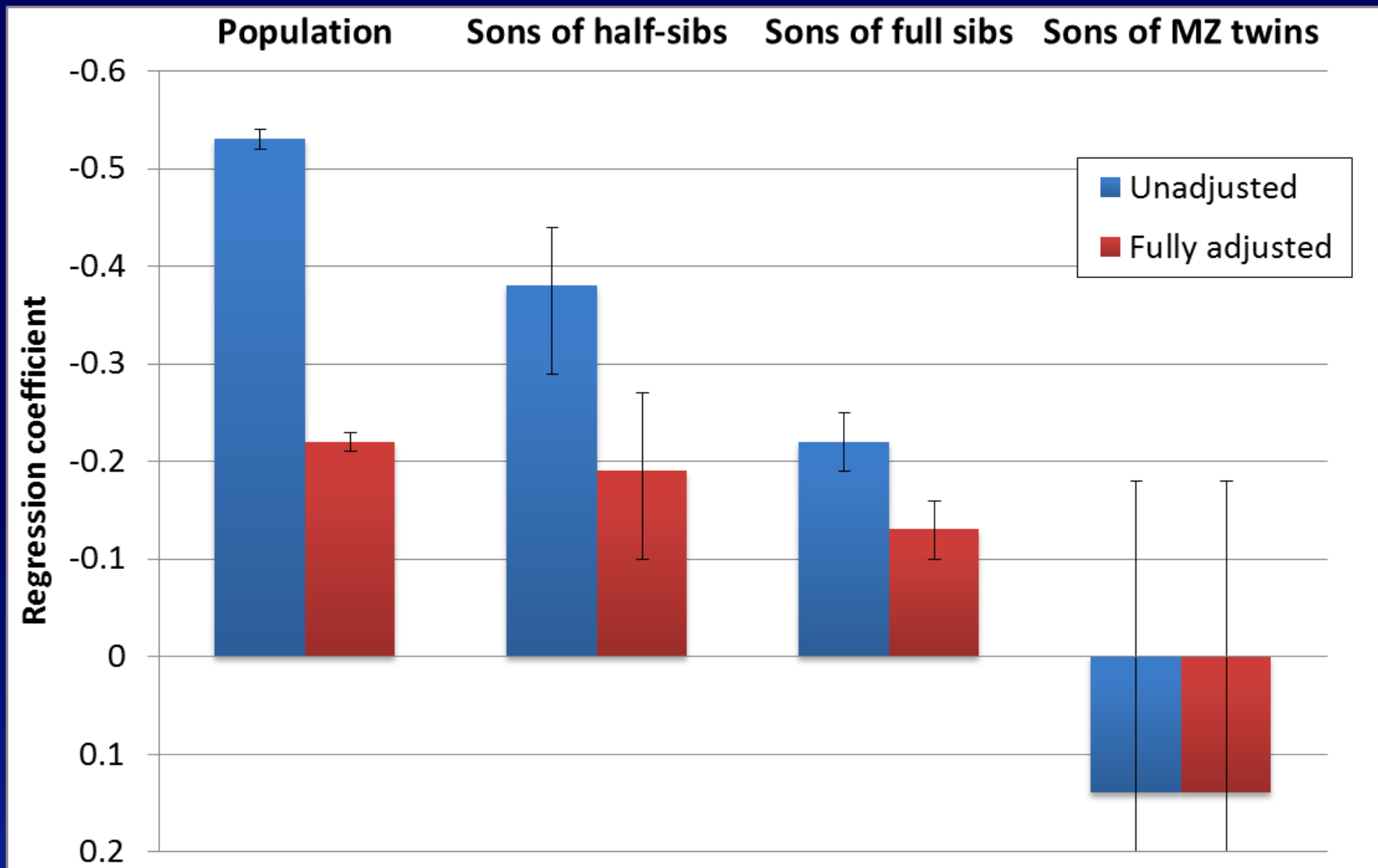
[1] Kuja-Halkola et al. 2014, *Behav Genet*

Results: IQ means
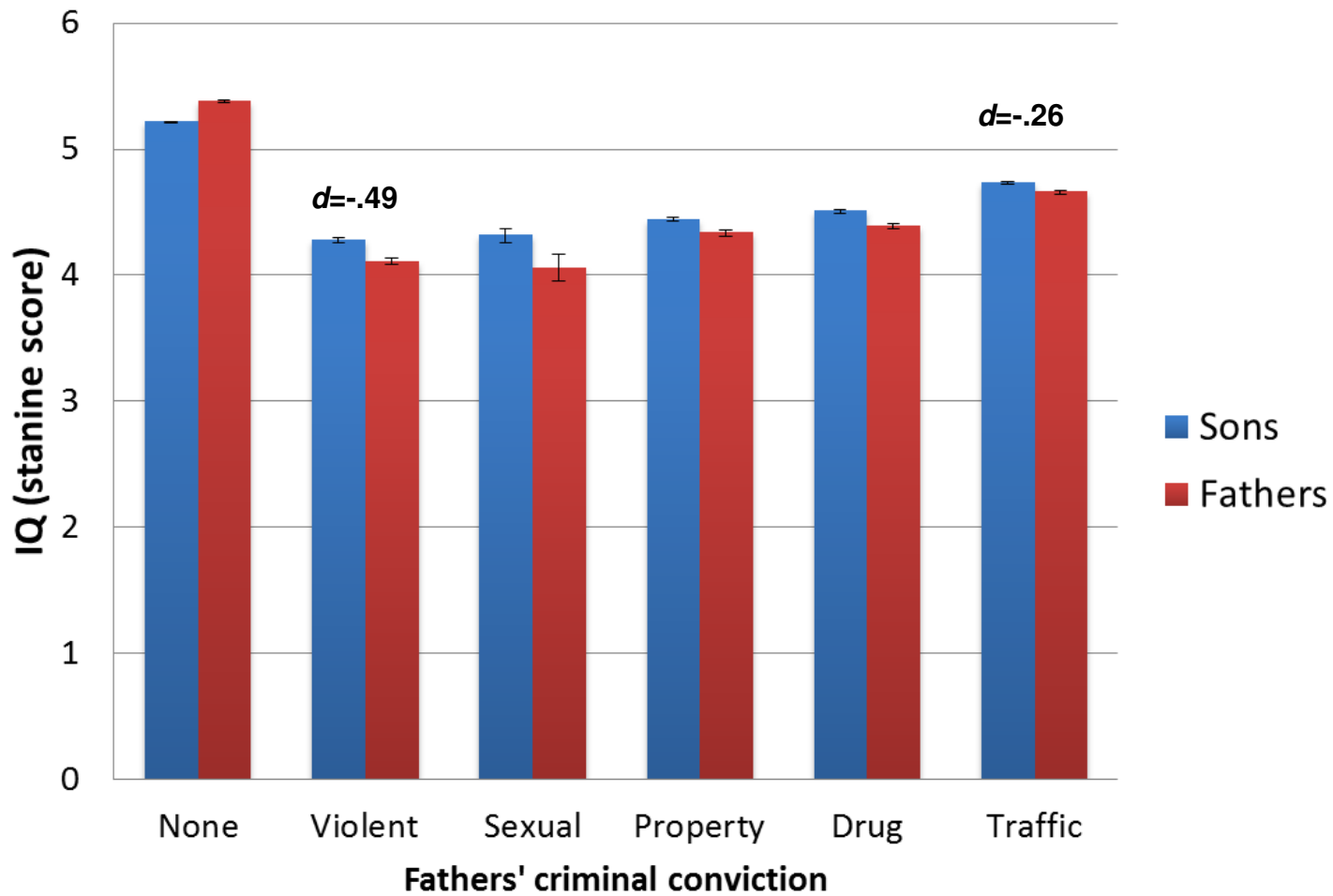
Results: Population regression

Results: Within-family regression (any crime)

Results: Variance component model

		Estimate (SE)
Crime	a^2	0.38 (0.033)
	c^2	0.04 (0.024)
	f^2	0.59 (0.014)
IQ	a^2	0.72 (0.020)
	c^2	0.08 (0.008)
	f^2	0.00 (0.001)
	e^2	0.20 (0.014)
Crime-IQ	A	**0.80 (0.040)**
	C	0.20 (0.040)
	F	0.00 (0.003)
Phenotypic correlation		-0.15 (0.002)

Results: Sensitivity analyses

- ✓ The association was not substantively affected by
    1) *Fathers' birth year*
    2) *Cognitive ability test version: paper-and-pencil vs. computerized*
- ✓ Restricting the analysis to convictions which took place between the sons' birth and conscription resulted in a stronger association (b=-0.62, 95% CI: -0.63, -0.61)
    - *The association was reduced in within-family models*
- ✓ Within-family models for fathers' IQ predicting sons' crimes also found a reduced association when more genetic factors were controlled for

Summary

- Men whose fathers have been convicted of crimes perform poorer in cognitive tests in late adolescence than do men whose fathers have no convictions

- Most serious crimes of the fathers are associated with poorest performance in sons (and fathers)

- Within-family analyses and quantitative genetic modeling did not support a causal effect of father's antisocial behavior

- Genetic factors explain most of the association

Comment

- Lower cognitive ability is not specific to crime type but associates with antisocial behavior more generally

- Genetic background of the intergenerational association in line with findings from twin and sibling comparison studies[1,2]

- Despite adversities related to parental crime, no evidence for a causal effect on offspring IQ

- Poorer cognitive ability is part of the inherited risk for antisocial behavior

[1] Koenen et al. 2006, *J Abnorm Psychol*
[2] Frisell et al. 2012, *PLos ONE*

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