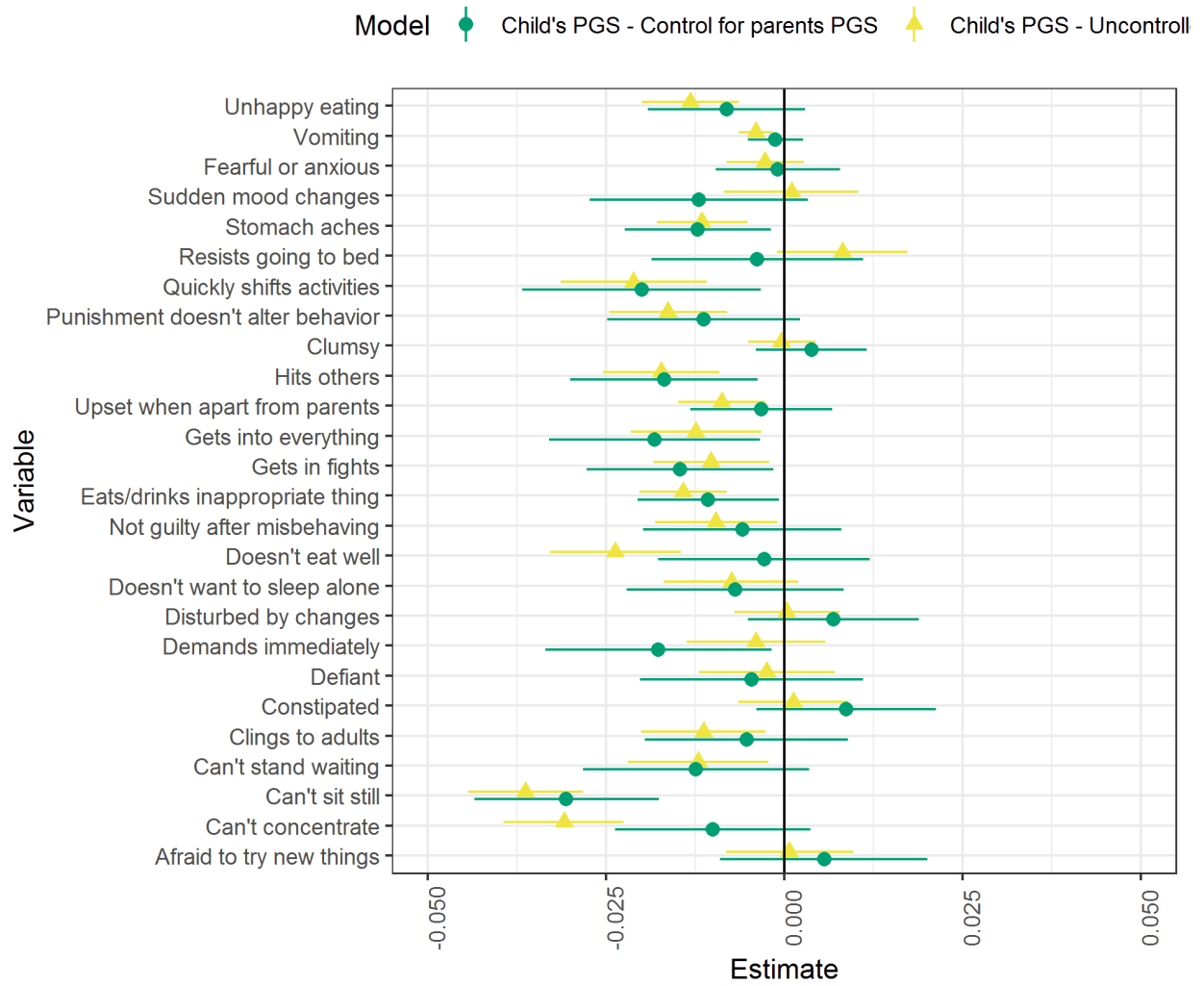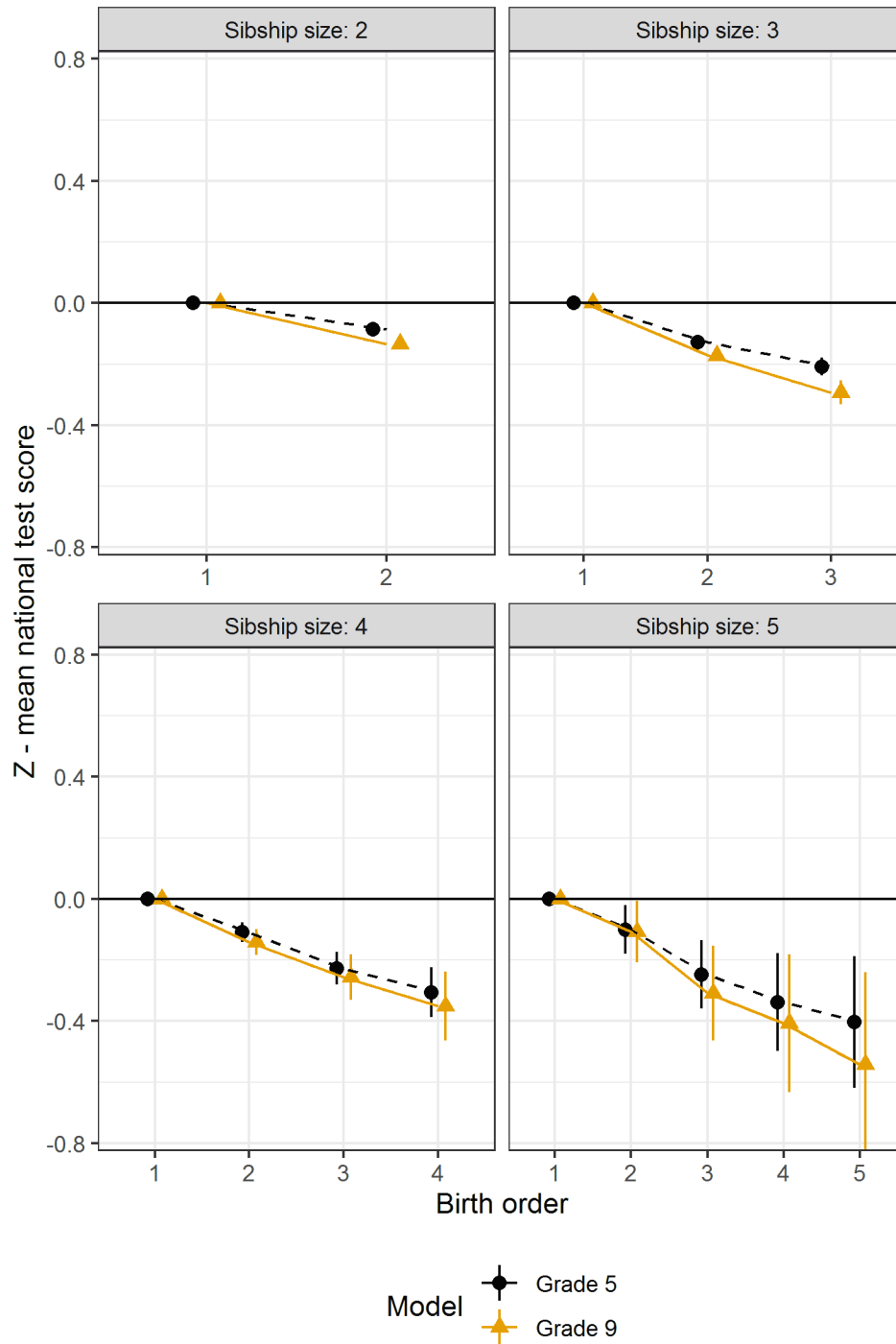**Supplementary Information for**
Birth Order Differences in Education Originate in Post-Natal
Environments

Martin Arstad Isungset   (ORCID: 0000-0001-9316-3279)
Jeremy Freese
Ole A. Andreassen   (ORCID: 0000-0002-4461-3568)
Torkild Hovde Lyngstad   (ORCID: 0000-0001-7830-9305)

Corresponding author: Martin Arstad Isungset
Email: m.a.isungset@sosgeo.uio.no

Fig. S1. Polygenic score and items from Child Behaviour Checklist (CBCL). Measured at 36 months. Full instrument documentation available here:
https://www.fhi.no/globalassets/dokumenterfiler/studier/den-norske-mor-far-og-barn--undersokelsenmoba/instrumentdokumentasjon/instrument-documentation-q6.pdf

Fig. S2. Birth order and educational achievement in 5th and 9th grade – child generation in the population. A,b Results from family-fixed effects linear regression models run separately by sibship size, with controls for sex and maternal age and cluster-robust standard errors. Firstborn serve as reference category. All point estimates presented with 95 % CI. N = 301,795
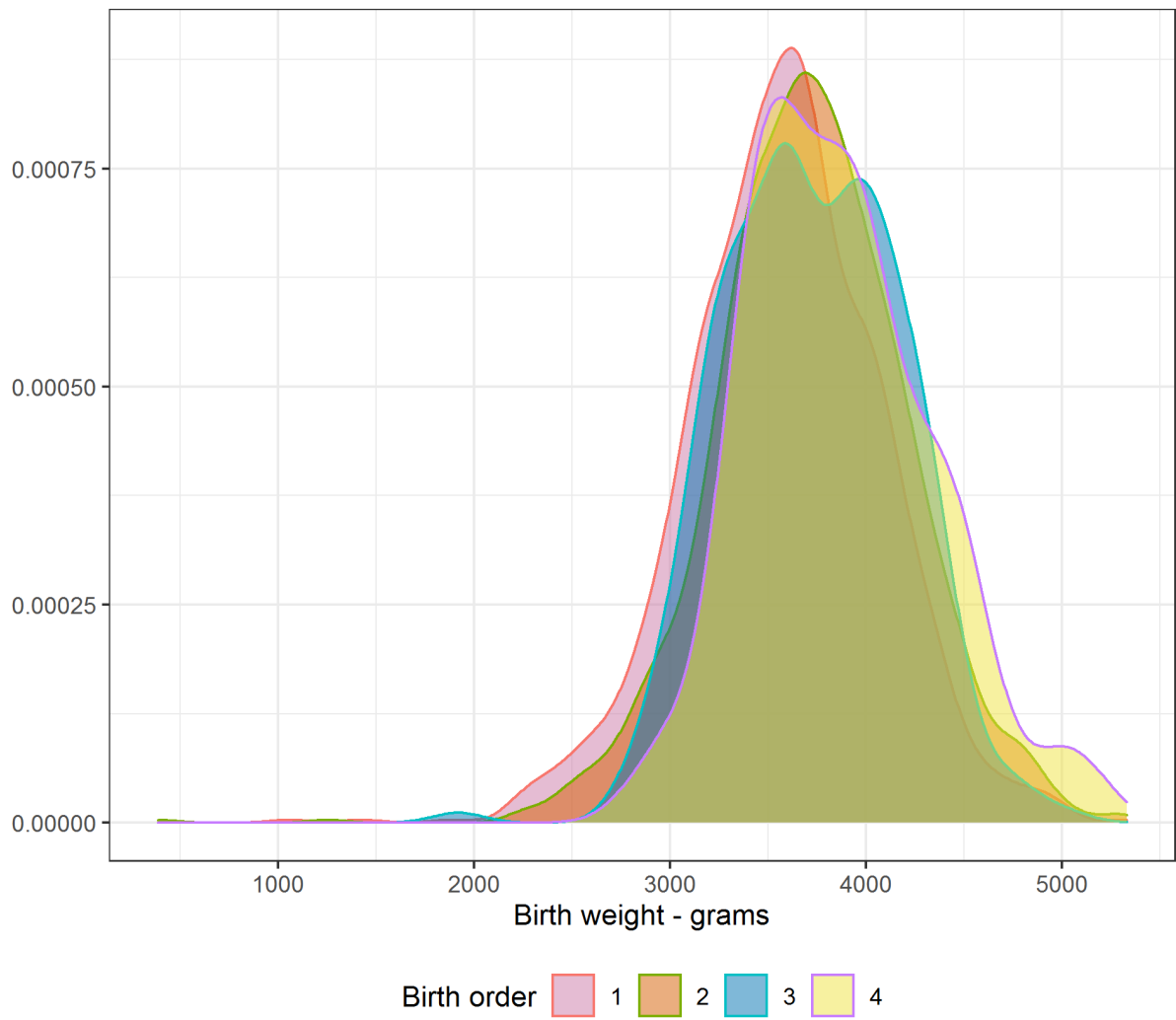
Fig. S3. Birth order birth weight - distribution plot. Child generation in MoBa-sample.

a)

b)
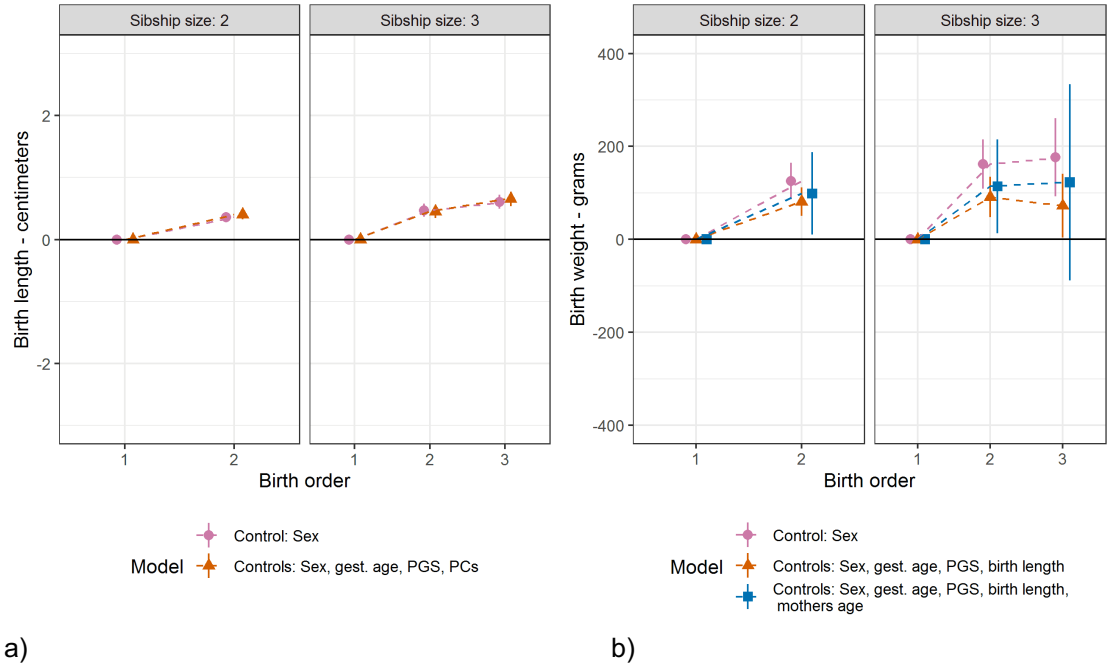
Fig. S4. Birth length, birth weight and birth order. A,b Results from linear regressions run separately by sibship size, with dummies for birth order. Children generation in the MoBa-sample (N = 8,188). Cluster robust standard errors, 95 % CI. Firstborns serve as reference category. In **a,** birth length, with different control variables, pink point: sex; orange triangle: sex, gestational age, educational attainment polygenic score, and principal components. In **b,** birth weight, with controls, pink point: sex; orange triangle: sex, gestational age, educational attainment polygenic score, and birth length
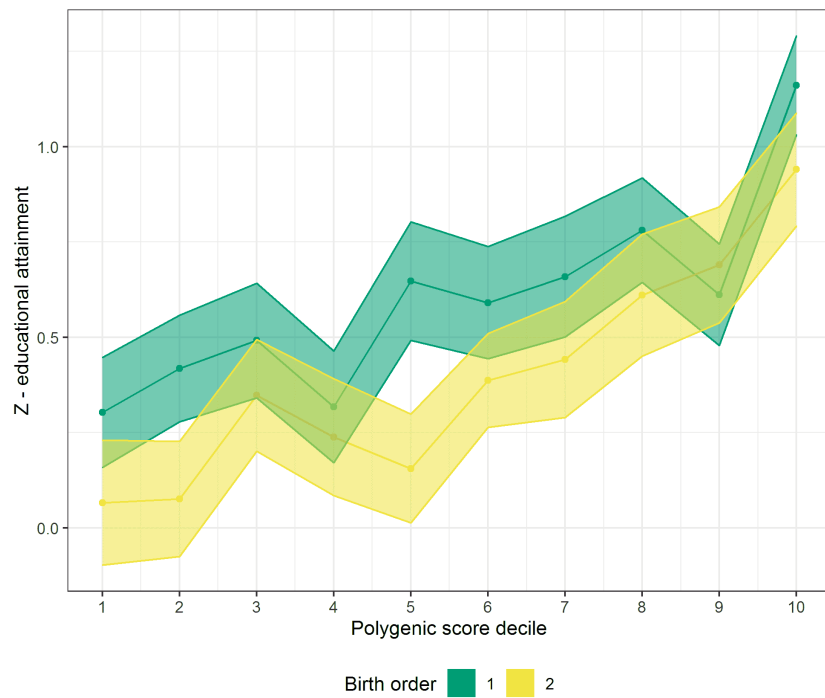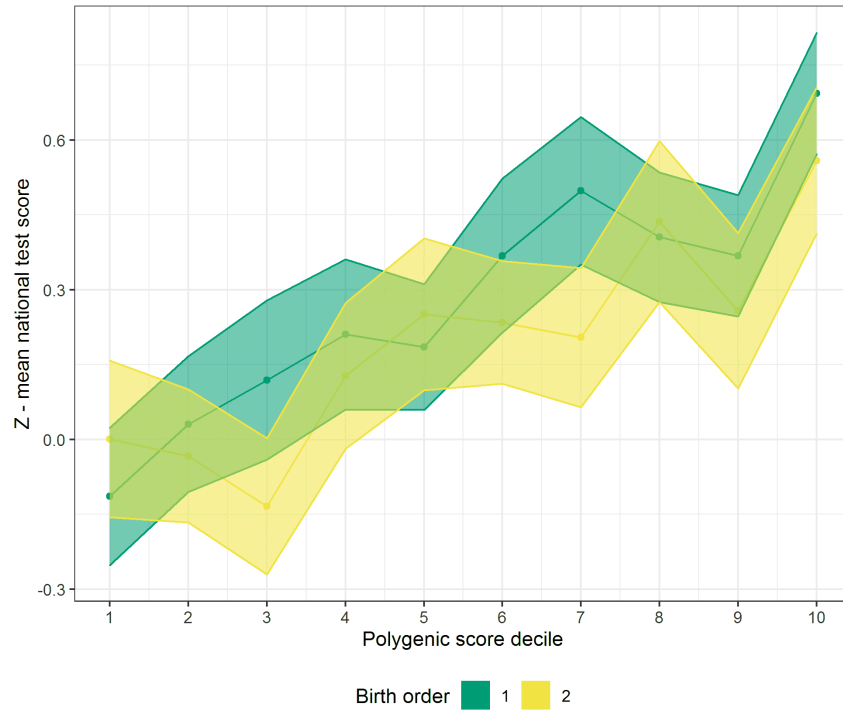
Fig. S5. Polygenic Score decile, birth order and educational achievement/attainment. Sibship size two only. Top panel: child generation in the MoBa-sample. Bottom panel: adult generation in the MoBa-sample. We use 83.4% confidence intervals used for point estimates so that non-overlapping estimates indicates a difference between estimates at 95% confidence (1)
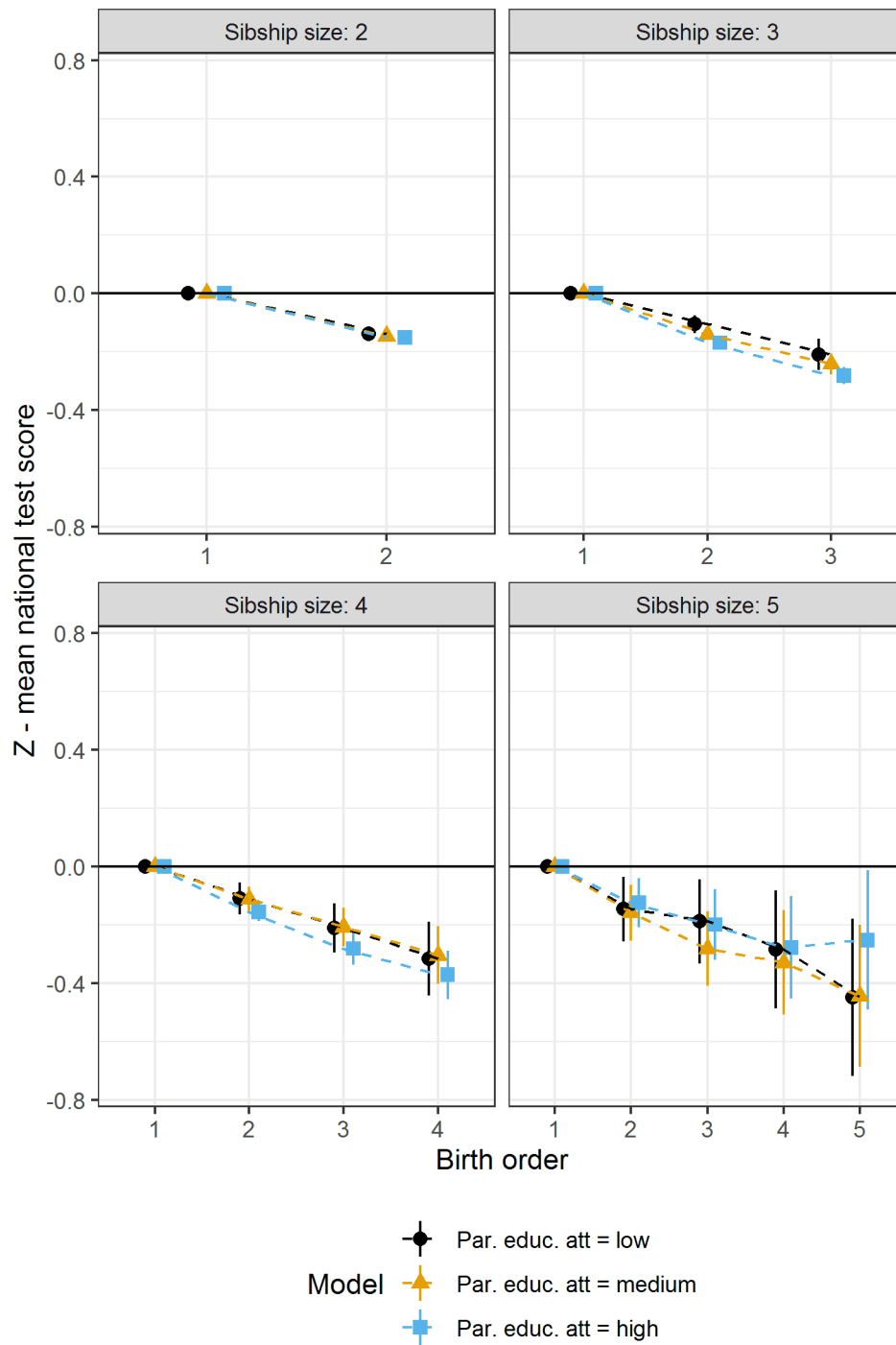
Fig S6. Parental educational attainment and birth order differences. Children - population. Parental educational attainment is the average parental educational attainment measured in years and then divided to treciles.

Table S1. Fertility decision x previous born child's PGS. Outcome is having had another child or not

	Dependent variable:		
	Dummy - Had another child = 1		
	(1)	(2)	(3)
Child PGS Minus Avg. Parents PGS	0.001		
	(-0.008, 0.009)		
Child PGS Minus Mother PGS		-0.005	
		(-0.012, 0.002)	
Child PGS Minus Father PGS			0.005
			(-0.002, 0.012)
Constant	0.793***	0.792***	0.800***
	(0.786, 0.799)	(0.786, 0.799)	(0.793, 0.807)
Observations	15,400	14,562	13,793
R^2	0.00000	0.0001	0.0001
Adjusted R^2	-0.0001	0.00004	0.00004
Residual Std. Error	0.405 (df = 15398)	0.405 (df = 14560)	0.400 (df = 13791)
F Statistic	0.015 (df = 1; 15398)	1.622 (df = 1; 14560)	1.608 (df = 1; 13791)
Note:			*$p < 0.05$. ** < 0.01, *** < 0.001

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Table S2. Maternal Age and Spacing - population. Outcome is the difference between first- and secondborn children in sibship size two in mean national test score. If maternal age mattered it would need to be inversely associated with test scores, but they are positively associated with test scores. The effect of age on the difference between siblings is also much larger than mothers age.

	Dependent variable:
	Diff. Between Sibs.
Age Difference Between Siblings	-0.020***
	(-0.022, -0.018)
Average Maternal Age At Birth	0.002***
	(0.002, 0.003)
Constant	0.091***
	(0.072, 0.110)
Observations	406,270
R^2	0.001
Adjusted R^2	0.001
Residual Std. Error	0.873 (df = 406267)
F Statistic	239.938*** (df = 2; 406267)
Note:	*p < 0.05. ** < 0.01, *** < 0.001

Table S3. Interaction between PGS and birth order on mean national test score. Child generation of the MoBa-sample. Family-level fixed effects and between-families linear models.

PGS x birth order interaction - children

	Dependent variable:	
	Z - Mean National Test Score	
	Family Fixed Effects OLS	OLS
	(1)	(2)
Birth Order	0.002	-0.060
	(-0.145, 0.150)	(-0.131, 0.012)
PGS	0.175***	0.219***
	(0.089, 0.262)	(0.195, 0.243)
Female	0.161	0.030
	(-0.016, 0.338)	(-0.018, 0.078)
Sibship Size		0.005
		(-0.034, 0.044)
PC1		-0.827*
		(-1.568, -0.087)
PC2		1.138*
		(0.196, 2.081)
PC3		-0.388
		(-1.596, 0.819)
PC4		1.022
		(-0.465, 2.509)
PC5		-1.735*
		(-3.295, -0.176)
PC6		-1.605*
		(-3.069, -0.141)
PC7		1.446
		(-0.006, 2.899)
PC8		0.373
		(-1.105, 1.851)
PC9		-1.189
		(-2.698, 0.320)
PC10		1.719*

		(0.393, 3.046)
Birth Order x PGS	-0.027	0.003
	(-0.071, 0.017)	(-0.010, 0.017)
Birth Order x Female	-0.056	-0.008
	(-0.151, 0.039)	(-0.034, 0.019)
Birth Order x Sibship Size		0.005
		(-0.015, 0.026)
Constant		0.232***
		(0.105, 0.359)
Observations	2,542	25,060
R^2	0.728	0.079
Adjusted R^2	0.448	0.078
Residual Std. Error	0.595 (df = 1251)	0.787 (df = 25042)
F Statistic		125.823*** (df = 17; 25042)
Note:		*p < 0.05. ** < 0.01, *** < 0.001

Table S4. Interaction between PGS and birth order. Adult generation of the MoBa-sample. Family-level fixed effects and between-families linear models.

	PGS x birth order interaction - parents	
	Dependent variable:	
	Z - Educational Attainment in Years	
	Family Fixed Effects OLS	OLS
	(1)	(2)
Birth Order	-0.166***	-0.080***
	(-0.254, -0.078)	(-0.109, -0.052)
PGS	0.093*	0.271***
	(0.021, 0.165)	(0.254, 0.287)
Female	0.135*	0.148***
	(0.007, 0.263)	(0.115, 0.181)
Sibship Size		-0.053***
		(-0.066, -0.039)
PC1		-0.104
		(-0.621, 0.414)
PC2		1.475***
		(0.805, 2.145)
PC3		-0.011
		(-0.881, 0.859)
PC4		-0.397
		(-1.468, 0.673)
PC5		-1.386*
		(-2.500, -0.271)
PC6		-0.882
		(-1.959, 0.195)
PC7		0.724
		(-0.346, 1.795)
PC8		-0.242
		(-1.326, 0.842)
PC9		-0.711
		(-1.805, 0.383)
PC10		-0.594
		(-1.577, 0.390)

Birth Order x PGS	0.029*	-0.002
	(0.001, 0.057)	(-0.010, 0.005)
Birth Order x Female	0.031	0.012
	(-0.023, 0.085)	(-0.003, 0.027)
Birth Order x Sibship Size		0.006***
		(0.002, 0.009)
Constant		0.362***
		(0.297, 0.428)
Observations	4,726	47,153
R^2	0.745	0.098
Adjusted R^2	0.420	0.097
Residual Std. Error	0.688 (df = 2075)	0.881 (df = 47135)
F Statistic		299.604*** (df = 17; 47135)

Note: *p < 0.05. ** < 0.01, *** < 0.001

Table S5. Parental educational attainment and average difference between first- and secondborn in sibship size 2 – child generation of the MoBa-sample. Outcome is the difference between first- and secondborn in mean national test score. Any positive coefficient from parental educational attainment indicate that higher educated parents have siblings where the difference between the first- and the secondborn is larger than those with lower education.

Difference between birth order 1 and 2 - sample

	Dependent variable:						
	Difference Between 1st and 2nd Born						
	OLS	OLS	OLS	OLS	OLS	OLS	OLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Z - Parental EA in Years	0.063**	0.046	0.051		0.046	0.051	
	(0.018, 0.108)	(-0.004, 0.096)	(-0.002, 0.103)		(-0.004, 0.096)	(-0.002, 0.103)	
Parental EA - Medium				0.147			0.111
				(-0.069, 0.364)			(-0.120, 0.343)
Parental EA - High				0.232*			0.206
				(0.026, 0.438)			(-0.014, 0.426)
PGS		0.037	0.033	0.038*	0.037	0.033	0.035
		(-0.0002, 0.075)	(-0.006, 0.073)	(0.001, 0.075)	(-0.0002, 0.075)	(-0.006, 0.073)	(-0.004, 0.073)
Female		0.071	0.058	0.074	0.071	0.058	0.060
		(-0.006, 0.147)	(-0.024, 0.140)	(-0.003, 0.150)	(-0.006, 0.147)	(-0.024, 0.140)	(-0.022, 0.142)
Birth Length			-0.002			-0.002	-0.004
			(-0.032, 0.029)			(-0.032, 0.029)	(-0.035, 0.027)
Gestational Age			0.008			0.008	0.008
			(-0.014, 0.030)			(-0.014, 0.030)	(-0.014, 0.030)
Birth Weight			-0.00003			-0.00003	-0.00003
			(-0.0002, 0.0001)			(-0.0002, 0.0001)	(-0.0002, 0.0001)
Constant	0.037	-0.061	-0.156	-0.231	-0.061	-0.156	-0.227

	(-0.016, 0.089)	(-0.187, 0.066)	(-1.511, 1.198)	(-0.466, 0.004)	(-0.187, 0.066)	(-1.511, 1.198)	(-1.583, 1.129)
Observations	2,161	1,929	1,711	1,929	1,929	1,711	1,711
R^2	0.003	0.007	0.007	0.009	0.007	0.007	0.008
Adjusted R^2	0.003	0.005	0.003	0.006	0.005	0.003	0.004
Residual Std. Error	0.844 (df = 2159)	0.855 (df = 1925)	0.847 (df = 1704)	0.854 (df = 1924)	0.855 (df = 1925)	0.847 (df = 1704)	0.846 (df = 1703)
F Statistic	7.488** (df = 1; 2159)	4.199** (df = 3; 1925)	1.909 (df = 6; 1704)	4.141** (df = 4; 1924)	4.199** (df = 3; 1925)	1.909 (df = 6; 1704)	2.023* (df = 7; 1703)

Note: *p**p***p<0.001

Table S6. Parental and Sibling Genetic Nurture. Child generation of the MoBa-sample.

	Parental and sibling genetic nurture					
	Dependent variable:					
	Z - Mean National Test Score					
	(1)	(2)	(3)	(4)	(5)	(6)
Own PGS	0.203***	0.187***	0.193***	0.171***	0.187***	0.175***
	(0.175, 0.232)	(0.152, 0.221)	(0.158, 0.228)	(0.127, 0.214)	(0.153, 0.221)	(0.131, 0.219)
Female	0.046	0.049	0.039	0.040	0.046	0.041
	(-0.011, 0.102)	(-0.010, 0.107)	(-0.021, 0.098)	(-0.020, 0.101)	(-0.012, 0.103)	(-0.020, 0.103)
Mothers PGS		0.027		0.029		0.011
		(-0.009, 0.062)		(-0.009, 0.067)		(-0.033, 0.054)
Fathers PGS			0.021	0.030		0.015
			(-0.015, 0.057)	(-0.008, 0.068)		(-0.029, 0.058)
Sibling PGS					0.045**	0.037
					(0.011, 0.079)	(-0.007, 0.081)
Constant	0.162***	0.152**	0.172***	0.162***	0.163***	0.158**
	(0.074, 0.251)	(0.061, 0.243)	(0.079, 0.265)	(0.067, 0.257)	(0.073, 0.252)	(0.062, 0.255)
Observations	2,861	2,739	2,605	2,518	2,762	2,436
R^2	0.064	0.063	0.064	0.064	0.071	0.069
Adjusted R^2	0.063	0.062	0.063	0.062	0.070	0.067
Residual Std. Error	0.773 (df = 2858)	0.775 (df = 2735)	0.776 (df = 2601)	0.776 (df = 2513)	0.770 (df = 2758)	0.774 (df = 2430)
F Statistic	97.878*** (df = 2; 2858)	61.365*** (df = 3; 2735)	59.590*** (df = 3; 2601)	42.671*** (df = 4; 2513)	70.583*** (df = 3; 2758)	36.018*** (df = 5; 2430)

Note: *p < 0.05. ** < 0.01, *** < 0.001

SI References

1.   M. J. Knol, W. R. Pestman, D. E. Grobbee, The (mis)use of overlap of confidence intervals to assess effect modification. *Eur. J. Epidemiol.* **26**, 253–254 (2011).