Supplementary materials

Social and Genetics Effects on Educational Achievement in Early Adolescence

2021 January 13th

Contents

Figures in main manuscript

Figure 1

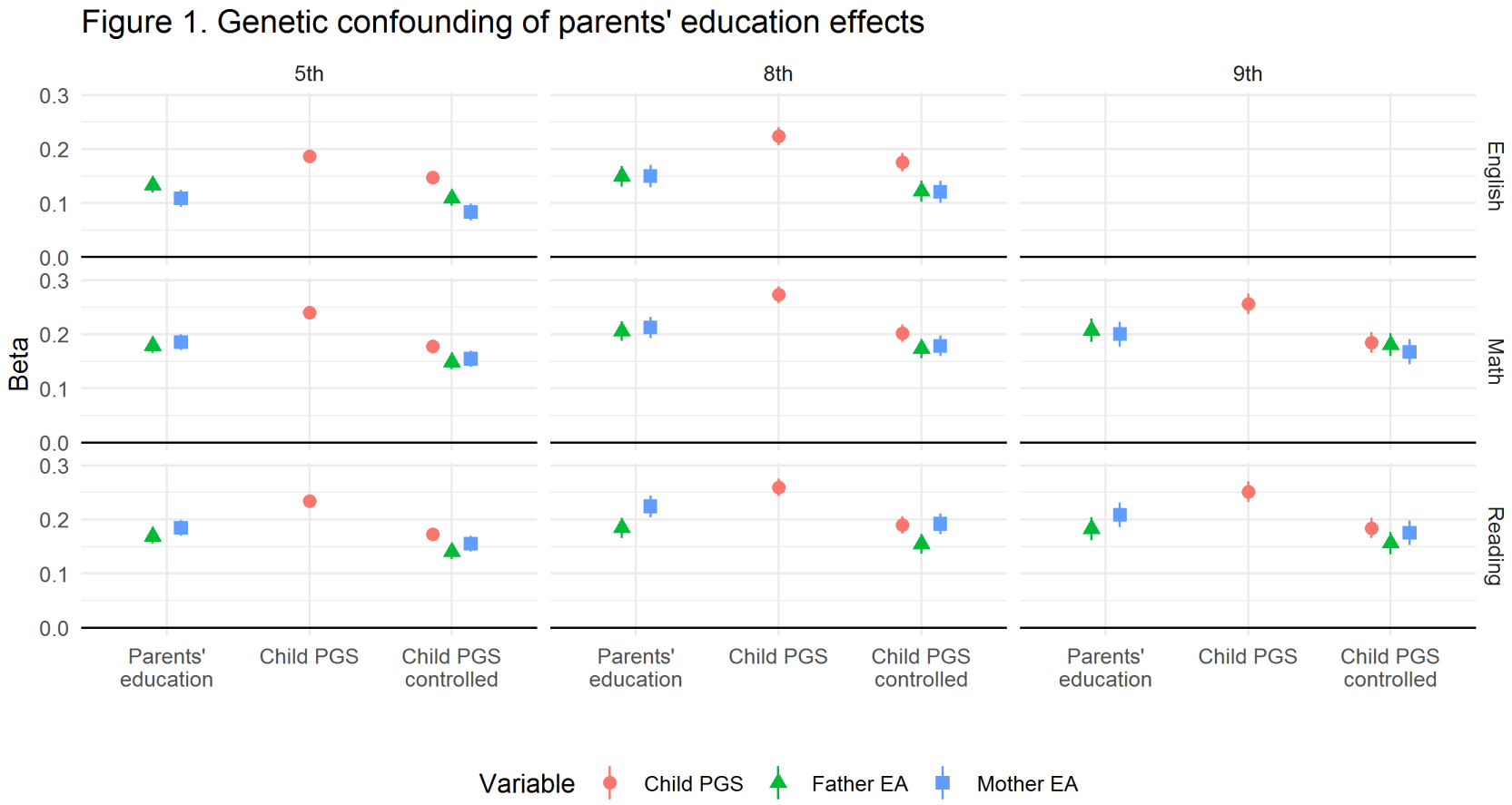


Figure 2

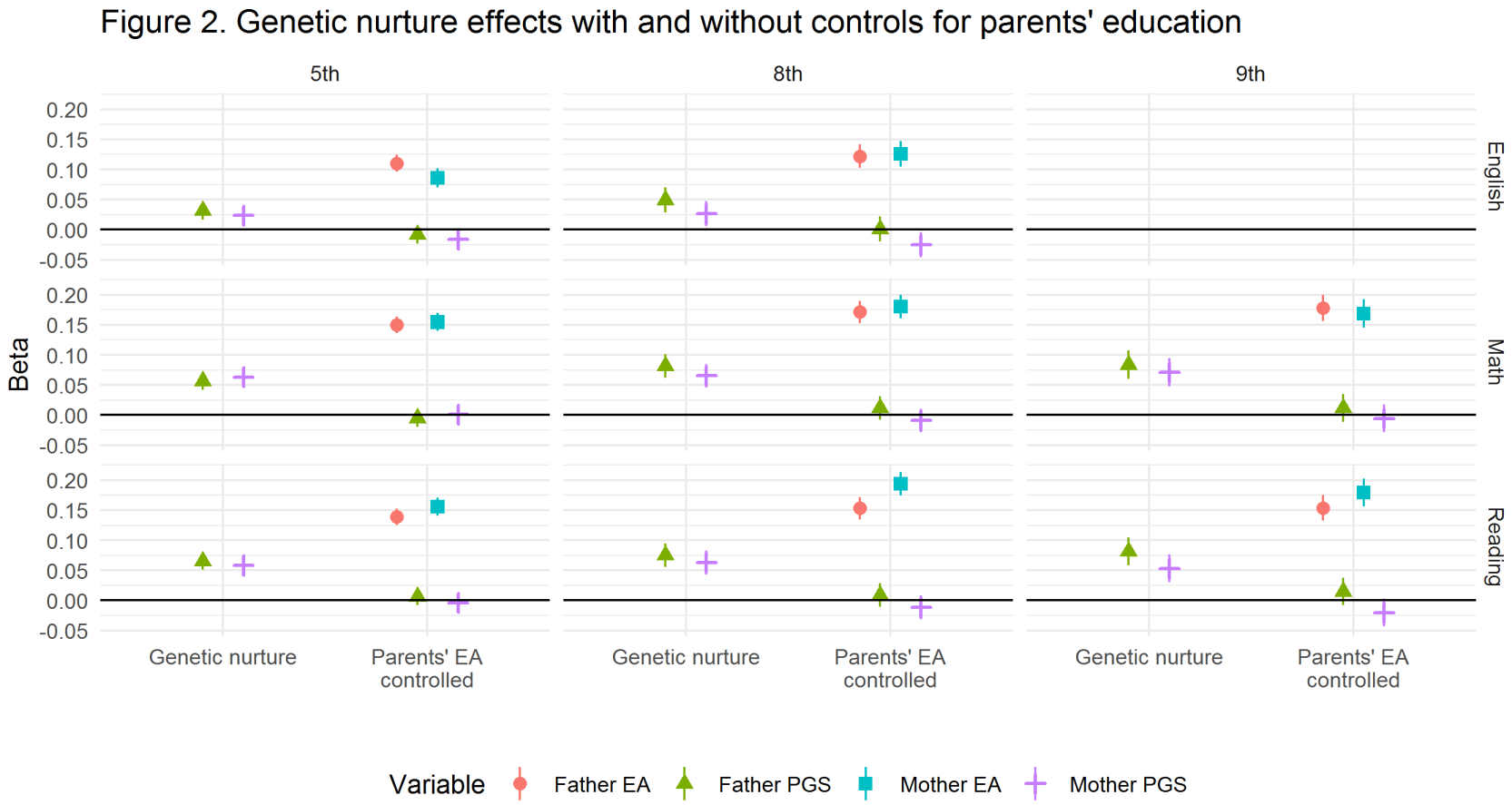


Figure 2. Genetic nurture effects with and without controls for parents' education
5th
8th
9th
English
Math
Reading
Beta
0.20
0.15
0.10
0.05
0.00
-0.05
Genetic nurture
Parents' EA controlled
Variable
Father EA
Father PGS
Mother EA
Mother PGS

Figure 3

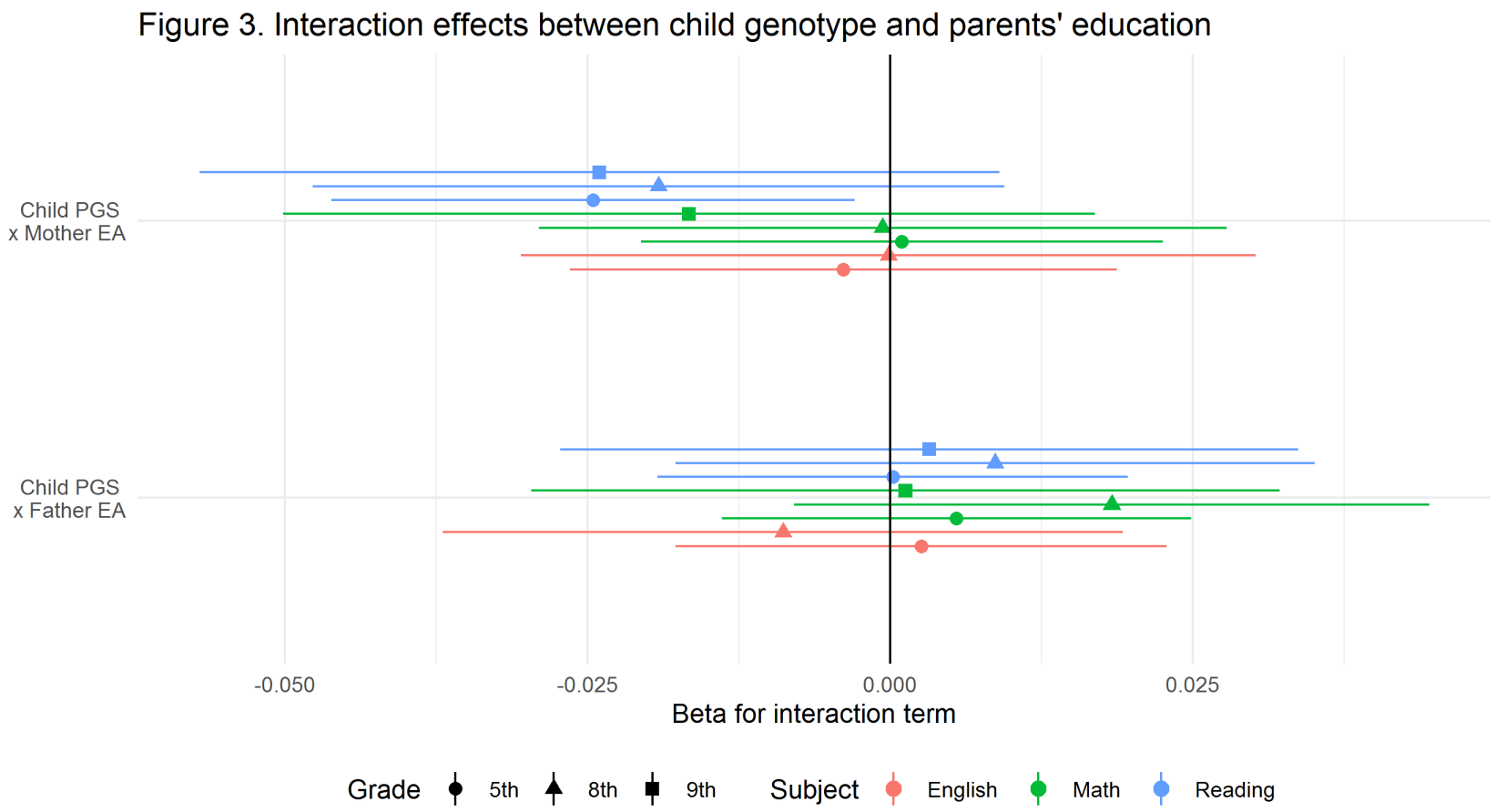


Figure 3. Interaction effects between child genotype and parents' education
Child PGS
x Mother EA
Child PGS
x Father EA
-0.050
-0.025
0.000
0.025
Beta for interaction term
Grade
5th
8th
9th
Subject
English
Math
Reading

Figure 4

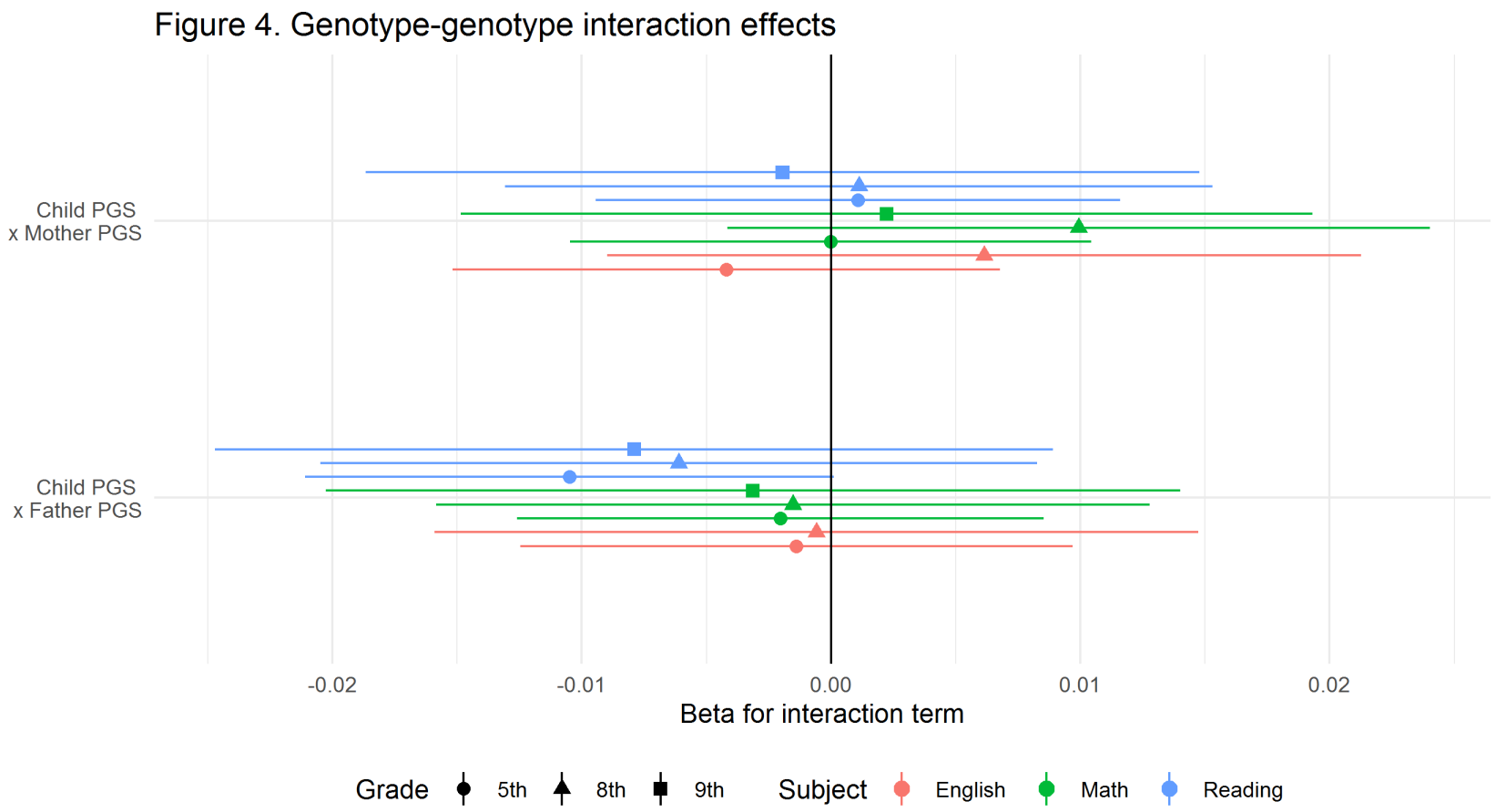
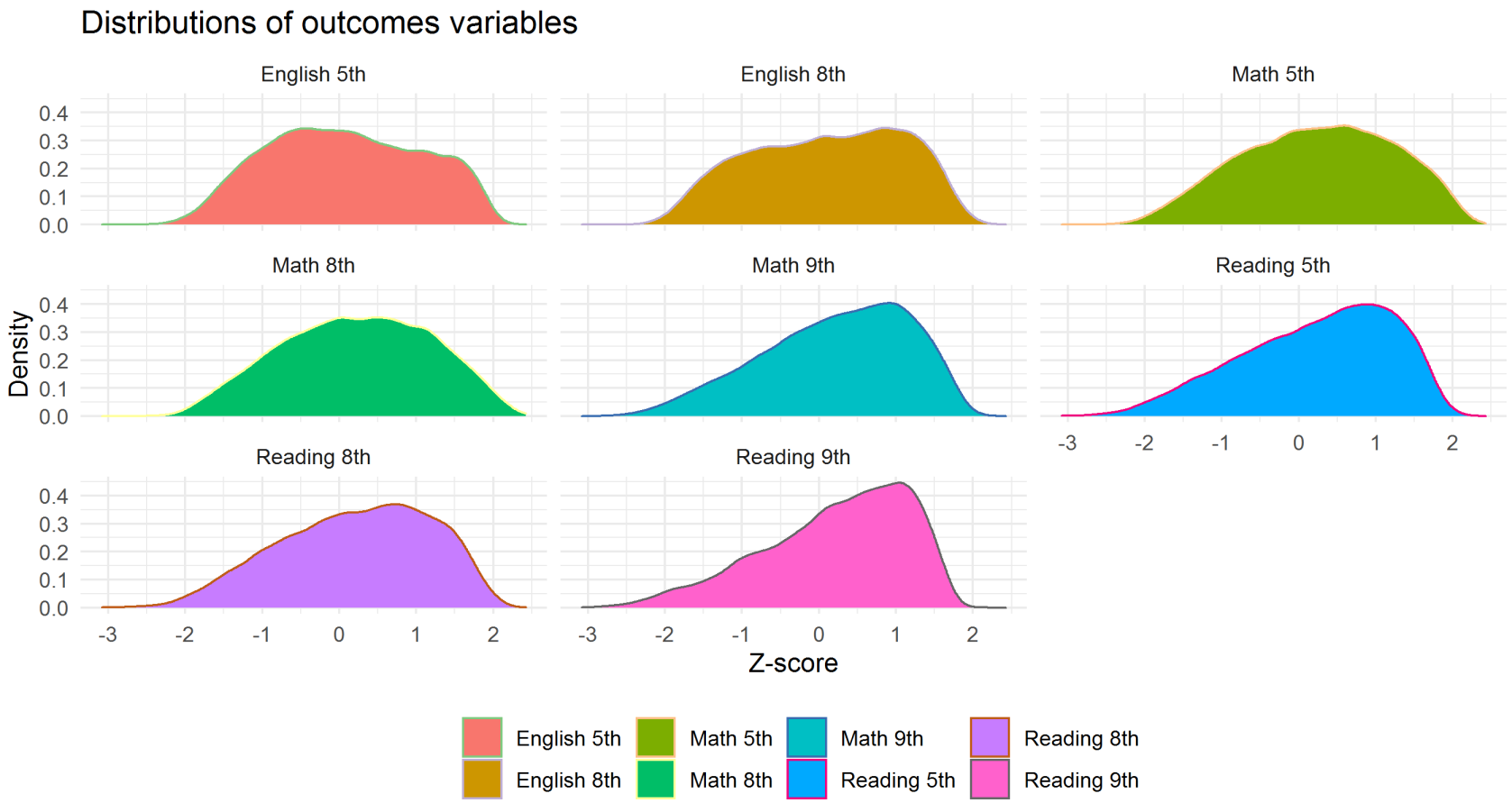


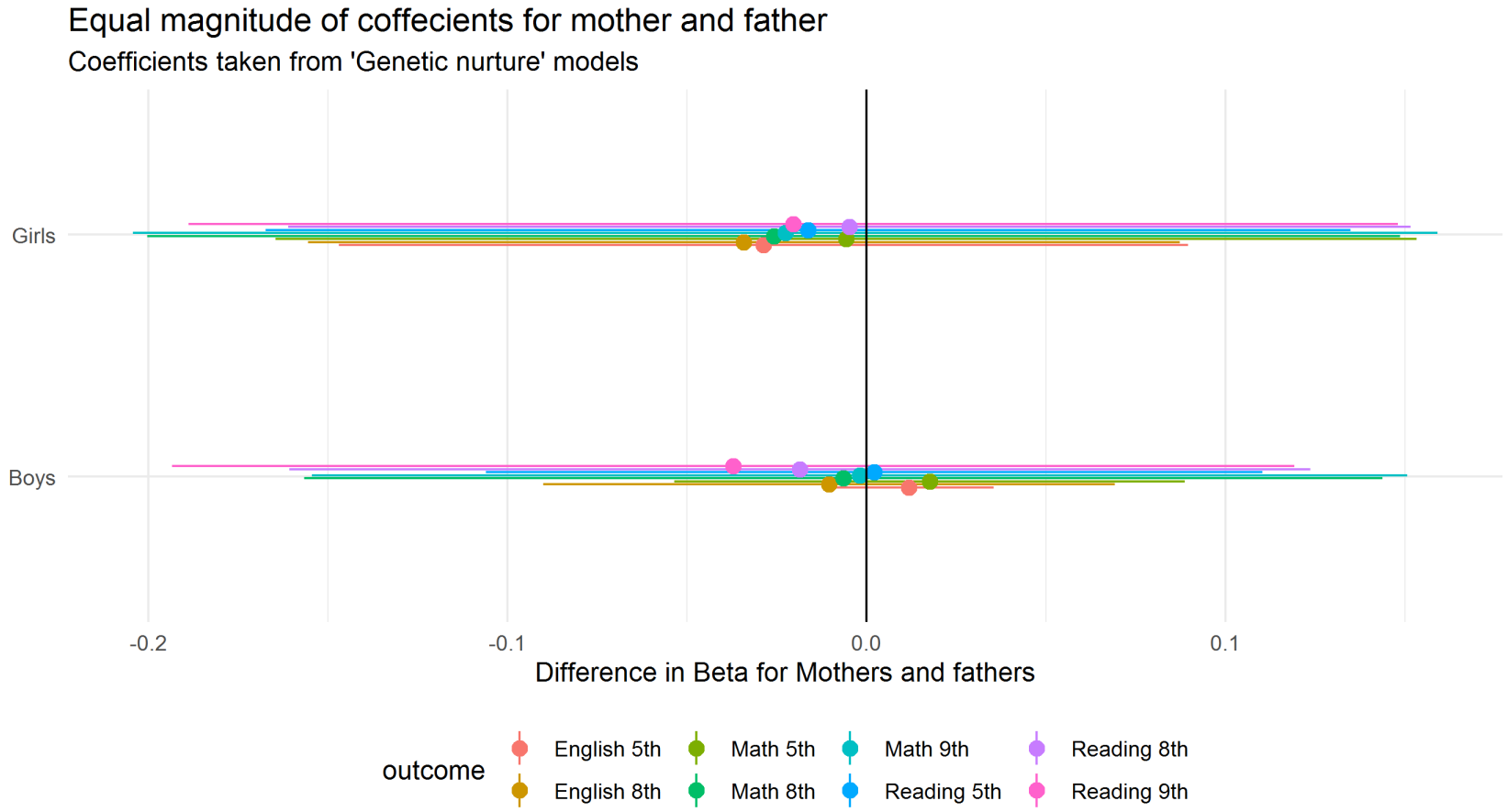
Figure 4. Genotype-genotype interaction effects
Child PGS
x Mother PGS
Child PGS
x Father PGS
-0.02
-0.01
0.00
0.01
0.02
Beta for interaction term
Grade
5th
8th
9th
Subject
English
Math
Reading

Densities of outcome variables



Equal magnitude of parents' coefficients

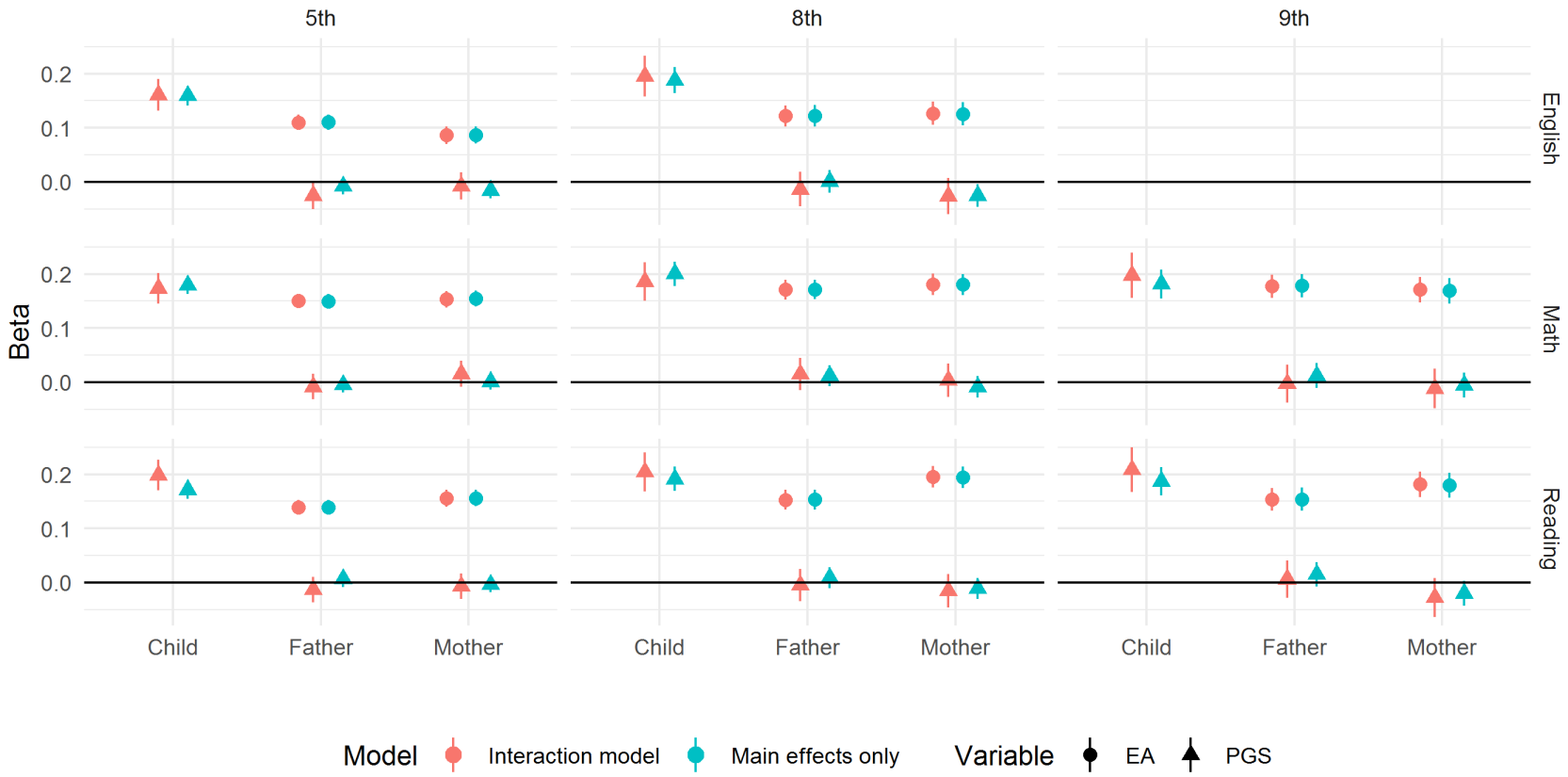
We also investigated the differences in the coefficients for "genetic nurture" effects for mothers and fathers. The plot show the difference with its associated confidence intervals.



Main coefficients with and without interactions

The interaction terms were largely non-significant. In the figure below, we document that also the main coefficients were untouched by inclusion of interaction terms.

Figure S2. Comparison of main coefficient estimates with and without interactions



Model statistics

Here, we report model statistics for each model. In the table below, each estimated model is represented with one row.

Outcome	Model	Sex	Adj. R^2	log L	AIC
English 5th	Child PGS	Both	0.0448259	-33814.194	67680.39
English 5th	Genetic nurture	Both	0.0455846	-33803.445	67662.89
English 5th	Parents' EA controlled	Both	0.0679017	-33230.438	66520.88
English 5th	Parents' education	Both	0.0474155	-33496.500	67047.00
English 5th	EA-PGS interaction	Both	0.0678697	-33227.851	66527.70
English 5th	PGS-PGS interaction	Both	0.0678567	-33230.023	66524.05
English 5th	Child PGS controlled	Both	0.0678175	-33232.538	66521.08
English 5th	Child PGS	Boys	0.0470292	-17565.776	35179.55
English 5th	Genetic nurture	Boys	0.0470384	-17564.713	35181.43
English 5th	Parents' EA controlled	Boys	0.0670733	-17285.617	34627.23
English 5th	Parents' education	Boys	0.0444880	-17434.698	34919.40
English 5th	EA-PGS interaction	Boys	0.0671360	-17282.195	34632.39
English 5th	PGS-PGS interaction	Boys	0.0673826	-17282.568	34625.14
English 5th	Child PGS controlled	Boys	0.0664022	-17291.055	34634.11
English 5th	Child PGS	Girls	0.0447047	-16167.460	32384.92
English 5th	Genetic nurture	Girls	0.0472833	-16150.103	32354.21
English 5th	Parents' EA controlled	Girls	0.0732037	-15847.428	31752.86
English 5th	Parents' education	Girls	0.0540384	-15971.730	31995.46
English 5th	EA-PGS interaction	Girls	0.0728554	-15846.674	31763.35
English 5th	PGS-PGS interaction	Girls	0.0732180	-15846.333	31754.67
English 5th	Child PGS controlled	Girls	0.0728219	-15850.901	31755.80
English 8th	Child PGS	Both	0.0591695	-17366.149	34778.30
English 8th	Genetic nurture	Both	0.0607831	-17354.255	34758.51
English 8th	Parents' EA controlled	Both	0.0944464	-16989.633	34033.27
English 8th	Parents' education	Both	0.0647876	-17194.103	34436.21
English 8th	EA-PGS interaction	Both	0.0942151	-16988.235	34042.47
English 8th	PGS-PGS interaction	Both	0.0943511	-16989.294	34036.59
English 8th	Child PGS controlled	Both	0.0941459	-16992.725	34035.45
English 8th	Child PGS	Boys	0.0682544	-8878.665	17801.33
English 8th	Genetic nurture	Boys	0.0690750	-8874.822	17797.64
English 8th	Parents' EA controlled	Boys	0.1023077	-8692.993	17437.99
English 8th	Parents' education	Boys	0.0661644	-8820.852	17687.70
English 8th	EA-PGS interaction	Boys	0.1018404	-8691.646	17447.29
English 8th	PGS-PGS interaction	Boys	0.1021717	-8692.474	17440.95

Outcome	Model	Sex	Adj. R^2	log L	AIC
English 8th	Child PGS controlled	Boys	0.1022513	-8694.198	17436.40
English 8th	Child PGS	Girls	0.0518387	-8464.855	16973.71
English 8th	Genetic nurture	Girls	0.0541548	-8456.216	16960.43
English 8th	Parents' EA controlled	Girls	0.0882958	-8272.150	16596.30
English 8th	Parents' education	Girls	0.0644462	-8353.630	16753.26
English 8th	EA-PGS interaction	Girls	0.0876605	-8271.294	16606.59
English 8th	PGS-PGS interaction	Girls	0.0885914	-8270.142	16596.28
English 8th	Child PGS controlled	Girls	0.0876604	-8275.312	16598.62
Math 5th	Child PGS	Both	0.0768550	-33501.222	67054.44
Math 5th	Genetic nurture	Both	0.0806092	-33449.833	66955.67
Math 5th	Parents' EA controlled	Both	0.1318699	-32472.388	65004.78
Math 5th	Parents' education	Both	0.1019034	-32890.132	65834.26
Math 5th	EA-PGS interaction	Both	0.1317728	-32470.756	65013.51
Math 5th	PGS-PGS interaction	Both	0.1318047	-32472.308	65008.62
Math 5th	Child PGS controlled	Both	0.1319208	-32472.669	65001.34
Math 5th	Child PGS	Boys	0.0723787	-17392.529	34833.06
Math 5th	Genetic nurture	Boys	0.0742570	-17378.770	34809.54
Math 5th	Parents' EA controlled	Boys	0.1287915	-16857.258	33770.52
Math 5th	Parents' education	Boys	0.0972672	-17080.759	34211.52
Math 5th	EA-PGS interaction	Boys	0.1285321	-16856.110	33780.22
Math 5th	PGS-PGS interaction	Boys	0.1287361	-16856.653	33773.31
Math 5th	Child PGS controlled	Boys	0.1282445	-16862.180	33776.36
Math 5th	Child PGS	Girls	0.0707809	-16073.173	32196.35
Math 5th	Genetic nurture	Girls	0.0774717	-16028.295	32110.59
Math 5th	Parents' EA controlled	Girls	0.1265407	-15566.330	31190.66
Math 5th	Parents' education	Girls	0.0967862	-15769.490	31590.98
Math 5th	EA-PGS interaction	Girls	0.1265810	-15563.045	31196.09
Math 5th	PGS-PGS interaction	Girls	0.1264281	-15566.104	31194.21
Math 5th	Child PGS controlled	Girls	0.1262450	-15569.370	31192.74
Math 8th	Child PGS	Both	0.0980092	-16948.501	33943.00
Math 8th	Genetic nurture	Both	0.1039261	-16905.473	33860.95
Math 8th	Parents' EA controlled	Both	0.1739889	-16253.393	32560.79
Math 8th	Parents' education	Both	0.1335188	-16558.056	33164.11
Math 8th	EA-PGS interaction	Both	0.1738097	-16251.761	32569.52
Math 8th	PGS-PGS interaction	Both	0.1739881	-16252.397	32562.79
Math 8th	Child PGS controlled	Both	0.1739207	-16254.918	32559.84
Math 8th	Child PGS	Boys	0.0948211	-8715.930	17475.86

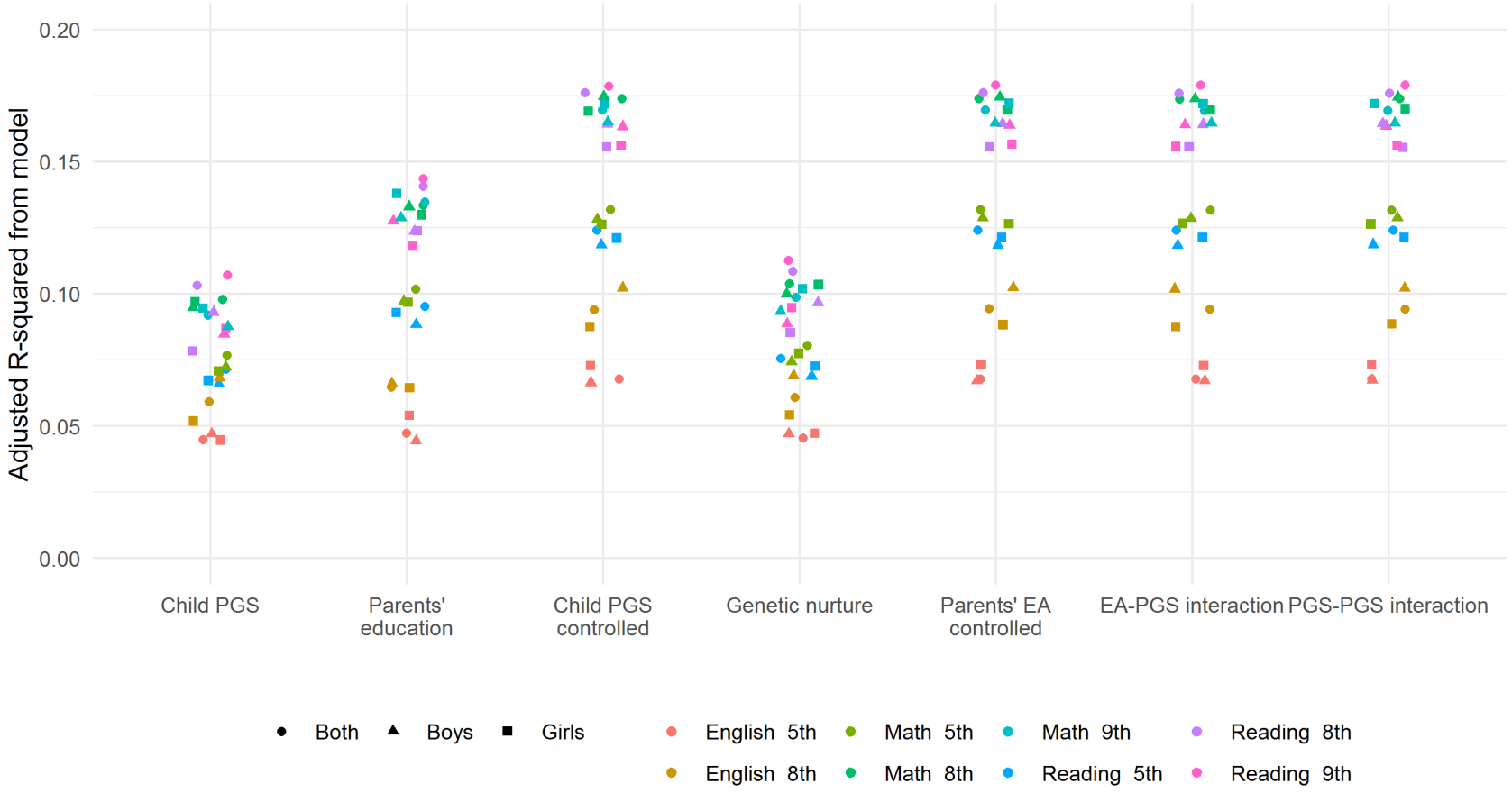
Outcome	Model	Sex	Adj. R^2	log L	AIC
Math 8th	Genetic nurture	Boys	0.1000368	-8696.134	17440.27
Math 8th	Parents' EA controlled	Boys	0.1744525	-8354.505	16761.01
Math 8th	Parents' education	Boys	0.1329913	-8514.263	17074.53
Math 8th	EA-PGS interaction	Boys	0.1738283	-8353.933	16771.87
Math 8th	PGS-PGS interaction	Boys	0.1745056	-8353.293	16762.59
Math 8th	Child PGS controlled	Boys	0.1746971	-8354.552	16757.10
Math 8th	Child PGS	Girls	0.0969589	-8216.376	16476.75
Math 8th	Genetic nurture	Girls	0.1034906	-8192.626	16433.25
Math 8th	Parents' EA controlled	Girls	0.1694817	-7881.636	15815.27
Math 8th	Parents' education	Girls	0.1299124	-8027.824	16101.65
Math 8th	EA-PGS interaction	Girls	0.1695582	-7878.336	15820.67
Math 8th	PGS-PGS interaction	Girls	0.1700593	-7878.469	15812.94
Math 8th	Child PGS controlled	Girls	0.1690668	-7884.192	15816.38
Math 9th	Child PGS	Both	0.0920617	-11371.496	22786.99
Math 9th	Genetic nurture	Both	0.0988639	-11337.807	22723.61
Math 9th	Parents' EA controlled	Both	0.1696304	-10906.082	21864.16
Math 9th	Parents' education	Both	0.1347436	-11085.335	22216.67
Math 9th	EA-PGS interaction	Both	0.1694914	-10903.796	21871.59
Math 9th	PGS-PGS interaction	Both	0.1694519	-10906.008	21868.02
Math 9th	Child PGS controlled	Both	0.1696642	-10906.910	21861.82
Math 9th	Child PGS	Boys	0.0875943	-5788.934	11619.87
Math 9th	Genetic nurture	Boys	0.0934519	-5773.772	11593.54
Math 9th	Parents' EA controlled	Boys	0.1646420	-5559.386	11168.77
Math 9th	Parents' education	Boys	0.1288162	-5652.668	11349.34
Math 9th	EA-PGS interaction	Boys	0.1646150	-5556.438	11174.88
Math 9th	PGS-PGS interaction	Boys	0.1646702	-5558.306	11170.61
Math 9th	Child PGS controlled	Boys	0.1650250	-5559.389	11164.78
Math 9th	Child PGS	Girls	0.0945750	-5568.443	11178.89
Math 9th	Genetic nurture	Girls	0.1019983	-5549.750	11145.50
Math 9th	Parents' EA controlled	Girls	0.1720788	-5332.991	10715.98
Math 9th	Parents' education	Girls	0.1380048	-5420.547	10885.09
Math 9th	EA-PGS interaction	Girls	0.1719392	-5330.332	10722.66
Math 9th	PGS-PGS interaction	Girls	0.1720307	-5332.109	10718.22
Math 9th	Child PGS controlled	Girls	0.1718525	-5334.580	10715.16
Reading 5th	Child PGS	Both	0.0716104	-33006.757	66065.51
Reading 5th	Genetic nurture	Both	0.0756759	-32952.130	65960.26
Reading 5th	Parents' EA controlled	Both	0.1241370	-32006.062	64072.12

Outcome	Model	Sex	Adj. R^2	log L	AIC
Reading 5th	Parents' education	Both	0.0952067	-32401.491	64856.98
Reading 5th	EA-PGS interaction	Both	0.1242533	-32001.450	64074.90
Reading 5th	PGS-PGS interaction	Both	0.1242075	-32004.086	64072.17
Reading 5th	Child PGS controlled	Both	0.1241590	-32006.759	64069.52
Reading 5th	Child PGS	Boys	0.0659728	-17169.052	34386.10
Reading 5th	Genetic nurture	Boys	0.0688829	-17148.707	34349.41
Reading 5th	Parents' EA controlled	Boys	0.1184405	-16656.632	33369.26
Reading 5th	Parents' education	Boys	0.0884949	-16863.658	33777.32
Reading 5th	EA-PGS interaction	Boys	0.1184207	-16653.763	33375.53
Reading 5th	PGS-PGS interaction	Boys	0.1186775	-16653.976	33367.95
Reading 5th	Child PGS controlled	Boys	0.1185364	-16656.965	33365.93
Reading 5th	Child PGS	Girls	0.0672166	-15790.035	31630.07
Reading 5th	Genetic nurture	Girls	0.0726457	-15753.892	31561.78
Reading 5th	Parents' EA controlled	Girls	0.1213255	-15297.763	30653.53
Reading 5th	Parents' education	Girls	0.0929628	-15488.911	31029.82
Reading 5th	EA-PGS interaction	Girls	0.1213229	-15294.772	30659.54
Reading 5th	PGS-PGS interaction	Girls	0.1213707	-15296.453	30654.91
Reading 5th	Child PGS controlled	Girls	0.1210936	-15300.340	30654.68
Reading 8th	Child PGS	Both	0.1033609	-16942.944	33931.89
Reading 8th	Genetic nurture	Both	0.1085171	-16905.191	33860.38
Reading 8th	Parents' EA controlled	Both	0.1761413	-16275.329	32604.66
Reading 8th	Parents' education	Both	0.1407292	-16543.020	33134.04
Reading 8th	EA-PGS interaction	Both	0.1760476	-16273.042	32612.08
Reading 8th	PGS-PGS interaction	Both	0.1760571	-16274.973	32607.95
Reading 8th	Child PGS controlled	Both	0.1760836	-16276.774	32603.55
Reading 8th	Child PGS	Boys	0.0930413	-8908.763	17861.53
Reading 8th	Genetic nurture	Boys	0.0966945	-8894.669	17837.34
Reading 8th	Parents' EA controlled	Boys	0.1643598	-8578.126	17208.25
Reading 8th	Parents' education	Boys	0.1237421	-8732.484	17510.97
Reading 8th	EA-PGS interaction	Boys	0.1641142	-8576.060	17216.12
Reading 8th	PGS-PGS interaction	Boys	0.1643775	-8577.054	17210.11
Reading 8th	Child PGS controlled	Boys	0.1643142	-8579.306	17206.61
Reading 8th	Child PGS	Girls	0.0783563	-7990.131	16024.26
Reading 8th	Genetic nurture	Girls	0.0853683	-7965.230	15978.46
Reading 8th	Parents' EA controlled	Girls	0.1555676	-7650.096	15352.19
Reading 8th	Parents' education	Girls	0.1238587	-7766.042	15578.08
Reading 8th	EA-PGS interaction	Girls	0.1555474	-7647.157	15358.31

Outcome	Model	Sex	Adj. R^2	log L	AIC
Reading 8th	PGS-PGS interaction	Girls	0.1553807	-7649.779	15355.56
Reading 8th	Child PGS controlled	Girls	0.1555374	-7651.211	15350.42
Reading 9th	Child PGS	Both	0.1070685	-11280.654	22605.31
Reading 9th	Genetic nurture	Both	0.1126015	-11252.532	22553.06
Reading 9th	Parents' EA controlled	Both	0.1791176	-10841.857	21735.71
Reading 9th	Parents' education	Both	0.1435572	-11027.198	22100.40
Reading 9th	EA-PGS interaction	Both	0.1790315	-10839.302	21742.60
Reading 9th	PGS-PGS interaction	Both	0.1790391	-10841.269	21738.54
Reading 9th	Child PGS controlled	Both	0.1787010	-10845.059	21738.12
Reading 9th	Child PGS	Boys	0.0847478	-5971.685	11985.37
Reading 9th	Genetic nurture	Boys	0.0886434	-5961.275	11968.55
Reading 9th	Parents' EA controlled	Boys	0.1637678	-5738.391	11526.78
Reading 9th	Parents' education	Boys	0.1274921	-5832.983	11709.97
Reading 9th	EA-PGS interaction	Boys	0.1639655	-5734.854	11531.71
Reading 9th	PGS-PGS interaction	Boys	0.1634926	-5738.106	11530.21
Reading 9th	Child PGS controlled	Boys	0.1632909	-5740.646	11527.29
Reading 9th	Child PGS	Girls	0.0872315	-5254.547	10551.09
Reading 9th	Genetic nurture	Girls	0.0947560	-5235.679	10517.36
Reading 9th	Parents' EA controlled	Girls	0.1565871	-5043.708	10137.42
Reading 9th	Parents' education	Girls	0.1183079	-5140.336	10324.67
Reading 9th	EA-PGS interaction	Girls	0.1556893	-5042.969	10147.94
Reading 9th	PGS-PGS interaction	Girls	0.1562518	-5043.554	10141.11
Reading 9th	Child PGS controlled	Girls	0.1560599	-5046.053	10138.11

How well do we predict test scores?

The figure below shows the variation in R^2 across models and outcomes.



Full regression tables

On the following pages, complete results from all models are listed in tabular form.

Models of Math Test in 5th Grade for Both.

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
Constant	0.226 ***	-0.110 ***	-0.049	0.229 ***	-0.049	-0.046	-0.048
	(0.031)	(0.031)	(0.031)	(0.030)	(0.031)	(0.031)	(0.031)
Child PGS	0.241 ***		0.177 ***	0.175 ***	0.179 ***	0.173 ***	0.179 ***
	(0.006)		(0.006)	(0.009)	(0.009)	(0.014)	(0.009)
Mother PGS				0.063 ***	0.001	0.015	0.001
				(0.007)	(0.007)	(0.012)	(0.007)
Father PGS				0.057 ***	-0.005	-0.008	-0.005
				(0.007)	(0.007)	(0.012)	(0.007)
Father EA		0.179 ***	0.149 ***		0.150 ***	0.150 ***	0.150 ***
		(0.007)	(0.007)		(0.007)	(0.007)	(0.007)
Mother EA		0.185 ***	0.155 ***		0.154 ***	0.153 ***	0.154 ***
		(0.008)	(0.008)		(0.008)	(0.008)	(0.008)
Child PGS x Father EA						0.005	
						(0.010)	
Child PGS x Mother EA						0.001	
						(0.011)	
Mother PGS x Father EA						-0.004	
						(0.008)	
Father PGS x Father EA						-0.001	
						(0.008)	
Mother PGS x Mother EA						-0.010	
						(0.009)	
Father PGS x Mother EA						0.004	
						(0.009)	

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
Child PGS x Mother PGS							-0.000
							(0.005)
Child PGS x Father PGS							-0.002
							(0.005)
N	24730	24531	24531	24730	24531	24531	24531
R2	0.078	0.103	0.133	0.082	0.133	0.133	0.133
logLik	-33501.2 22	-32890.1 32	-32472.6 69	-33449.8 33	-32472.3 88	-32470.7 56	-32472.3 08
AIC	67054.44 5	65834.26 4	65001.33 8	66955.66 7	65004.77 6	65013.51 1	65008.61 7
		**	* p < 0.0	01; ** p	< 0.01; *	p < 0.05	.

Models of Math Test in 8th Grade for Both.

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
Constant	0.282 ***	-0.115 **	-0.039	0.289 ***	-0.039	-0.036	-0.043
	(0.037)	(0.037)	(0.037)	(0.037)	(0.037)	(0.037)	(0.037)
Child PGS	0.273 ***		0.202 ***	0.194 ***	0.200 ***	0.186 ***	0.201 ***
	(0.008)		(0.008)	(0.012)	(0.011)	(0.018)	(0.011)
Mother PGS				0.065 ***	-0.009	0.003	-0.009
				(0.010)	(0.010)	(0.016)	(0.010)
Father PGS				0.082 ***	0.012	0.015	0.012
				(0.010)	(0.010)	(0.015)	(0.010)
Father EA		0.205 ***	0.173 ***		0.171 ***	0.171 ***	0.171 ***
		(0.009)	(0.009)		(0.009)	(0.009)	(0.009)
Mother EA		0.212 ***	0.179 ***		0.180 ***	0.180 ***	0.180 ***
		(0.010)	(0.010)		(0.010)	(0.010)	(0.010)
Child PGS x Father EA						0.018	
						(0.013)	
Child PGS x Mother EA						-0.001	
						(0.014)	
Mother PGS x Father EA						-0.008	
						(0.011)	
Father PGS x Father EA						-0.014	
						(0.011)	
Mother PGS x Mother EA						-0.005	
						(0.012)	
Father PGS x Mother EA						0.008	
						(0.012)	
Child PGS x Mother PGS							0.010
							(0.007)
Child PGS x Father PGS							-0.002

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
							(0.007)
N	12771	12676	12676	12771	12676	12676	12676
R2	0.099	0.135	0.175	0.106	0.176	0.176	0.176
logLik	-16948.5 01	-16558.0 56	-16254.9 18	-16905.4 73	-16253.3 93	-16251.7 61	-16252.3 97
AIC	33943.00 2	33164.11 1	32559.83 5	33860.94 6	32560.78 6	32569.52 2	32562.79 3
		**	* p < 0.0	01; ** p	< 0.01; *	p < 0.05	.

Models of Math Test in 9th Grade for Both.

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
Constant	0.238 ***	-0.143 ***	-0.075 *	0.247 ***	-0.074	-0.074	-0.074
	(0.038)	(0.039)	(0.038)	(0.038)	(0.038)	(0.039)	(0.039)
Child PGS	0.256 ***		0.185 ***	0.173 ***	0.182 ***	0.198 ***	0.182 ***
	(0.010)		(0.010)	(0.014)	(0.014)	(0.021)	(0.014)
Mother PGS				0.071 ***	-0.006	-0.012	-0.006
				(0.012)	(0.012)	(0.019)	(0.012)
Father PGS				0.084 ***	0.012	-0.003	0.012
				(0.012)	(0.012)	(0.018)	(0.012)
Father EA		0.207 ***	0.180 ***		0.178 ***	0.177 ***	0.178 ***
		(0.011)	(0.011)		(0.011)	(0.011)	(0.011)
Mother EA		0.200 ***	0.168 ***		0.169 ***	0.171 ***	0.169 ***
		(0.012)	(0.012)		(0.012)	(0.012)	(0.012)
Child PGS x Father EA						0.001	
						(0.016)	
Child PGS x Mother EA						-0.017	
						(0.017)	
Mother PGS x Father EA						-0.001	
						(0.014)	
Father PGS x Father EA						-0.016	
						(0.013)	
Mother PGS x Mother EA						0.007	
						(0.014)	
Father PGS x Mother EA						0.028	
						(0.014)	
Child PGS x Mother PGS							0.002
							(0.009)
Child PGS x Father PGS							-0.003

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
							(0.009)
N	8693	8638	8638	8693	8638	8638	8638
R2	0.094	0.137	0.172	0.101	0.172	0.172	0.172
logLik	-11371.4 96	-11085.3 35	-10906.9 10	-11337.8 07	-10906.0 82	-10903.7 96	-10906.0 08
AIC	22786.99 2	22216.67 0	21861.81 9	22723.61 4	21864.16 5	21871.59 2	21868.01 6
		**	* p < 0.0	01; ** p	< 0.01; *	p < 0.05	.

Models of Reading Test in 5th Grade for Both.

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
Constant	0.059	-0.271 ***	-0.212 ***	0.061 *	-0.212 ***	-0.210 ***	-0.207 ***
	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)
Child PGS	0.234 ***		0.173 ***	0.167 ***	0.171 ***	0.198 ***	0.171 ***
	(0.006)		(0.006)	(0.009)	(0.009)	(0.014)	(0.009)
Mother PGS				0.059 ***	-0.004	-0.007	-0.004
				(0.007)	(0.007)	(0.012)	(0.007)
Father PGS				0.065 ***	0.006	-0.013	0.007
				(0.007)	(0.007)	(0.012)	(0.007)
Father EA		0.169 ***	0.140 ***		0.139 ***	0.139 ***	0.139 ***
		(0.007)	(0.007)		(0.007)	(0.007)	(0.007)
Mother EA		0.184 ***	0.155 ***		0.156 ***	0.156 ***	0.156 ***
		(0.008)	(0.008)		(0.008)	(0.008)	(0.008)
Child PGS x Father EA						0.000	
						(0.010)	
Child PGS x Mother EA						-0.025 *	
						(0.011)	
Mother PGS x Father EA						-0.001	
						(0.008)	
Father PGS x Father EA						-0.004	
						(0.008)	
Mother PGS x Mother EA						0.004	
						(0.009)	
Father PGS x Mother EA						0.021 *	
						(0.009)	
Child PGS x Mother PGS							0.001
							(0.005)
Child PGS x Father PGS							-0.010

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
							(0.005)
N	24438	24244	24244	24438	24244	24244	24244
R2	0.073	0.096	0.125	0.077	0.125	0.125	0.125
logLik	-33006.7 57	-32401.4 91	-32006.7 59	-32952.1 30	-32006.0 62	-32001.4 50	-32004.0 86
AIC	66065.51 4	64856.98 1	64069.51 9	65960.26 0	64072.12 5	64074.89 9	64072.17 2
		**	* p < 0.0	01; ** p	< 0.01; *	p < 0.05	.

Models of Reading Test in 8th Grade for Both.

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
Constant	0.046	-0.336 ***	-0.267 ***	0.053	-0.268 ***	-0.268 ***	-0.266 ***
	(0.037)	(0.038)	(0.037)	(0.037)	(0.037)	(0.037)	(0.037)
Child PGS	0.259 ***		0.190 ***	0.185 ***	0.191 ***	0.204 ***	0.191 ***
	(0.008)		(0.008)	(0.012)	(0.011)	(0.018)	(0.012)
Mother PGS				0.063 ***	-0.011	-0.015	-0.011
				(0.010)	(0.010)	(0.016)	(0.010)
Father PGS				0.075 ***	0.009	-0.005	0.009
				(0.010)	(0.010)	(0.015)	(0.010)
Father EA		0.184 ***	0.155 ***		0.153 ***	0.153 ***	0.153 ***
		(0.009)	(0.009)		(0.009)	(0.009)	(0.009)
Mother EA		0.224 ***	0.192 ***		0.194 ***	0.195 ***	0.194 ***
		(0.010)	(0.010)		(0.010)	(0.010)	(0.010)
Child PGS x Father EA						0.009	
						(0.013)	
Child PGS x Mother EA						-0.019	
						(0.015)	
Mother PGS x Father EA						-0.005	
						(0.012)	
Father PGS x Father EA						-0.015	
						(0.011)	
Mother PGS x Mother EA						0.007	
						(0.012)	
Father PGS x Mother EA						0.025 *	
						(0.012)	
Child PGS x Mother PGS							0.001
							(0.007)
Child PGS x Father PGS							-0.006

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
							(0.007)
N	12745	12650	12650	12745	12650	12650	12650
R2	0.105	0.142	0.178	0.110	0.178	0.178	0.178
logLik	-16942.9 44	-16543.0 20	-16276.7 74	-16905.1 91	-16275.3 29	-16273.0 42	-16274.9 73
AIC	33931.88 7	33134.04 0	32603.54 8	33860.38 1	32604.65 8	32612.08 3	32607.94 6
		**	* p < 0.0	01; ** p	< 0.01; *	p < 0.05	.

Models of Reading Test in 9th Grade for Both.

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
Constant	0.065	-0.299 ***	-0.231 ***	0.073 *	-0.233 ***	-0.233 ***	-0.228 ***
	(0.037)	(0.038)	(0.037)	(0.037)	(0.038)	(0.038)	(0.038)
Child PGS	0.251 ***		0.184 ***	0.179 ***	0.187 ***	0.209 ***	0.186 ***
	(0.010)		(0.010)	(0.014)	(0.013)	(0.021)	(0.013)
Mother PGS				0.053 ***	-0.020	-0.028	-0.020
				(0.012)	(0.012)	(0.018)	(0.012)
Father PGS				0.082 ***	0.015	0.006	0.015
				(0.012)	(0.012)	(0.018)	(0.012)
Father EA		0.183 ***	0.156 ***		0.154 ***	0.153 ***	0.154 ***
		(0.011)	(0.011)		(0.011)	(0.011)	(0.011)
Mother EA		0.209 ***	0.176 ***		0.180 ***	0.181 ***	0.180 ***
		(0.012)	(0.012)		(0.012)	(0.012)	(0.012)
Child PGS x Father EA						0.003	
						(0.016)	
Child PGS x Mother EA						-0.024	
						(0.017)	
Mother PGS x Father EA						-0.016	
						(0.013)	
Father PGS x Father EA						-0.012	
						(0.013)	
Mother PGS x Mother EA						0.020	
						(0.014)	
Father PGS x Mother EA						0.018	
						(0.014)	
Child PGS x Mother PGS							-0.002
							(0.009)
Child PGS x Father PGS							-0.008

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
							(0.009)
N	8726	8670	8670	8726	8670	8670	8670
R2	0.109	0.146	0.181	0.115	0.181	0.182	0.182
logLik	-11280.6 54	-11027.1 98	-10845.0 59	-11252.5 32	-10841.8 57	-10839.3 02	-10841.2 69
AIC	22605.30 8	22100.39 6	21738.11 9	22553.06 4	21735.71 4	21742.60 4	21738.53 7
		**	* p < 0.0	01; ** p	< 0.01; *	p < 0.05	.

Models of English Test in 5th Grade for Both.

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
Constant	0.080 *	-0.148 ***	-0.097 **	0.080 *	-0.101 **	-0.103 **	-0.098 **
	(0.031)	(0.032)	(0.032)	(0.031)	(0.032)	(0.032)	(0.032)
Child PGS	0.187 ***		0.147 ***	0.156 ***	0.159 ***	0.161 ***	0.159 ***
	(0.006)		(0.006)	(0.009)	(0.009)	(0.015)	(0.009)
Mother PGS				0.024 **	-0.016 *	-0.008	-0.015 *
				(0.008)	(0.008)	(0.013)	(0.008)
Father PGS				0.032 ***	-0.008	-0.025 *	-0.008
				(0.008)	(0.008)	(0.013)	(0.008)
Father EA		0.133 ***	0.109 ***		0.110 ***	0.110 ***	0.110 ***
		(0.007)	(0.007)		(0.007)	(0.007)	(0.007)
Mother EA		0.109 ***	0.083 ***		0.086 ***	0.086 ***	0.086 ***
		(0.008)	(0.008)		(0.008)	(0.008)	(0.008)
Child PGS x Father EA						0.003	
						(0.010)	
Child PGS x Mother EA						-0.004	
						(0.012)	
Mother PGS x Father EA						-0.004	
						(0.009)	
Father PGS x Father EA						0.005	
						(0.009)	
Mother PGS x Mother EA						-0.004	
						(0.010)	
Father PGS x Mother EA						0.012	
						(0.010)	
Child PGS x Mother PGS							-0.004
							(0.006)
Child PGS x Father PGS							-0.001

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
							(0.006)
N	24536	24338	24338	24536	24338	24338	24338
R2	0.046	0.048	0.069	0.047	0.069	0.069	0.069
logLik	-33814.1 94	-33496.5 00	-33232.5 38	-33803.4 45	-33230.4 38	-33227.8 51	-33230.0 23
AIC	67680.38 9	67047.00 0	66521.07 5	67662.88 9	66520.87 5	66527.70 3	66524.04 7
		**	* p < 0.0	01; ** p	< 0.01; *	p < 0.05	.

Models of English Test in 8th Grade for Both.

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
Constant	0.164 ***	-0.121 **	-0.057	0.167 ***	-0.063	-0.063	-0.066
	(0.039)	(0.040)	(0.039)	(0.038)	(0.039)	(0.040)	(0.040)
Child PGS	0.224 ***		0.176 ***	0.183 ***	0.188 ***	0.195 ***	0.188 ***
	(0.009)		(0.009)	(0.012)	(0.012)	(0.019)	(0.012)
Mother PGS				0.027 *	-0.025 *	-0.026	-0.025 *
				(0.011)	(0.011)	(0.017)	(0.011)
Father PGS				0.049 ***	0.001	-0.014	0.001
				(0.011)	(0.011)	(0.016)	(0.011)
Father EA		0.150 ***	0.122 ***		0.122 ***	0.122 ***	0.122 ***
		(0.010)	(0.010)		(0.010)	(0.010)	(0.010)
Mother EA		0.150 ***	0.121 ***		0.126 ***	0.127 ***	0.126 ***
		(0.011)	(0.011)		(0.011)	(0.011)	(0.011)
Child PGS x Father EA						-0.009	
						(0.014)	
Child PGS x Mother EA						-0.000	
						(0.015)	
Mother PGS x Father EA						0.007	
						(0.012)	
Father PGS x Father EA						-0.002	
						(0.012)	
Mother PGS x Mother EA						-0.005	
						(0.013)	
Father PGS x Mother EA						0.016	
						(0.013)	
Child PGS x Mother PGS							0.006
							(0.008)
Child PGS x Father PGS							-0.001

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
							(0.008)
N	12691	12596	12596	12691	12596	12596	12596
R2	0.061	0.066	0.096	0.062	0.096	0.096	0.096
logLik	-17366.1 49	-17194.1 03	-16992.7 25	-17354.2 55	-16989.6 33	-16988.2 35	-16989.2 94
AIC	34778.29 8	34436.20 7	34035.45 0	34758.50 9	34033.26 6	34042.47 0	34036.58 8
		**	* p < 0.0	01; ** p	< 0.01; *	p < 0.05	.

Models of Math Test in 5th Grade for Boys.

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
Constant	0.238 ***	-0.100 *	-0.043	0.243 ***	-0.053	-0.053	-0.048
	(0.043)	(0.044)	(0.043)	(0.043)	(0.043)	(0.044)	(0.044)
Child PGS	0.251 ***		0.186 ***	0.203 ***	0.209 ***	0.216 ***	0.208 ***
	(0.009)		(0.009)	(0.013)	(0.012)	(0.021)	(0.012)
Mother PGS				0.052 ***	-0.011	-0.010	-0.011
				(0.011)	(0.011)	(0.017)	(0.011)
Father PGS				0.035 **	-0.034 **	-0.041 *	-0.034 **
				(0.011)	(0.011)	(0.018)	(0.011)
Father EA		0.196 ***	0.166 ***		0.173 ***	0.173 ***	0.173 ***
		(0.010)	(0.010)		(0.010)	(0.010)	(0.010)
Mother EA		0.175 ***	0.143 ***		0.145 ***	0.143 ***	0.144 ***
		(0.011)	(0.011)		(0.011)	(0.011)	(0.011)
Child PGS x Father EA						0.003	
						(0.014)	
Child PGS x Mother EA						-0.009	
						(0.016)	
Mother PGS x Father EA						-0.000	
						(0.012)	
Father PGS x Father EA						0.011	
						(0.012)	
Mother PGS x Mother EA						-0.001	
						(0.013)	
Father PGS x Mother EA						-0.002	
						(0.014)	
Child PGS x Mother PGS							-0.003
							(0.008)
Child PGS x Father PGS							-0.007

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
							(0.008)
N	12587	12491	12491	12587	12491	12491	12491
R2	0.074	0.099	0.130	0.076	0.131	0.131	0.131
logLik	-17392.5 29	-17080.7 59	-16862.1 80	-17378.7 70	-16857.2 58	-16856.1 10	-16856.6 53
AIC	34833.05 7	34211.51 8	33776.36 1	34809.54 0	33770.51 6	33780.22 0	33773.30 6
		**	* p < 0.0	01; ** p	< 0.01; *	p < 0.05	.

Models of Math Test in 8th Grade for Boys.

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
Constant	0.289 ***	-0.101	-0.037	0.303 ***	-0.037	-0.031	-0.031
	(0.051)	(0.052)	(0.051)	(0.051)	(0.051)	(0.052)	(0.052)
Child PGS	0.282 ***		0.210 ***	0.204 ***	0.212 ***	0.213 ***	0.211 ***
	(0.012)		(0.012)	(0.017)	(0.016)	(0.026)	(0.016)
Mother PGS				0.069 ***	-0.004	0.001	-0.004
				(0.014)	(0.014)	(0.023)	(0.014)
Father PGS				0.075 ***	0.001	0.009	0.000
				(0.014)	(0.014)	(0.022)	(0.014)
Father EA		0.214 ***	0.185 ***		0.185 ***	0.185 ***	0.185 ***
		(0.013)	(0.013)		(0.013)	(0.013)	(0.013)
Mother EA		0.212 ***	0.175 ***		0.176 ***	0.175 ***	0.176 ***
		(0.014)	(0.014)		(0.014)	(0.014)	(0.014)
Child PGS x Father EA						0.003	
						(0.019)	
Child PGS x Mother EA						-0.004	
						(0.021)	
Mother PGS x Father EA						-0.001	
						(0.016)	
Father PGS x Father EA						-0.012	
						(0.016)	
Mother PGS x Mother EA						-0.004	
						(0.017)	
Father PGS x Mother EA						0.001	
						(0.018)	
Child PGS x Mother PGS							0.004
							(0.010)
Child PGS x Father PGS							-0.016

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
							(0.010)
N	6504	6459	6459	6504	6459	6459	6459
R2	0.098	0.136	0.178	0.103	0.178	0.178	0.178
logLik	-8715.93 0	-8514.26 3	-8354.55 2	-8696.13 4	-8354.50 5	-8353.93 3	-8353.29 3
AIC	17475.86 0	17074.52 6	16757.10 3	17440.26 9	16761.01 0	16771.86 6	16762.58 6
		**	* p < 0.0	01; ** p	< 0.01; *	p < 0.05	.

Models of Math Test in 9th Grade for Boys.

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
Constant	0.245 ***	-0.115 *	-0.060	0.260 ***	-0.060	-0.060	-0.052
	(0.052)	(0.053)	(0.052)	(0.052)	(0.053)	(0.053)	(0.053)
Child PGS	0.260 ***		0.191 ***	0.179 ***	0.191 ***	0.231 ***	0.189 ***
	(0.014)		(0.014)	(0.020)	(0.020)	(0.031)	(0.020)
Mother PGS				0.074 ***	-0.001	-0.028	-0.000
				(0.017)	(0.017)	(0.027)	(0.017)
Father PGS				0.076 ***	0.001	-0.006	0.000
				(0.017)	(0.017)	(0.026)	(0.017)
Father EA		0.211 ***	0.189 ***		0.189 ***	0.188 ***	0.189 ***
		(0.015)	(0.015)		(0.016)	(0.016)	(0.016)
Mother EA		0.193 ***	0.157 ***		0.157 ***	0.159 ***	0.157 ***
		(0.017)	(0.016)		(0.017)	(0.017)	(0.017)
Child PGS x Father EA						-0.014	
						(0.022)	
Child PGS x Mother EA						-0.029	
						(0.025)	
Mother PGS x Father EA						-0.004	
						(0.019)	
Father PGS x Father EA						-0.014	
						(0.019)	
Mother PGS x Mother EA						0.029	
						(0.021)	
Father PGS x Mother EA						0.017	
						(0.021)	
Child PGS x Mother PGS							0.002
							(0.013)
Child PGS x Father PGS							-0.018

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
							(0.012)
N	4396	4371	4371	4396	4371	4371	4371
R2	0.092	0.133	0.169	0.098	0.169	0.170	0.169
logLik	-5788.93 4	-5652.66 8	-5559.38 9	-5773.77 2	-5559.38 6	-5556.43 8	-5558.30 6
AIC	11619.86 7	11349.33 6	11164.77 7	11593.54 5	11168.77 1	11174.87 5	11170.61 2
		**	* p < 0.0	01; ** p	< 0.01; *	p < 0.05	.

Models of Reading Test in 5th Grade for Boys.

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
Constant	0.036	-0.300 ***	-0.246 ***	0.042	-0.248 ***	-0.251 ***	-0.237 ***
	(0.044)	(0.045)	(0.044)	(0.044)	(0.044)	(0.044)	(0.044)
Child PGS	0.244 ***		0.183 ***	0.184 ***	0.190 ***	0.227 ***	0.189 ***
	(0.009)		(0.009)	(0.013)	(0.013)	(0.021)	(0.013)
Mother PGS				0.056 ***	-0.005	-0.021	-0.005
				(0.011)	(0.011)	(0.018)	(0.011)
Father PGS				0.054 ***	-0.008	-0.035	-0.008
				(0.011)	(0.011)	(0.018)	(0.011)
Father EA		0.180 ***	0.151 ***		0.153 ***	0.152 ***	0.153 ***
		(0.010)	(0.010)		(0.010)	(0.010)	(0.010)
Mother EA		0.180 ***	0.149 ***		0.150 ***	0.151 ***	0.149 ***
		(0.011)	(0.011)		(0.011)	(0.011)	(0.011)
Child PGS x Father EA						-0.008	
						(0.014)	
Child PGS x Mother EA						-0.027	
						(0.016)	
Mother PGS x Father EA						0.002	
						(0.012)	
Father PGS x Father EA						0.003	
						(0.012)	
Mother PGS x Mother EA						0.012	
						(0.014)	
Father PGS x Mother EA						0.022	
						(0.014)	
Child PGS x Mother PGS							-0.009
							(0.008)
Child PGS x Father PGS							-0.012

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
							(0.008)
N	12398	12305	12305	12398	12305	12305	12305
R2	0.068	0.090	0.120	0.071	0.120	0.121	0.121
logLik	-17169.0 52	-16863.6 58	-16656.9 65	-17148.7 07	-16656.6 32	-16653.7 63	-16653.9 76
AIC	34386.10 4	33777.31 5	33365.93 0	34349.41 3	33369.26 4	33375.52 5	33367.95 1
		**	* p < 0.0	01; ** p	< 0.01; *	p < 0.05	.

Models of Reading Test in 8th Grade for Boys.

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
Constant	0.007	-0.368 ***	-0.303 ***	0.020	-0.309 ***	-0.310 ***	-0.300 ***
	(0.053)	(0.054)	(0.053)	(0.053)	(0.054)	(0.054)	(0.054)
Child PGS	0.285 ***		0.214 ***	0.219 ***	0.227 ***	0.242 ***	0.226 ***
	(0.012)		(0.012)	(0.018)	(0.017)	(0.027)	(0.017)
Mother PGS				0.052 ***	-0.022	-0.039	-0.022
				(0.015)	(0.015)	(0.023)	(0.015)
Father PGS				0.071 ***	-0.002	-0.004	-0.002
				(0.015)	(0.015)	(0.023)	(0.015)
Father EA		0.196 ***	0.166 ***		0.167 ***	0.166 ***	0.167 ***
		(0.014)	(0.013)		(0.014)	(0.014)	(0.014)
Mother EA		0.227 ***	0.188 ***		0.191 ***	0.194 ***	0.191 ***
		(0.015)	(0.015)		(0.015)	(0.015)	(0.015)
Child PGS x Father EA						0.001	
						(0.020)	
Child PGS x Mother EA						-0.015	
						(0.022)	
Mother PGS x Father EA						-0.005	
						(0.017)	
Father PGS x Father EA						-0.022	
						(0.017)	
Mother PGS x Mother EA						0.020	
						(0.018)	
Father PGS x Mother EA						0.019	
						(0.018)	
Child PGS x Mother PGS							-0.004
							(0.011)
Child PGS x Father PGS							-0.013

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
							(0.011)
N	6487	6441	6441	6487	6441	6441	6441
R2	0.096	0.127	0.167	0.100	0.167	0.168	0.168
logLik	-8908.76 3	-8732.48 4	-8579.30 6	-8894.66 9	-8578.12 6	-8576.06 0	-8577.05 4
AIC	17861.52 6	17510.96 8	17206.61 2	17837.33 8	17208.25 3	17216.11 9	17210.10 9
		**	* p < 0.0	01; ** p	< 0.01; *	p < 0.05	.

Models of Reading Test in 9th Grade for Boys.

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
Constant	0.028	-0.346 ***	-0.286 ***	0.043	-0.294 ***	-0.299 ***	-0.288 ***
	(0.054)	(0.055)	(0.054)	(0.054)	(0.054)	(0.055)	(0.055)
Child PGS	0.268 ***		0.197 ***	0.205 ***	0.216 ***	0.260 ***	0.215 ***
	(0.014)		(0.014)	(0.021)	(0.020)	(0.032)	(0.020)
Mother PGS				0.041 *	-0.036 *	-0.067 *	-0.036 *
				(0.018)	(0.018)	(0.028)	(0.018)
Father PGS				0.078 ***	-0.001	-0.017	-0.001
				(0.018)	(0.017)	(0.027)	(0.017)
Father EA		0.214 ***	0.192 ***		0.193 ***	0.191 ***	0.193 ***
		(0.016)	(0.016)		(0.016)	(0.016)	(0.016)
Mother EA		0.207 ***	0.168 ***		0.174 ***	0.178 ***	0.174 ***
		(0.017)	(0.017)		(0.017)	(0.018)	(0.017)
Child PGS x Father EA						-0.014	
						(0.023)	
Child PGS x Mother EA						-0.032	
						(0.026)	
Mother PGS x Father EA						-0.013	
						(0.020)	
Father PGS x Father EA						-0.009	
						(0.019)	
Mother PGS x Mother EA						0.041	
						(0.022)	
Father PGS x Mother EA						0.023	
						(0.021)	
Child PGS x Mother PGS							-0.005
							(0.013)
Child PGS x Father PGS							-0.006

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
							(0.013)
N	4410	4384	4384	4410	4384	4384	4384
R2	0.089	0.131	0.167	0.093	0.168	0.169	0.168
logLik	-5971.68 5	-5832.98 3	-5740.64 6	-5961.27 5	-5738.39 1	-5734.85 4	-5738.10 6
AIC	11985.37 1	11709.96 5	11527.29 2	11968.55 1	11526.78 1	11531.70 8	11530.21 2
		**	* p < 0.0	01; ** p	< 0.01; *	p < 0.05	.

Models of English Test in 5th Grade for Boys.

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
Constant	-0.027	-0.239 ***	-0.190 ***	-0.026	-0.201 ***	-0.206 ***	-0.192 ***
	(0.045)	(0.046)	(0.046)	(0.045)	(0.046)	(0.046)	(0.046)
Child PGS	0.195 ***		0.159 ***	0.184 ***	0.187 ***	0.196 ***	0.187 ***
	(0.009)		(0.009)	(0.013)	(0.013)	(0.022)	(0.013)
Mother PGS				0.016	-0.019	-0.014	-0.018
				(0.011)	(0.011)	(0.019)	(0.011)
Father PGS				0.004	-0.036 **	-0.068 ***	-0.036 **
				(0.011)	(0.011)	(0.019)	(0.011)
Father EA		0.137 ***	0.112 ***		0.118 ***	0.119 ***	0.119 ***
		(0.010)	(0.010)		(0.011)	(0.011)	(0.011)
Mother EA		0.092 ***	0.065 ***		0.068 ***	0.068 ***	0.067 ***
		(0.011)	(0.011)		(0.012)	(0.012)	(0.012)
Child PGS x Father EA						-0.003	
						(0.015)	
Child PGS x Mother EA						-0.005	
						(0.017)	
Mother PGS x Father EA						0.002	
						(0.013)	
Father PGS x Father EA						0.017	
						(0.013)	
Mother PGS x Mother EA						-0.006	
						(0.014)	
Father PGS x Mother EA						0.015	
						(0.014)	
Child PGS x Mother PGS							-0.020 *
							(0.008)
Child PGS x Father PGS							0.002

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
							(0.008)
N	12434	12339	12339	12434	12339	12339	12339
R2	0.049	0.046	0.068	0.049	0.069	0.070	0.069
logLik	-17565.7 76	-17434.6 98	-17291.0 55	-17564.7 13	-17285.6 17	-17282.1 95	-17282.5 68
AIC	35179.55 1	34919.39 6	34634.11 1	35181.42 7	34627.23 3	34632.38 9	34625.13 7
		**	* p < 0.0	01; ** p	< 0.01; *	p < 0.05	.

Models of English Test in 8th Grade for Boys.

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
Constant	0.140 **	-0.135 *	-0.075	0.146 **	-0.083	-0.084	-0.077
	(0.054)	(0.055)	(0.054)	(0.054)	(0.055)	(0.055)	(0.055)
Child PGS	0.247 ***		0.200 ***	0.212 ***	0.218 ***	0.239 ***	0.217 ***
	(0.012)		(0.012)	(0.018)	(0.018)	(0.028)	(0.018)
Mother PGS				0.027	-0.022	-0.030	-0.022
				(0.015)	(0.015)	(0.024)	(0.015)
Father PGS				0.038 *	-0.014	-0.036	-0.014
				(0.015)	(0.015)	(0.024)	(0.015)
Father EA		0.157 ***	0.129 ***		0.132 ***	0.131 ***	0.132 ***
		(0.014)	(0.014)		(0.014)	(0.014)	(0.014)
Mother EA		0.146 ***	0.111 ***		0.114 ***	0.115 ***	0.114 ***
		(0.015)	(0.015)		(0.015)	(0.015)	(0.015)
Child PGS x Father EA						-0.023	
						(0.020)	
Child PGS x Mother EA						-0.001	
						(0.022)	
Mother PGS x Father EA						0.013	
						(0.018)	
Father PGS x Father EA						0.008	
						(0.017)	
Mother PGS x Mother EA						-0.004	
						(0.019)	
Father PGS x Mother EA						0.015	
						(0.019)	
Child PGS x Mother PGS							-0.004
							(0.011)
Child PGS x Father PGS							-0.009

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
							(0.011)
N	6447	6402	6402	6447	6402	6402	6402
R2	0.071	0.069	0.105	0.072	0.106	0.106	0.106
logLik	-8878.66 5	-8820.85 2	-8694.19 8	-8874.82 2	-8692.99 3	-8691.64 6	-8692.47 4
AIC	17801.33 1	17687.70 4	17436.39 6	17797.64 4	17437.98 7	17447.29 2	17440.94 8
		**	* p < 0.0	01; ** p	< 0.01; *	p < 0.05	.

Models of Math Test in 5th Grade for Girls.

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
Constant	0.060	-0.274 ***	-0.211 ***	0.060	-0.206 ***	-0.200 ***	-0.209 ***
	(0.040)	(0.040)	(0.040)	(0.040)	(0.040)	(0.040)	(0.040)
Child PGS	0.230 ***		0.169 ***	0.146 ***	0.150 ***	0.129 ***	0.150 ***
	(0.008)		(0.008)	(0.012)	(0.012)	(0.019)	(0.012)
Mother PGS				0.075 ***	0.013	0.040 *	0.013
				(0.010)	(0.010)	(0.017)	(0.010)
Father PGS				0.080 ***	0.025 *	0.025	0.025 *
				(0.010)	(0.010)	(0.016)	(0.010)
Father EA		0.161 ***	0.131 ***		0.127 ***	0.127 ***	0.127 ***
		(0.009)	(0.009)		(0.010)	(0.010)	(0.010)
Mother EA		0.196 ***	0.167 ***		0.165 ***	0.164 ***	0.165 ***
		(0.011)	(0.010)		(0.011)	(0.011)	(0.011)
Child PGS x Father EA						0.009	
						(0.014)	
Child PGS x Mother EA						0.011	
						(0.015)	
Mother PGS x Father EA						-0.008	
						(0.012)	
Father PGS x Father EA						-0.013	
						(0.012)	
Mother PGS x Mother EA						-0.018	
						(0.013)	
Father PGS x Mother EA						0.011	
						(0.013)	
Child PGS x Mother PGS							0.003
							(0.007)
Child PGS x Father PGS							0.003

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
							(0.007)
N	12143	12040	12040	12143	12040	12040	12040
R2	0.073	0.099	0.128	0.079	0.128	0.129	0.129
logLik	-16073.1 73	-15769.4 90	-15569.3 70	-16028.2 95	-15566.3 30	-15563.0 45	-15566.1 04
AIC	32196.34 6	31590.98 0	31192.74 0	32110.59 0	31190.66 1	31196.09 0	31194.20 8
		**	* p < 0.0	01; ** p	< 0.01; *	p < 0.05	.

Models of Math Test in 8th Grade for Girls.

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
Constant	0.160 ***	-0.221 ***	-0.154 ***	0.159 ***	-0.155 ***	-0.156 ***	-0.169 ***
	(0.045)	(0.046)	(0.045)	(0.045)	(0.046)	(0.046)	(0.046)
Child PGS	0.264 ***		0.194 ***	0.183 ***	0.189 ***	0.159 ***	0.190 ***
	(0.011)		(0.011)	(0.016)	(0.016)	(0.025)	(0.016)
Mother PGS				0.062 ***	-0.014	0.004	-0.015
				(0.014)	(0.014)	(0.022)	(0.014)
Father PGS				0.088 ***	0.023	0.020	0.022
				(0.014)	(0.014)	(0.021)	(0.014)
Father EA		0.196 ***	0.161 ***		0.157 ***	0.156 ***	0.156 ***
		(0.013)	(0.013)		(0.013)	(0.013)	(0.013)
Mother EA		0.212 ***	0.182 ***		0.185 ***	0.186 ***	0.185 ***
		(0.014)	(0.014)		(0.014)	(0.014)	(0.014)
Child PGS x Father EA						0.035	
						(0.019)	
Child PGS x Mother EA						0.001	
						(0.020)	
Mother PGS x Father EA						-0.014	
						(0.016)	
Father PGS x Father EA						-0.019	
						(0.016)	
Mother PGS x Mother EA						-0.006	
						(0.017)	
Father PGS x Mother EA						0.017	
						(0.017)	
Child PGS x Mother PGS							0.015
							(0.010)
Child PGS x Father PGS							0.013

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
							(0.010)
N	6267	6217	6217	6267	6217	6217	6217
R2	0.100	0.133	0.172	0.107	0.173	0.174	0.174
logLik	-8216.37 6	-8027.82 4	-7884.19 2	-8192.62 6	-7881.63 6	-7878.33 6	-7878.46 9
AIC	16476.75 2	16101.64 7	15816.38 5	16433.25 2	15815.27 2	15820.67 2	15812.93 8
		**	* p < 0.0	01; ** p	< 0.01; *	p < 0.05	.

Models of Math Test in 9th Grade for Girls.

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
Constant	0.144 **	-0.238 ***	-0.177 ***	0.142 **	-0.178 ***	-0.177 ***	-0.187 ***
	(0.049)	(0.051)	(0.050)	(0.049)	(0.050)	(0.051)	(0.051)
Child PGS	0.253 ***		0.179 ***	0.168 ***	0.174 ***	0.167 ***	0.174 ***
	(0.014)		(0.014)	(0.020)	(0.019)	(0.030)	(0.019)
Mother PGS				0.069 ***	-0.011	-0.000	-0.011
				(0.017)	(0.017)	(0.026)	(0.017)
Father PGS				0.091 ***	0.023	0.000	0.023
				(0.017)	(0.017)	(0.025)	(0.017)
Father EA		0.202 ***	0.170 ***		0.166 ***	0.165 ***	0.166 ***
		(0.015)	(0.015)		(0.016)	(0.016)	(0.016)
Mother EA		0.207 ***	0.178 ***		0.181 ***	0.182 ***	0.181 ***
		(0.017)	(0.017)		(0.017)	(0.017)	(0.017)
Child PGS x Father EA						0.016	
						(0.022)	
Child PGS x Mother EA						-0.006	
						(0.024)	
Mother PGS x Father EA						0.001	
						(0.019)	
Father PGS x Father EA						-0.017	
						(0.019)	
Mother PGS x Mother EA						-0.012	
						(0.020)	
Father PGS x Mother EA						0.036	
						(0.020)	
Child PGS x Mother PGS							0.003
							(0.012)
Child PGS x Father PGS							0.014

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
							(0.012)
N	4297	4267	4267	4297	4267	4267	4267
R2	0.099	0.142	0.176	0.106	0.177	0.178	0.177
logLik	-5568.44 3	-5420.54 7	-5334.58 0	-5549.75 0	-5332.99 1	-5330.33 2	-5332.10 9
AIC	11178.88 5	10885.09 4	10715.15 9	11145.50 1	10715.98 2	10722.66 3	10718.21 9
		**	* p < 0.0	01; ** p	< 0.01; *	p < 0.05	.

Models of Reading Test in 5th Grade for Girls.

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
Constant	0.214 ***	-0.110 **	-0.050	0.213 ***	-0.049	-0.045	-0.050
	(0.039)	(0.040)	(0.040)	(0.039)	(0.040)	(0.040)	(0.040)
Child PGS	0.223 ***		0.163 ***	0.149 ***	0.154 ***	0.171 ***	0.154 ***
	(0.008)		(0.008)	(0.012)	(0.012)	(0.019)	(0.012)
Mother PGS				0.060 ***	-0.004	0.004	-0.004
				(0.010)	(0.010)	(0.017)	(0.010)
Father PGS				0.076 ***	0.021 *	0.007	0.021 *
				(0.010)	(0.010)	(0.016)	(0.010)
Father EA		0.157 ***	0.129 ***		0.125 ***	0.126 ***	0.125 ***
		(0.009)	(0.009)		(0.009)	(0.010)	(0.010)
Mother EA		0.190 ***	0.162 ***		0.163 ***	0.161 ***	0.163 ***
		(0.010)	(0.010)		(0.011)	(0.011)	(0.011)
Child PGS x Father EA						0.010	
						(0.014)	
Child PGS x Mother EA						-0.024	
						(0.015)	
Mother PGS x Father EA						-0.004	
						(0.012)	
Father PGS x Father EA						-0.010	
						(0.011)	
Mother PGS x Mother EA						-0.004	
						(0.013)	
Father PGS x Mother EA						0.021	
						(0.013)	
Child PGS x Mother PGS							0.011
							(0.007)
Child PGS x Father PGS							-0.008

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
							(0.007)
N	12040	11939	11939	12040	11939	11939	11939
R2	0.069	0.095	0.123	0.075	0.123	0.124	0.124
logLik	-15790.0 35	-15488.9 11	-15300.3 40	-15753.8 92	-15297.7 63	-15294.7 72	-15296.4 53
AIC	31630.07 0	31029.82 2	30654.68 1	31561.78 4	30653.52 5	30659.54 5	30654.90 7
		**	* p < 0.0	01; ** p	< 0.01; *	p < 0.05	.

Models of Reading Test in 8th Grade for Girls.

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
Constant	0.334 ***	-0.035	0.022	0.333 ***	0.024	0.024	0.020
	(0.044)	(0.045)	(0.044)	(0.043)	(0.044)	(0.044)	(0.044)
Child PGS	0.234 ***		0.167 ***	0.152 ***	0.158 ***	0.169 ***	0.158 ***
	(0.011)		(0.011)	(0.016)	(0.015)	(0.024)	(0.015)
Mother PGS				0.074 ***	-0.001	0.005	-0.001
				(0.014)	(0.014)	(0.021)	(0.014)
Father PGS				0.079 ***	0.019	-0.008	0.019
				(0.014)	(0.013)	(0.020)	(0.013)
Father EA		0.172 ***	0.143 ***		0.140 ***	0.139 ***	0.140 ***
		(0.013)	(0.012)		(0.013)	(0.013)	(0.013)
Mother EA		0.222 ***	0.195 ***		0.196 ***	0.195 ***	0.196 ***
		(0.014)	(0.014)		(0.014)	(0.014)	(0.014)
Child PGS x Father EA						0.015	
						(0.018)	
Child PGS x Mother EA						-0.023	
						(0.019)	
Mother PGS x Father EA						-0.002	
						(0.016)	
Father PGS x Father EA						-0.006	
						(0.015)	
Mother PGS x Mother EA						-0.005	
						(0.016)	
Father PGS x Mother EA						0.031	
						(0.016)	
Child PGS x Mother PGS							0.006
							(0.010)
Child PGS x Father PGS							0.002

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
							(0.010)
N	6258	6209	6209	6258	6209	6209	6209
R2	0.081	0.127	0.159	0.089	0.159	0.160	0.159
logLik	-7990.13 1	-7766.04 2	-7651.21 1	-7965.23 0	-7650.09 6	-7647.15 7	-7649.77 9
AIC	16024.26 1	15578.08 4	15350.42 2	15978.46 0	15352.19 2	15358.31 3	15355.55 8
		**	* p < 0.0	01; ** p	< 0.01; *	p < 0.05	.

Models of Reading Test in 9th Grade for Girls.

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
Constant	0.400 ***	0.063	0.120 **	0.399 ***	0.122 **	0.124 **	0.125 **
	(0.045)	(0.047)	(0.046)	(0.045)	(0.046)	(0.047)	(0.047)
Child PGS	0.236 ***		0.174 ***	0.157 ***	0.163 ***	0.165 ***	0.163 ***
	(0.013)		(0.013)	(0.018)	(0.018)	(0.028)	(0.018)
Mother PGS				0.064 ***	-0.007	0.003	-0.007
				(0.015)	(0.016)	(0.024)	(0.016)
Father PGS				0.084 ***	0.029	0.026	0.029
				(0.015)	(0.015)	(0.023)	(0.015)
Father EA		0.149 ***	0.118 ***		0.113 ***	0.114 ***	0.113 ***
		(0.014)	(0.014)		(0.014)	(0.015)	(0.015)
Mother EA		0.212 ***	0.184 ***		0.186 ***	0.185 ***	0.186 ***
		(0.016)	(0.015)		(0.016)	(0.016)	(0.016)
Child PGS x Father EA						0.018	
						(0.021)	
Child PGS x Mother EA						-0.016	
						(0.022)	
Mother PGS x Father EA						-0.012	
						(0.018)	
Father PGS x Father EA						-0.011	
						(0.018)	
Mother PGS x Mother EA						0.000	
						(0.018)	
Father PGS x Mother EA						0.012	
						(0.018)	
Child PGS x Mother PGS							-0.000
							(0.011)
Child PGS x Father PGS							-0.006

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
							(0.011)
N	4316	4286	4286	4316	4286	4286	4286
R2	0.091	0.122	0.160	0.099	0.161	0.161	0.161
logLik	-5254.54 7	-5140.33 6	-5046.05 3	-5235.67 9	-5043.70 8	-5042.96 9	-5043.55 4
AIC	10551.09 5	10324.67 1	10138.10 5	10517.35 8	10137.41 6	10147.93 8	10141.10 8
		**	* p < 0.0	01; ** p	< 0.01; *	p < 0.05	.

Models of English Test in 5th Grade for Girls.

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
Constant	0.092 *	-0.147 ***	-0.097 *	0.091 *	-0.099 *	-0.097 *	-0.102 *
	(0.040)	(0.042)	(0.041)	(0.040)	(0.041)	(0.042)	(0.042)
Child PGS	0.178 ***		0.135 ***	0.129 ***	0.131 ***	0.127 ***	0.131 ***
	(0.008)		(0.009)	(0.012)	(0.012)	(0.020)	(0.012)
Mother PGS				0.031 **	-0.013	-0.002	-0.013
				(0.010)	(0.011)	(0.017)	(0.011)
Father PGS				0.059 ***	0.020	0.016	0.019
				(0.010)	(0.011)	(0.017)	(0.011)
Father EA		0.130 ***	0.107 ***		0.104 ***	0.104 ***	0.104 ***
		(0.010)	(0.010)		(0.010)	(0.010)	(0.010)
Mother EA		0.126 ***	0.103 ***		0.106 ***	0.105 ***	0.106 ***
		(0.011)	(0.011)		(0.011)	(0.011)	(0.011)
Child PGS x Father EA						0.008	
						(0.014)	
Child PGS x Mother EA						-0.002	
						(0.016)	
Mother PGS x Father EA						-0.010	
						(0.012)	
Father PGS x Father EA						-0.007	
						(0.012)	
Mother PGS x Mother EA						-0.002	
						(0.013)	
Father PGS x Mother EA						0.009	
						(0.013)	
Child PGS x Mother PGS							0.011
							(0.008)
Child PGS x Father PGS							-0.005

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
							(0.008)
N	12102	11999	11999	12102	11999	11999	11999
R2	0.047	0.056	0.075	0.049	0.075	0.075	0.075
logLik	-16167.4 60	-15971.7 30	-15850.9 01	-16150.1 03	-15847.4 28	-15846.6 74	-15846.3 33
AIC	32384.92 0	31995.46 0	31755.80 2	32354.20 5	31752.85 6	31763.34 8	31754.66 5
		**	* p < 0.0	01; ** p	< 0.01; *	p < 0.05	.

Models of English Test in 8th Grade for Girls.

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
Constant	0.072	-0.202 ***	-0.152 **	0.071	-0.157 **	-0.156 **	-0.169 ***
	(0.047)	(0.049)	(0.049)	(0.047)	(0.049)	(0.049)	(0.049)
Child PGS	0.201 ***		0.152 ***	0.155 ***	0.159 ***	0.155 ***	0.160 ***
	(0.012)		(0.012)	(0.017)	(0.017)	(0.027)	(0.017)
Mother PGS				0.026	-0.029	-0.027	-0.029
				(0.015)	(0.015)	(0.024)	(0.015)
Father PGS				0.060 ***	0.015	0.008	0.015
				(0.015)	(0.015)	(0.023)	(0.015)
Father EA		0.143 ***	0.116 ***		0.114 ***	0.113 ***	0.113 ***
		(0.014)	(0.014)		(0.014)	(0.014)	(0.014)
Mother EA		0.154 ***	0.130 ***		0.136 ***	0.137 ***	0.137 ***
		(0.015)	(0.015)		(0.015)	(0.015)	(0.015)
Child PGS x Father EA						0.003	
						(0.020)	
Child PGS x Mother EA						0.002	
						(0.021)	
Mother PGS x Father EA						0.006	
						(0.017)	
Father PGS x Father EA						-0.011	
						(0.017)	
Mother PGS x Mother EA						-0.006	
						(0.018)	
Father PGS x Mother EA						0.016	
						(0.018)	
Child PGS x Mother PGS							0.016
							(0.011)
Child PGS x Father PGS							0.007

	Child PGS	Parents' educatio n	Child PGS controll ed	Genetic nurture	Parents' EA controll ed	EA-PGS interact ion	PGS-PGS interact ion
							(0.011)
N	6244	6194	6194	6244	6194	6194	6194
R2	0.055	0.068	0.091	0.057	0.092	0.092	0.092
logLik	-8464.85 5	-8353.63 0	-8275.31 2	-8456.21 6	-8272.15 0	-8271.29 4	-8270.14 2
AIC	16973.70 9	16753.25 9	16598.62 3	16960.43 1	16596.30 0	16606.58 8	16596.28 3
		**	* p < 0.0	01; ** p	< 0.01; *	p < 0.05	.

Complete analysis code

```
library(tidyverse)
library(data.table)
library(broom)
library(summarytools)
library(here)
library(huxtable)
library(skimr)
###
### Data construction part
###

### Choose to build data or not
FLAG_BUILD_DATA=FALSE

if (FLAG_BUILD_DATA==TRUE) {
  ### Get basic demography data
  fasteoppl <- fread("Z:/data/durable/data/registers/original/csv/w19_0634_faste_oppl_ut.csv") %>%
    mutate(cohort = as.numeric(str_sub(foedsels_aar_mnd,1,4))) %>%
    mutate(female = as.numeric(kjoenn)-1)

  ### Read genetics data
  genetic_trios <- fread("Z:/data/durable/data/genetics/PGS/post-rosa-qc/genetic-trios.csv")

  education <- fread("Z:/data/durable/data/registers/original/csv/w19_0634_utd_1970_2018_ut.csv") %>%
    select(w19_0634_lnr, contains("BU_"))

  allinfo <- select(fasteoppl, w19_0634_lnr, cohort, female) %>%
      left_join(education, by="w19_0634_lnr") %>%
      mutate(eduyr = cohort+30) %>%
      mutate(eduyr = if_else(eduyr>2018, 2018, eduyr)) %>%
      mutate(eduvar = str_c("BU_",as.character(eduyr))) %>%
      mutate(education = get(eduvar)) %>%
      mutate(edlevel = as.double(str_sub(education,1,1))) %>%
      mutate(eduyears = case_when(edlevel==1 ~ 6.0,
                                  edlevel==2 ~ 9.0,
                                  edlevel==3 ~ 10.0,
```

```
                                edlevel==4 ~ 12.0,
                                edlevel==5 ~ 14.0,
                                edlevel==6 ~ 16.0,
                                edlevel==7 ~ 18.0,
                                edlevel==8 ~ 21.0,
                                TRUE ~ edlevel)) %>%
    mutate(eduyears_z = scale.default(eduyears)) %>%
    select(-starts_with("BU_"), -eduvar)


### Natl std. tests data in wide format
nasjprov <- fread("Z:/data/durable/data/registers/original/csv/w19_0634_nasjonale_prover_ut.csv")
nprover <-   select(nasjprov, w19_0634_lnr, PROVE, AARGANG, POENG, DELTATTSTATUS) %>%
  filter(PROVE %in% c("NPENG08","NPREG08","NPLES08","NPENG05","NPREG09","NPLES05","NPREG05","NPLES09")) %>%
  filter(DELTATTSTATUS=="D") %>%
  filter(POENG>0) %>%
  select(-DELTATTSTATUS) %>%
  group_by(w19_0634_lnr, PROVE) %>%
  arrange(desc(AARGANG)) %>%
  slice(1) %>%
  group_by(PROVE, AARGANG) %>%
  mutate(zresult = scale.default(POENG)) %>%
  ungroup %>%
  gather(info, value, -w19_0634_lnr, -PROVE) %>%
  mutate(info = if_else(info=="zresult", "",info)) %>%
  unite(col = varname, PROVE, info, sep="", remove=T) %>%
  spread(varname, value) %>%
  as.data.frame


### Link together various data components

### IMPORTANT: This step excludes everyone who are not in the genetic data files
### This is done to limit the size of the data set (from 8.3M to 98K).
outcomes <- c("NPREG05","NPREG08","NPREG09","NPLES05","NPLES08","NPLES09","NPENG05","NPENG08")
df <- genetic_trios %>%
  left_join(select(nprover, w19_0634_lnr, one_of(outcomes)), by=c(child_w19_0634_lnr = "w19_0634_lnr")) %>%
  left_join(prefixit(allinfo, prefix="child_"), by="child_w19_0634_lnr") %>%
```

```
    left_join(prefixit(allinfo, prefix="mother_"), by="mother_w19_0634_lnr") %>%
    left_join(prefixit(allinfo, prefix="father_"), by="father_w19_0634_lnr")
  nrow(df)
  names(df)

  myscale <- function(x) { return(scale.default(x)) }

  complete_trios <- df %>%
    ungroup %>%
    # Remove those without genotype information
    filter(child_SENTRIXID!="") %>%
    filter(mother_SENTRIXID!="") %>%
    filter(father_SENTRIXID!="") %>%
    filter_at(vars(contains("_EA1")), function(x) !is.na(x)) %>%
    # Scale the PGS with N(0,1)
    mutate(father_EA1 = myscale(father_EA1)) %>%
    mutate(mother_EA1 = myscale(mother_EA1)) %>%
    mutate(child_EA1 =  myscale(child_EA1)) %>%
    mutate_at(outcomes, as.numeric) %>%
    as_tibble


  ### Save final data set
  fwrite(complete_trios, file = here("complete-trios.csv"))
} else {
  complete_trios <- fread(here("complete-trios.csv")) %>%
    # Make sure outcomes are numeric
    mutate_at(vars(starts_with("NP")), as.numeric)
  nrow(complete_trios)
  names(complete_trios)
}


### ###################################################################
### ANALYSIS PART STARTS HERE ########################################
### ###################################################################

###
```

```r
### LINEAR MODELS OF PGS EFFECTS ON STANDARDIZED TEST SCORES
###

###
### Eight outcomes: Three subjects and three measurement points, but no English test in 9th grade.
###
outcomes <- c("NPREG05","NPREG08","NPREG09","NPLES05","NPLES08","NPLES09","NPENG05","NPENG08")
names(outcomes) <- c("Math 5th","Math 8th","Math 9th","Reading 5th","Reading 8th","Reading 9th","English 5th","English 8th")

### Predictor variables
pgsname <- "EA1"
ea_genetic_nurture <- str_c(c("mother_","father_"), pgsname)
ea_child <- str_c("child_", pgsname)
all_genetics <- c(ea_child,unlist(ea_genetic_nurture))
### Control variables definition
controls <- paste(c("child_female + as.factor(child_cohort)", paste(str_c("child_PC",1:10),collapse = " + "), "as_factor(child_BATCH)"), c
### Parental SES variables
parental_ses_vars <- c("father_eduyears_z", "mother_eduyears_z")
parental_ses_interactions <- str_c(paste(all_genetics, collapse=" + "), " + ", paste(unlist(map(parental_ses_vars, ~str_c(.x, "*",all_gene

### Model definitions
model_defs <- list(
  child_model = str_c(ea_child," + ",controls),
  parental_educ = str_c(paste(parental_ses_vars, collapse=" + "), " + ", controls),
  social_child_pgs = str_c(ea_child, " + ", paste(parental_ses_vars, collapse=" + "), " + ", controls),
  nurture_model = str_c(ea_child, " + ", paste(ea_genetic_nurture, collapse = " + "),"+",controls),
  parental_ctrl_model = str_c(ea_child, " + ", paste(ea_genetic_nurture, collapse = " + "),"+ ", paste(parental_ses_vars, collapse=" + ")
  parental_int_model = parental_ses_interactions,
  pgs_pgs_int = paste(c(str_c(ea_child,"*",paste(ea_genetic_nurture)), parental_ses_vars, controls), collapse="+")
)

### Estimate models and store results
estimate_model <- function(outcome,model_def, edf) {
  m <- lm(data=edf, formula=as.formula(str_c(outcome,"~", model_def)))
  return(m)
}

modnames <- str_c(rep(names(outcomes), times=length(model_defs)), ":", rep(names(model_defs), each=length(outcomes)))
```

```r
bothsex_models <- map(model_defs, function(x) map(outcomes, estimate_model, x, complete_trios)) %>%
  flatten %>%
  setNames(nm = str_c(modnames,":Both"))

male_models <- map(model_defs, function(x) map(outcomes, estimate_model, x, filter(complete_trios, child_female==0))) %>%
  flatten %>%
  setNames(nm = str_c(modnames, ":Boys"))

female_models <- map(model_defs, function(x) map(outcomes, estimate_model, x, filter(complete_trios, child_female==1))) %>%
  flatten %>%
  setNames(nm = str_c(modnames, ":Girls"))

all_models <- c(bothsex_models, male_models, female_models)
length(all_models)

###
### RESULTS PRESENTATION PART
###
### Definitions
###
sexes <- c("Both","Boys","Girls")
coefs_toshow <- c("Constant" = "(Intercept)",
                  "Child PGS" = ea_child, "Mother PGS" = "mother_EA1", "Father PGS" = "father_EA1",
                  "Father EA" = "father_eduyears_z", "Mother EA" = "mother_eduyears_z",
                  "Child PGS \nx Father EA" = "child_EA1:father_eduyears_z",
                  "Child PGS \nx Mother EA" = "child_EA1:mother_eduyears_z",
                  "Mother PGS \nx Father EA" = "mother_EA1:father_eduyears_z",
                  "Father PGS \nx Father EA" = "father_EA1:father_eduyears_z",
                  "Mother PGS \nx Mother EA" = "mother_EA1:mother_eduyears_z",
                  "Father PGS \nx Mother EA" = "father_EA1:mother_eduyears_z",
                  "Child PGS \nx Mother PGS" = "child_EA1:mother_EA1",
                  "Child PGS \nx Father PGS" = "child_EA1:father_EA1"
) %>% data.frame(term = .) %>% rownames_to_column(var = "label")
coefs_toshow_list <- coefs_toshow$term %>% setNames(coefs_toshow$label)


model_labels <- c("Child PGS" = "child_model",
                  "Parents'\neducation" = "parental_educ",
```

```
                  "Child PGS\ncontrolled" = "social_child_pgs",
                  "Genetic nurture" = "nurture_model",
                  "Parents' EA\ncontrolled" = "parental_ctrl_model",
                  "EA-PGS interaction" = "parental_int_model",
                  "PGS-PGS interaction" = "pgs_pgs_int")

results_linear_all <- map(all_models,~broom::tidy(.x,conf.int=T)) %>%
  bind_rows(.id="model") %>%
  separate(col = model, into=c("outcome","model_def","sex"), remove = T, sep = ":") %>%
  mutate(grade=str_sub(outcome, start=-3), subject=str_sub(outcome,end=-4)) %>%
  mutate(role = case_when(str_detect(term,"father") ~ "Father", str_detect(term,"mother") ~ "Mother", TRUE~"Child")) %>%
  left_join(coefs_toshow, by="term") %>%
  left_join(data.table(model_def = model_labels, model_label = names(model_labels)), by="model_def")

###
### Plot theme definitions
###
mytheme <- theme_minimal() + theme(legend.position = "bottom")

###
### Part 0. Table of sample descriptives
###
descvars <- c(outcomes, "child_cohort", "father_cohort", "mother_cohort", ea_child, ea_genetic_nurture, "father_eduyears","mother_eduyears
options(scipen = 100000)
myskim <- skim_with(numeric = sfl(complete = n_complete, complete_rate=NULL, hist=NULL,n=NULL))
desc_table <- complete_trios %>%
  select(one_of(descvars)) %>%
  mutate_all(as.numeric) %>%
  myskim %>%
  left_join(data.frame(skim_variable = descvars, Variable =  names(descvars))) %>%
  as_tibble %>%
  select(Variable, N = numeric.complete, Mean = numeric.mean, Std.Dev. = numeric.sd, P25 = numeric.p25, Median = numeric.p50, P75 = numeri
  mutate_if(is.numeric, ~round(.x,2))

###
### Part 1. Zero-order parental education and PGS models
###
plotdf <- results_linear_all %>%
```

```
  filter(term %in% c(ea_child, parental_ses_vars), model_def %in% c("parental_educ","child_model","social_child_pgs")) %>%
  mutate(model_label = factor(model_label, levels = c("Parents'\neducation","Child PGS","Child PGS\ncontrolled")))

plot_models <- function(df) {
  theplot <-  df %>%
    ggplot(aes(color=label, y=estimate, x=model_label, shape=label)) +
      geom_point(position =position_dodge2(width=0.4)) +
      geom_pointrange(mapping = aes(y = estimate, ymin=conf.low, ymax=conf.high), position=position_dodge2(width = 0.4)) +
      geom_hline(yintercept=0, color="black") +
      scale_x_discrete() +
      scale_y_continuous() +
      ylab("Beta") + xlab("") +
      guides(color = guide_legend("Variable"), shape = guide_legend("Variable")) +
      facet_grid(subject~grade, drop = T) +
      labs(title = "Figure 1. Genetic confounding of parents' education effects") +
      mytheme
}

confounding_plots <- split(plotdf,plotdf$sex) %>%
  map(.f = plot_models)


###
### Part 2. Genetic nurture and parental education
###
plotdf <- results_linear_all %>%
  filter(term %in% c(ea_genetic_nurture, parental_ses_vars), model_def %in% c("nurture_model","parental_ctrl_model")) %>%
  mutate(model_label = factor(model_label, levels = c("Genetic nurture","Parents' EA\ncontrolled","Child PGS\ncontrolled")))


plot_models <- function(df) {
  theplot <-  df %>%
    ggplot(aes(color=label, y=estimate, x=model_label, shape=label)) +
    geom_point(position =position_dodge2(width=0.4)) +
    geom_pointrange(mapping = aes(y = estimate, ymin=conf.low, ymax=conf.high), position=position_dodge2(width = 0.4)) +
    geom_hline(yintercept=0, color="black") +
    scale_x_discrete() +
    scale_y_continuous() +
```

```
    ylab("Beta") + xlab("") +
    guides(color = guide_legend("Variable"), shape = guide_legend("Variable")) +
    facet_grid(subject~grade, drop = T) +
    labs(title = "Figure 2. Genetic nurture effects with and without controls for parents' education") +
  mytheme
}

geneticnurture_plots <- split(plotdf,plotdf$sex) %>%
  map(.f = plot_models)


###
###  Part 3: Parental education -- genotype interactions
###
plotdf_inteffects <- results_linear_all %>%
  filter(term!="(Intercept)") %>%
  filter(model_def %in% c("parental_int_model")) %>%
  filter(str_detect(string = term, pattern = ":")) %>%
  mutate(grade=str_sub(outcome, start=-3), subject=str_sub(outcome,end=-4))

plot_inteffects <- function(df) {
  ggplot(df, aes(x=label, y=estimate, color=subject, shape=grade, ymax=conf.high, ymin=conf.low)) +
    geom_point(position = position_dodge2(width=0.4)) +
    geom_pointrange(mapping = aes(y = estimate, ymin=conf.low, ymax=conf.high), position=position_dodge2(width = 0.4)) +
    geom_hline(yintercept = 0, color="black") +
    scale_x_discrete() +
    scale_y_continuous() +
    ylab("Beta for interaction term") + xlab("") +
    guides(color = guide_legend("Subject"), shape = guide_legend("Grade")) +
    coord_flip() +
    labs(title = "Figure 3. Interaction effects between child genotype and parents' education") +
    mytheme
}

inteffects_plots <- split(plotdf_inteffects, plotdf_inteffects$sex) %>%
  map(plot_inteffects)
```

```r
###
### Part 4. Genotype-genotype interactions
###
plotdf_pgspgsint <- results_linear_all %>%
  filter(model_def %in% c("pgs_pgs_int")) %>%
  filter(str_detect(string = term, pattern = ":")) %>%
  mutate(grade=str_sub(outcome, start=-3), subject=str_sub(outcome,end=-4))

plot_pgspgsint <- function(df) {
    ggplot(df, aes(x=label, y=estimate, color=subject, shape=grade, ymax=conf.high, ymin=conf.low)) +
      geom_point(position = position_dodge2(width=0.4)) +
      geom_pointrange(mapping = aes(y = estimate, ymin=conf.low, ymax=conf.high), position=position_dodge2(width = 0.4)) +
      geom_hline(yintercept = 0, color="black") +
      scale_x_discrete() +
      scale_y_continuous() +
      ylab("Beta for interaction term") + xlab("") +
      guides(color = guide_legend("Subject"), shape = guide_legend("Grade")) +
      coord_flip() +
      labs(title = "Figure 4. Genotype-genotype interaction effects") +
      mytheme
}

pgspgsint_plots <- split(plotdf_pgspgsint, plotdf_pgspgsint$sex) %>%
  map(plot_pgspgsint)




###
### Supplementary materials
###

### Past S1. Distributions of outcome variables
distplot <- complete_trios %>%
  select(outcomes) %>%
  gather(outcome, value) %>%
```

```
  drop_na %>%
  group_by(outcome) %>%
  ggplot(aes(fill=outcome,color=outcome)) +
    geom_density(aes(x=value)) +
    scale_color_manual(values = RColorBrewer::brewer.pal(8,"Accent")) +
    facet_wrap(~outcome) +
    labs(title="Distributions of outcomes variables") +
    xlab("Z-score") + ylab("Density") +
    mytheme + theme(legend.title = element_blank())


###
### Part S2. Equal importance of mother's and father's PGS?
###
parental_importance <- results_linear_all %>% filter(model_def=="nurture_model") %>%
  filter(sex!="Both") %>%
  filter(term %in% c(ea_child, ea_genetic_nurture)) %>%
  select(outcome, sex, term, estimate, std.error) %>%
  group_by(outcome, sex, term) %>%
  gather(num, value, estimate, std.error) %>%
  mutate(parm = str_c(term,"_",num)) %>%
  ungroup %>%
  select(-term,-num) %>%
  spread(parm, value) %>%
  mutate(parents_diff = mother_EA1_estimate-father_EA1_estimate) %>%
  mutate(parents_diff_se = sqrt(((mother_EA1_std.error^2)+(father_EA1_estimate^2)))) %>%
  ungroup %>%
  mutate(conf.low = parents_diff-parents_diff_se*1.96) %>%
  mutate(conf.high = parents_diff+parents_diff_se*1.96)

parental_importance_plot <- ggplot(parental_importance, aes(x=sex, y=parents_diff, ymin=conf.low, ymax=conf.high, color=outcome)) +
  geom_pointrange(position=position_dodge2(width=0.1)) +
  geom_hline(yintercept = 0) +
  xlab("") +  ylab("Difference in Beta for Mothers and fathers") +
  labs(title = "Equal magnitude of coffecients for mother and father",
       subtitle = "Coefficients taken from 'Genetic nurture' models") +
  coord_flip() +
  mytheme
```

```
### Part S3. Plot difference in main effects with/without interactions.
plotdf3 <- results_linear_all %>%
  filter(model_def %in% c("parental_ctrl_model","parental_int_model")) %>%
  filter(term %in% c(ea_child, ea_genetic_nurture, parental_ses_vars)) %>%
  mutate(grade=str_sub(outcome, start=-3), subject=str_sub(outcome,end=-4)) %>%
  mutate(Role = case_when(str_detect(term,"father") ~ "Father", str_detect(term,"mother") ~ "Mother", TRUE~"Child")) %>%
  mutate(Model = if_else(model_def=="parental_ctrl_model","Main effects only","Interaction model")) %>%
  mutate(Variable = if_else(str_detect(term, pattern = pgsname), "PGS","EA")) %>%
  filter(sex=="Both")

plot_models <- function(df) {
  theplot <-  df %>%
    ggplot(aes(x=Role, y=estimate, color=Model, shape=Variable)) +
    geom_point(position =position_dodge2(width=0.4)) +
    geom_pointrange(mapping = aes(y = estimate, ymin=conf.low, ymax=conf.high), position=position_dodge2(width = 0.4)) +
    geom_hline(yintercept = 0, color="black") +
    scale_x_discrete() +
    scale_y_continuous() +
    ylab("Beta") + xlab("") +
    facet_grid(subject~grade, drop = T) +
    labs(title = "Figure S2. Comparison of main coefficient estimates with and without interactions") +
    theme_minimal() +
    theme(legend.position = "bottom")
  return(theplot)
}
intcomparison_plot <- plot_models(plotdf3)



###
### Part S4. How well do these models predict test score results?
###
df <- tibble(model_def = as.character(names(model_defs)), model_label = names(model_labels)) %>% mutate_all(as.character)

all_model_stats <- map(all_models, glance) %>%
  bind_rows(.id="model") %>%
```

```
  separate(col = model, into = c("outcome","model_def","sex"), sep=":") %>%
  mutate(grade=str_sub(outcome, start=-3), subject=str_sub(outcome,end=-4)) %>%
  mutate(outcome = str_c(subject," ",grade)) %>%
  mutate(model_def = as.character(model_def)) %>%
  left_join(df, by="model_def") %>%
  arrange(model_def) %>%
  mutate(model_label = factor(model_label,levels=names(model_labels)))

predictwell_plot <- all_model_stats %>% arrange(model_def, adj.r.squared) %>% mutate(k = row_number()) %>%
  ggplot(aes(y=adj.r.squared, x=model_label, color=outcome, shape=sex)) +
  geom_jitter(width = 0.1) +
  scale_x_discrete() +
  scale_y_continuous(limits = c(0,0.2)) +
  ylab("Adjusted R-squared from model") + xlab("") +
  guides(color = guide_legend(""), shape = guide_legend("", ncol=3)) +   theme_minimal() +
  theme(legend.position = "bottom")


###
### Part S5. Model statistics table for appendix
###
model_stats <- all_model_stats %>%
  select(outcome, model_label, sex, adj.r.squared, logLik, AIC) %>%
  setNames(nm=c("Outcome","Model","Sex", "Adj. R^2","log L", "AIC")) %>%
  arrange(Outcome, Sex)


###
### Part S6. Complete models results for appendix
###
maketab <- function(outcome,sex) {

  themods <- map(names(model_defs), ~function(model_def, outcome = therow$outcome, sex = therow$sex) str_c(outcome, ":", model_def, ":", s
  modnames <- str_c(outcome,":", names(model_defs),":", sex)

  themods <- all_models[modnames] %>% setNames(nm=names(model_labels))
  mycaption <- str_c("\n\n### Models of ", str_sub(outcome, end = -4) ,"Test in ",str_sub(outcome, start=-3), " Grade for ", sex, ".\n")
```

```
  mytab <- huxtable::huxreg(themods, coefs = coefs_toshow_list) %>%
    set_caption(value = mycaption)

  return(mytab)
}


regression_tables <-  map2(rep(names(outcomes), times=3), rep(sexes, each=length(outcomes)), maketab)


###
### Produce materials for Rmd / manuscript
###
resultspath <- here("ea-genetic-nurture/results")
if (dir.exists(resultspath)) {
} else {
  dir.create(resultspath)
}

### Save figures to correct format
saved_figures <- list(figure1 = confounding_plots$Both,
                      figure2 = geneticnurture_plots$Both,
                      figure3 = inteffects_plots$Both,
                      figure4 = pgspgsint_plots$Both,
                      figureS1 = distplot,
                      figureS2 = parental_importance_plot,
                      figureS3 = intcomparison_plot,
                      figureS4 = predictwell_plot
  )

savefig <- function(x,y) {
  ggsave(filename = str_c(resultspath,"/",y,".png"), plot = x,
         device = "png", dpi = "retina")
  return(0)
}
map2(.x = saved_figures, .y = names(saved_figures), ~savefig(.x,.y))

### Save tables for later printing
```

```r
saved_tables <- c("desc_table",
                  "regression_tables",
                  "model_stats")
save(list = saved_tables, file = str_c(resultspath,"/tables.Rdata"))
```

MoBa Genetics Post-imputation procedure

The MoBa Genetics data were, after imputation, subjected to a quality control procedure, as is standard practice in uses of genotype information for polygenic scores.

```
Post-imputation quality control procedure for MoBa genetic data, conducted in p805.

N.B. procedure written by E. Corfield/T. Zayats, with additional annotation by R. Cheesman. Software required for steps is plink unless ot


1. Convert the vcf format imputed dosages into plink format hard genotypes
2. Select high quality SNPs
2.1. Keep SNPs with INFO >= 0.8 in all batches
2.2. remove SNPs with a MAF<1%
2.3. Remove duplicate SNPs (by position and rsid)
2.4. merge chromosomes into one file
2.5. Update individuals to include MoBa pedigree (i.e. trio family ID) and sex data
3. identify the core EUR sample
3.1. temporarily remove SNPs with a call rate threshold of 95% (--geno)
3.2. temporarily remove individuals with a call rate threshold of 95% (--mind)
3.3. temporarily remove SNPs with a HWE threshold of p<0.001
3.4. PCA with 1000 Genomes reference (having conducted LD pruning with r2 parameter 0.1 and removed SNPs in long-range LD regions) : ident

4. QC the core EUR sample
4.1. call rate for SNPs 98% (--geno)
4.2. call rate for individuals 98% (--mind)
4.3. HWE p<0.000001
4.4. remove heterozygosity outliers F-het +/- 0.2 of the sample (nb before this, temporarily LD pruned the data with r2 parameter 0.1, and
4.5. sex check : remove individuals whose reported sex mismatches SNP-based sex
4.6. Duplicates check

4.6.1. run IBD analysis of duplicates reported by MoBa to identify real duplicates based on the genetic data (--genome; threshold of pihat
4.6.2. within the real duplicates run a concordance analysis and remove SNPs with poor concordance between duplicate individuals (<99%; us
```

4.6.3. Remove one individual from a pair/trio of real duplicates (based on SNP missingness) in this case there was no missingness so selec

4.7. KING analysis to identify relatedness within and across batch (use the king --build --ibs --related --degree 2 flags). Additional ste
4.8. Mendelian error check (--me 0.05 0.01 --set-me-missing --mendel-duos). Additional steps: the ME check requires complete sex informati
4.9. Cryptic relatedness check : remove individuals with excessive numbers of close relatives. (Prior to running checks for, re-run KING s
4.10. PCA with reference (since individuals have changed; same steps as 3.3)
4.11. PCA without reference
4.12. batch effects check
4.12.1. test for association between batch and SNPs (plink --mh2 --within)
4.12.2. remove any significant SNPs
5. Filter out sex chromosomes and re-run steps 4.1 to 4.4.

The polygenic scores were then created using a no overlap-sample with the EA3 sumstats. The software used was PRSice.