

Supplementary Information

Genetics affects choice of academic subjects as well as achievement

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Supplementary Table 1. Sex limitation model fitting sub-model comparisons. All comparisons are made with the full sex-limitation model as explained in the Methods. ep= estimated parameters; -2LL= -2 log-likelihood; df= degrees of freedom; AIC= Akaike's information criteria; diffLL= change in log-likelihood; diffdf= change in degrees of freedom.

A-level mean grade

Qualitative genetic differences							
Model	ep	-2LL	df	AIC	diffLL	diffdf	p
FullHetACE	9	16545.85	6067	4411.85	-	-	-
HetACE	8	16546.29	6068	4410.29	0.45	1	0.5
Qualitative environmental differences							
Model	ep	-2LL	df	AIC	diffLL	diffdf	p
cFullHetACE	9	16545.85	6067	4411.85	-	-	-
HetACE	8	16546.29	6068	4410.29	0.45	1	0.5
Quantitative genetic differences							
Model	ep	-2LL	df	AIC	diffLL	diffdf	p
HetACE	8	16546.29	6068	4410.29	-	-	-
HomACE	5	16561.16	6071	4419.16	14.86	3	0

Humanities mean grade

Qualitative genetic differences							
Model	ep	-2LL	df	AIC	diffLL	diffdf	p
FullHetACE	9	7164.26	2586	1992.26	-	-	-
HetACE	8	7164.26	2587	1990.26	0	1	0.97
Qualitative environmental differences							
Model	ep	-2LL	df	AIC	diffLL	diffdf	p
cFullHetACE	9	7164.26	2586	1992.26	-	-	-
HetACE	8	7164.26	2587	1990.26	0	1	0.97
Quantitative genetic differences							
Model	ep	-2LL	df	AIC	diffLL	diffdf	p
HetACE	8	7164.26	2587	1990.26	-	-	-
HomACE	5	7176.78	2590	1996.78	12.53	3	0.01

STEM mean grade

Qualitative genetic differences							
Model	ep	-2LL	df	AIC	diffLL	diffdf	p
FullHetACE	9	9366.22	3399	2568.22	-	-	-
HetACE	8	9366.27	3400	2566.27	0.05	1	0.82
Qualitative environmental differences							
Model	ep	-2LL	df	AIC	diffLL	diffdf	p
cFullHetACE	9	9366.22	3399	2568.22	-	-	-
HetACE	8	9366.27	3400	2566.27	0.05	1	0.82
Quantitative genetic differences							
Model	ep	-2LL	df	AIC	diffLL	diffdf	p
HetACE	8	9366.27	3400	2566.27	-	-	-
HomACE	5	9372.89	3403	2566.89	6.61	3	0.09

Mathematics mean grade

Qualitative genetic differences							
Model	ep	-2LL	df	AIC	diffLL	diffdf	p
FullHetACE	9	5497.6	1993	1511.6	-	-	-
HetACE	8	5497.95	1994	1509.95	0.35	1	0.55
Qualitative environmental differences							
Model	ep	-2LL	df	AIC	diffLL	diffdf	p
cFullHetACE	9	5498.73	1993	1512.73	-	-	-
HetACE	8	5497.95	1994	1509.95	-0.79	1	1
Quantitative genetic differences							
Model	ep	-2LL	df	AIC	diffLL	diffdf	p
HetACE	8	5497.95	1994	1509.95	-	-	-
HomACE	5	5518.38	1997	1524.38	20.43	3	0

Biology mean grade

Qualitative genetic differences							
Model	ep	-2LL	df	AIC	diffLL	diffdf	p
FullHetACE	9	4481.7	1625	1231.7	-	-	-
HetACE	8	4481.91	1626	1229.91	0.21	1	0.64
Qualitative environmental differences							
Model	ep	-2LL	df	AIC	diffLL	diffdf	p
cFullHetACE	9	4481.7	1625	1231.7	-	-	-
HetACE	8	4481.91	1626	1229.91	0.21	1	0.64
Quantitative genetic differences							
Model	ep	-2LL	df	AIC	diffLL	diffdf	p
HetACE	8	4481.91	1626	1229.91	-	-	-
HomACE	5	4490.56	1629	1232.56	8.65	3	0.03

Physics mean grade

Qualitative genetic differences							
Model	ep	-2LL	df	AIC	diffLL	diffdf	p
FullHetACE	9	2319.59	837	645.59	-	-	-
HetACE	8	2319.81	838	643.81	0.22	1	0.64
Qualitative environmental differences							
Model	ep	-2LL	df	AIC	diffLL	diffdf	p
cFullHetACE	9	2319.52	837	645.52	-	-	-
HetACE	8	2319.81	838	643.81	0.29	1	0.59
Quantitative genetic differences							
Model	ep	-2LL	df	AIC	diffLL	diffdf	p
HetACE	8	2319.81	838	643.81	-	-	-
HomACE	5	2322.17	841	640.17	2.35	3	0.5

Chemistry mean grade

Qualitative genetic differences							
Model	ep	-2LL	df	AIC	diffLL	diffdf	p
FullHetACE	9	3472.7	1267	938.7	-	-	-
HetACE	8	3472.7	1268	936.7	0	1	1
Qualitative environmental differences							
Model	ep	-2LL	df	AIC	diffLL	diffdf	p
cFullHetACE	9	3472.7	1267	938.7	-	-	-
HetACE	8	3472.7	1268	936.7	0	1	1
Quantitative genetic differences							
Model	ep	-2LL	df	AIC	diffLL	diffdf	p
HetACE	8	3472.7	1268	936.7	-	-	-
HomACE	5	3483.09	1271	941.09	10.4	3	0.02

English mean grade

Qualitative genetic differences							
Model	ep	-2LL	df	AIC	diffLL	diffdf	p
FullHetACE	9	4980.84	1809	1362.84	-	-	-
HetACE	8	4981.73	1810	1361.73	0.89	1	0.34
Qualitative environmental differences							
Model	ep	-2LL	df	AIC	diffLL	diffdf	p
cFullHetACE	9	4980.77	1809	1362.77	-	-	-
HetACE	8	4981.73	1810	1361.73	0.95	1	0.33
Quantitative genetic differences							
Model	ep	-2LL	df	AIC	diffLL	diffdf	p
HetACE	8	4981.73	1810	1361.73	-	-	-
HomACE	5	4984.88	1813	1358.88	3.15	3	0.37

Second language mean grade

Qualitative genetic differences							
Model	ep	-2LL	df	AIC	diffLL	diffdf	p
FullHetACE	9	1497.69	544	409.69	-	-	-
HetACE	8	1497.69	545	407.69	0	1	1
Qualitative environmental differences							
Model	ep	-2LL	df	AIC	diffLL	diffdf	p
cFullHetACE	9	1497.69	544	409.69	-	-	-
HetACE	8	1497.69	545	407.69	0	1	1
Quantitative genetic differences							
Model	ep	-2LL	df	AIC	diffLL	diffdf	p
HetACE	8	1497.69	545	407.69	-	-	-
HomACE	5	1499.21	548	403.21	1.52	3	0.68

History mean grade

Qualitative genetic differences							
Model	ep	-2LL	df	AIC	diffLL	diffdf	p
FullHetACE	9	3556.09	1279	998.09	-	-	-
HetACE	8	3556.09	1280	996.09	0	1	1
Qualitative environmental differences							
Model	ep	-2LL	df	AIC	diffLL	diffdf	p
cFullHetACE	9	3556.09	1279	998.09	-	-	-
HetACE	8	3556.09	1280	996.09	0	1	1
Quantitative genetic differences							
Model	ep	-2LL	df	AIC	diffLL	diffdf	p
HetACE	8	3556.09	1280	996.09	-	-	-
HomACE	5	3567.82	1283	1001.82	11.73	3	0.01

Geography mean grade

Qualitative genetic differences							
Model	ep	-2LL	df	AIC	diffLL	diffdf	p
FullHetACE	9	2816.36	1018	780.36	-	-	-
HetACE	8	2816.36	1019	778.36	0	1	1
Qualitative environmental differences							
Model	ep	-2LL	df	AIC	diffLL	diffdf	p
cFullHetACE	9	2816.36	1018	780.36	-	-	-
HetACE	8	2816.36	1019	778.36	0	1	1
Quantitative genetic differences							
Model	ep	-2LL	df	AIC	diffLL	diffdf	p
HetACE	8	2816.36	1019	778.36	-	-	-
HomACE	5	2820.89	1022	776.89	4.53	3	0.21

Psychology mean grade

Qualitative genetic differences							
Model	ep	-2LL	df	AIC	diffLL	diffdf	p
FullHetACE	9	3371.81	1208	955.81	-	-	-
HetACE	8	3371.81	1209	953.81	0	1	1
Qualitative environmental differences							
Model	ep	-2LL	df	AIC	diffLL	diffdf	p
cFullHetACE	9	3371.81	1208	955.81	-	-	-
HetACE	8	3371.81	1209	953.81	0	1	1
Quantitative genetic differences							
Model	ep	-2LL	df	AIC	diffLL	diffdf	p
HetACE	8	3371.81	1209	953.81	-	-	-
HomACE	5	3376.84	1212	952.84	5.03	3	0.17

Supplementary Table 2. Sex limitation model fitting results, showing A, C, E, estimates separately for males and females. A- additive genetic; C- shared environmental; E- non-shared environmental proportions of the variance (95% confidence intervals)

Subject	Males			Females		
	A	C	E	A	C	E
A-level mean grade	0.57 (0.38-0.69)	0.08 (0-0.24)	0.35 (0.31-0.41)	0.52 (0.36-0.69)	0.15 (0-0.29)	0.33 (0.29-0.37)
Humanities mean grade	0.55 (0.18-0.72)	0.09 (0-0.40)	0.36 (0.28-0.48)	0.45 (0.10-0.65)	0.12 (0-0.43)	0.43 (0.35-0.53)
STEM mean grade	0.60 (0.34-0.69)	0.03 (0-0.25)	0.37 (0.31-0.45)	0.61 (0.36-0.76)	0.10 (0-0.33)	0.29 (0.24-0.35)
Mathematics mean grade	0.51 (0.15-0.67)	0.08 (0-0.38)	0.41 (0.33-0.52)	0.70 (0.34-0.77)	0.00 (0-0.33)	0.30 (0.23-0.40)
Biology grade	0.23 (0-0.74)	0.46 (0-0.72)	0.31 (0.21-0.46)	0.65 (0.35-0.80)	0.09 (0-0.36)	0.26 (0.19-0.36)
Physics grade	0.36 (0-0.79)	0.37 (0-0.71)	0.27 (0.19-0.40)	0.45 (0-0.82)	0.21 (0-0.75)	0.34 (0.18-0.70)
Chemistry grade	0.76 (0.40-0.85)	0.03 (0-0.35)	0.21 (0.15-0.43)	0.56 (0.17-0.85)	0.23 (0-0.58)	0.21 (0.15-0.31)
English composite grade	0.38 (0-0.80)	0.33 (0-0.72)	0.30 (0.18-0.51)	0.34 (0.04-0.72)	0.40 (0.02-0.66)	0.26 (0.21-0.34)
Second language mean grade	0.82 (0.04-0.94)	0.06 (0-0.74)	0.12 (0.06-0.37)	0.47 (0-0.84)	0.30 (0-0.74)	0.23 (0.15-0.37)
History grade	0.38 (0-0.67)	0.20 (0-0.55)	0.42 (0.27-0.65)	0.10 (0-0.65)	0.56 (0.04-0.73)	0.34 (0.24-0.47)
Geography grade	0.24 (0-0.78)	0.47 (0-0.74)	0.29 (0.18-0.47)	0.63 (0.21-0.80)	0.09 (0-0.44)	0.28 (0.19-0.44)
Psychology grade	0.00 (0-0.72)	0.73 (0-0.84)	0.27 (0.16-0.48)	0.45 (0.07-0.68)	0.14 (0-0.48)	0.41 (0.30-0.56)

Supplementary Table S3. Model fitting results for liability threshold analyses for A-level choice with twin tetrachoric correlations. A-additive genetic; C- shared environmental; E- non-shared environmental proportions of the variance (95% confidence intervals)

Subject choice	A	C	E	Twin tetrachoric correlations	
				MZ	DZ
A-level	0.44 (0.38-0.51)	0.47 (0.41-0.53)	0.08 (0.07-0.10)	0.92 (0.90-0.93)	0.69 (0.66-0.72)
Humanities composite	0.50 (0.36-0.64)	0.18 (0.07-0.30)	0.31 (0.27-0.36)	0.69 (0.64-0.74)	0.44 (0.38-0.49)
STEM composite	0.60 (0.50-0.71)	0.23 (0.14-0.32)	0.17 (0.14-0.32)	0.83 (0.80-0.86)	0.65 (0.49-0.57)
Mathematics	0.77 (0.65-0.88)	0.08 (0-0.19)	0.15 (0.12-0.18)	0.86 (0.82-0.89)	0.47 (0.41-0.52)
Biology	0.64 (0.47-0.76)	0.07 (0-0.21)	0.29 (0.24-0.35)	0.71 (0.67-0.75)	0.39 (0.34-0.43)
Physics	0.80 (0.65-0.85)	0.00 (0-0.13)	0.20 (0.15-0.26)	0.81 (0.74-0.86)	0.38 (0.29-0.46)
Chemistry	0.57 (0.40-0.74)	0.20 (0.05-0.33)	0.23 (0.18-0.29)	0.77 (0.71-0.82)	0.48 (0.41-0.54)
English composite	0.65 (0.57-0.70)	0.00 (0-0.06)	0.35 (0.30-0.41)	0.67 (0.61-0.73)	0.27 (0.20-0.33)
Second language	0.75 (0.52-0.88)	0.09 (0-0.29)	0.17 (0.11-0.23)	0.84 (0.78-0.89)	0.45 (0.35-0.55)
History	0.53 (0.33-0.71)	0.13 (0-0.29)	0.34 (0.28-0.41)	0.66 (0.59-0.73)	0.40 (0.33-0.47)
Geography	0.52 (0.29-0.71)	0.13 (0-0.31)	0.35 (0.28-0.43)	0.65 (0.57-0.72)	0.40 (0.32-0.47)
Psychology	0.65 (0.55-0.71)	0 (0-0)	0.35 (0.29-0.41)	0.69 (0.62-0.75)	0.26 (0.17-0.34)

Supplementary Table S4. Model fitting results for univariate analyses for A-level exam achievement with twin intraclass correlations (N of complete pairs). A-additive genetic; C- shared environmental; E- non-shared environmental proportions of the variance (95% confidence intervals)

Subject	A	C	E	Twin intraclass correlations	
				MZ	DZ
A-level mean grade	0.59 (0.48-0.69)	0.07 (0-0.16)	0.34 (0.31-0.37)	0.64 (1076) (0.60-0.68)	0.36 (1972) (0.32-0.41)
Humanities mean grade	0.49 (0.28-0.66)	0.11 (0-0.29)	0.39 (0.33-0.47)	0.61 (462) (0.53-0.68)	0.36 (815) (0.26-0.45)
STEM mean grade	0.65 (0.49-0.71)	0.02 (0-0.16)	0.33 (0.29-0.38)	0.65 (616) (0.59-0.70)	0.32 (1106) (0.25-0.40)
Mathematics mean grade	0.63 (0.44-0.69)	0.00 (0-0.16)	0.37 (0.31-0.44)	0.63 (364) (0.55-0.70)	0.24 (648) (0.12-0.36)
Biology grade	0.63 (0.37-0.78)	0.11 (0-0.32)	0.27 (0.22-0.35)	0.71 (279) (0.62-0.78)	0.43 (533) (0.29-0.55)
Physics grade	0.49 (0.12-0.78)	0.22 (0-0.54)	0.29 (0.21-0.40)	0.71 (151) (0.57-0.80)	0.51 (292) (0.28-0.68)
Chemistry grade	0.76 (0.49-0.84)	0.03 (0-0.28)	0.21 (0.16-0.28)	0.79 (225) (0.71-0.85)	0.38 (421) (0.22-0.52)
English composite grade	0.54 (0.29-0.77)	0.19 (0-0.41)	0.27 (0.22-0.34)	0.71 (312) (0.62-0.78)	0.45 (592) (0.31-0.57)
Second language mean grade	0.60 (0.20-0.86)	0.20 (0-0.55)	0.21 (0.21-0.31)	0.64 (110) (0.47-0.77)	0.47 (164) (0.15-0.70)
History grade	0.35 (0.03-0.69)	0.29 (0-0.54)	0.36 (0.28-0.48)	0.64 (235) (0.51-0.74)	0.46 (440) (0.29-0.60)
Geography grade	0.49 (0.15-0.78)	0.23 (0-0.51)	0.28 (0.21-0.40)	0.74 (182) (0.61-0.83)	0.49 (312) (0.30-0.64)
Psychology grade	0.45 (0.05-0.71)	0.17 (0-0.51)	0.38 (0.29-0.51)	0.58 (221) (0.43-0.69)	0.39 (379) (0.17-0.57)