Supplemental Materials For:

Attained SES as a moderator of adult cognitive performance:

Testing gene-environment interaction in various cognitive domains

The authors have composed the Integral Supplemental Materials to include additional information regarding methods, results, tables, and figures that will contribute to interested readers' understanding and are relevant to any interest in replication.

Supplemental Materials *Table of Contents:*

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I. Supplemental Method

Measures

Cognitive Measures. The cognitive tests used in the current study reflect those tests available for harmonization across more than one study in the IGEMS consortium, and do not reflect the full cognitive batteries available in each separate sample. Due to differences in administration and scoring across studies, it was necessary to re-scale the cognitive scores to a common metric. Participants were divided into the following four age groups based on availability of data across the cognitive tests: below 50, 50 to 59.99, 60 to 69.99, and 70 plus. Samples from the Swedish studies were pooled due to similarity in test procedures. Similarly, the two Danish studies were pooled as well. After using regression to adjust for the main effect of sex for each test within these study-country combinations, scores for each cognitive test were placed on a T-score scale (M = 50, SD = 10) in 10-year age groups relative to the 50-59.99 year age groups. Cognitive test scores were then winsorized within age group, limiting scores to the ±3 SD range from the age group mean.

Attained SES. As noted in the main article, harmonization of SES was conducted with all available data in the full IGEMS sample (i.e. 9 twin studies). Initially, participants identifying as housewives/husbands were scored zero on this harmonized SES scale. We considered it reasonable to use spousal occupation information as the attained SES score for housewives/husbands where available because, in our largely older-aged cohorts, significant portions of participants were categorized as housewives and among married individuals, resource-related associations tend to be shared. Though elective use of resources (for example, family financial planning and choice of leisure activities) tends to be associated with individual level of education (Antonides, 2011), large portions of our older cohorts were employed in

agrarian occupations, and it is likely that farm wives engaged in similar daily activities as their husbands.

To standardize attained SES scores across studies, participants were split into five age groups: below 50, 50 to 59.99, 60 to 69.99, and 70 to 79.99, and 80 plus due to likely cohort differences in SES structure as experienced by different age groups and differences in heritability and nonshared environmental influences in late life (Finkel & Reynolds, 2009; Johnson, McGue, & Deary, 2014; Reynolds et al., 2005). To control potential country differences, SES scores were first z-scored within country, with ages 50 to 59.99 as the referent group (i.e. means and standard deviations in the other groups were stated relative to those in this group, placing all on the same scale). Then, all SES values were linearly transformed to a T-score scale with a mean of 50 and a standard deviation of 10 in the ages 50 to 59.99.

Rearing SES. As for attained SES, parents coded as housewife/husband were scored 0 and excluded from the analyses if no occupational information was available for the other parent. Reports of twins reared together were averaged for mothers' and fathers' occupation. In the full IGEMS sample of twin pairs reared together the correlation between each twin's report for rearing SES was 0.82, with 79% of twins reporting zero difference (note these descriptives exclude VETSA in which rearing SES was averaged between twins prior to inclusion in IGEMS). For twins reared apart, the correlation for rearing SES was 0.32. The highest occupation score of the two parents was taken as the pair's rearing SES, except that we retained the individual reports for twins reared apart (182 twin pairs in SATSA; 6 twin pairs in MTSADA).

Individually-attained SES. For sensitivity analyses, participants' individual-attained SES (rather than the aforementioned household-level indicator) was constructed using only

participant's reported occupation. In this case, an attained SES score of 0 was retained for housewives/husbands and used in the analyses. Individually-attained SES was standardized in the same manner as household-level attained SES, by age group and country, and put on a T-score scale with a mean of 50 and a standard deviation of 10 in the ages 50 to 59.99. In this subsample, just over 50% of the participants were women (total N=12,055).

Statistical Analysis

This Purcell model has previously been used in studies using some of the twin samples included in IGEMS (Johnson, Deary, McGue, & Christensen, 2009; Johnson & Krueger, 2005). van der Sluis, Posthuma, and Dolan (2012) has noted that the Purcell (2002) univariate moderation model can indicate false moderation when the moderator is shared by the twins and is correlated with the outcome, but this situation was not relevant to the bivariate model used in these analyses, as each twin had individually-coded attained SES.

II. Supplemental Results

Age moderation of cognitive performance

Age moderation analyses of Synonyms, controlling for attained SES, indicated greater variance in cognitive performance for older individuals, largely due to greater genetic influences, as well as shared and nonshared environmental variances (see Figure S2). Age moderation analyses indicated generally stable overall variance for Digits Forward in older individuals, but with smaller genetic influences and greater nonshared and shared environmental influences at older ages (see Figure S2). Age moderation analyses of Digits Backward indicated very little difference in total variance for cognitive performance, but with evidence of smaller genetic influences and greater shared and nonshared environmental influences at older ages (see Figure S2). For Block Design, age moderation analyses indicated less variance in cognitive performance

for older individuals due to smaller contributions of shared environmental influences and additive genetic influences at older ages. There was also evidence of greater nonshared environmental influences for older individuals' performance on Block Design (see Figure S2). For Symbol Digit, greater variance in cognitive performance for older individuals was observed, largely due to greater genetic influences, with smaller contributions of nonshared environmental influences (see Figure S2).

Differences by Region. For Symbol Digit, the patterns of overall A variance were very similar between regions, but for the U.S. sample this was a function of moderation on the unique path (β_{XU}) whereas for the Scandinavian samples it was due to moderation on the common path (β_{XC}). Given the common moderation observed in the Scandinavian sample, we conducted a test for uniformly nonlinear main effects, which was not significant [$\chi_s(1) = 0.61$, $p = 0.433$]. That said, the betas (β_{XC}, β_{XU}) offset each other in direction, one negative, one positive (Supplemental Table S4); this is most strongly evident in the Scandinavian and full-sample analyses and less so in the U.S. sample where moderation of unique variance dominated. This suggested that neither the moderation model nor nonlinear main effects model captured the full picture. Unfortunately, we cannot determine if these results are due to test type confounding with country/region or whether they may indicate real regional differences in mechanisms for moderation. Fuller examinations of regional differences in other studies are required to identify the mechanisms relating attained SES to cognitive abilities at both population and individual levels.

Rearing SES adjustments. As noted in the main paper, bivariate moderation models including rearing SES and attained SES as moderators of adult cognitive performance (Figure S3) produced patterns of moderation by attained SES on the ACE variance components similar to the main results (Figure 3). Estimates from univariate models with rearing SES as a moderator of

adult cognitive performance for Synonyms (verbal) and Symbol Digit (perceptual speed) are shown in Figure S5. Results for rearing SES moderation patterns are consistent between the bivariate and univariate model, indicating that less variance in cognitive performance at high levels of rearing SES is due mainly to suppression of genetic effects, and showing nonshared environmental effects remain fairly steady.

Individually-attained SES as a moderator

In comparing the full model results between household-level attained SES and participants' individually-attained SES (see Figures S1 and S6), for the most part, we see the same general trends in how attained SES moderates adult cognitive performance such that genetic influences on the common pathway are slightly larger at high levels of individually-attained SES compared to low individually-attained SES. For the unique pathway, genetic influences were relatively stable or suppressed at high levels of individually-attained SES. Notably, these moderation trends were also evident for Symbol Digit, with unique genetic variance stable by level of individually-attained SES. In comparison to the household-level SES indicator, we do see clearer shifts in shared environmental variance on the Unique pathway, with attenuated effects evident at high levels of individually-attained SES.

Table S1 *Mixed Effects Regression Analyses accounting for pair dependencies*

Effect	B	SE (B)	DF	t	*P*
Attained SES					
Intercept	49.256	0.14	6096	350.56	<.01
Sex	-0.277	0.19	6097	-1.45	.15
Age (years)	-0.169	0.01	6097	-20.89	<.01
Rearing SES					
Intercept	50.469	0.13	5885	380.11	<.01
Sex	-0.003	0.05	5867	-0.06	.96
Age (years)	-0.057	0.01	5867	-5.46	<.01
Synonyms					
Intercept	48.408	0.23	2267	207.68	<.01
Sex	-1.170	0.34	2035	-3.49	<.01
Attained SES	0.285	0.02	2035	18.17	<.01
Age (years)	-0.123	0.01	2035	-8.69	<.01
Attained SES * Age (years)	0.004	0.00	2035	3.77	<.01
Symbol Digit					
Intercept	45.818	0.18	3845	248.79	<.01
Sex	0.853	0.24	3169	3.62	<.01
Attained SES	0.253	0.01	3169	21.58	<.01
Age (years)	-0.542	0.01	3169	-45.88	<.01
Attained SES * Age (years)	0.003	0.00	3169	2.48	.01
Digits Forward					
Intercept	49.741	0.16	4146	305.23	<.01
Sex	0.186	0.24	3709	0.79	.43
Attained SES	0.166	0.01	3709	14.34	<.01
Age (years)	-0.050	0.01	3709	-4.23	<.01
Attained SES * Age (years)	-0.001	0.00	3709	-0.78	.43
Digits Backward					
Intercept	49.211	0.15	4639	318.77	<.01
Sex	0.335	0.22	4078	1.52	.13
Attained SES	0.163	0.01	4078	15.54	<.01
Age (years)	-0.128	0.01	4078	-12.14	<.01
Attained SES * Age (years)	0.003	0.00	4078	2.77	<.01
Block Design					
Intercept	46.147	0.39	1191	119.60	<.01
Sex	0.795	0.44	952	1.81	.07
Attained SES	0.222	0.02	952	9.23	<.01
Age (years)	-0.381	0.02	952	-19.85	<.01
Attained SES *Age (years)	-0.002	0.00	952	-1.11	.25

Note. Analyses centered age on 60 years and attained SES (t-scored) on 50. Attained SES in this table corresponds to household-level Attained SES

Table S2
Mixed Effects Regression Analyses including Attained SES Linear and Quadratic Terms

Effect	B	SE (B)	DF	t	*p*
Synonyms					
Intercept	48.128	0.27	2221	179.36	<.01
Sex	-1.244	0.33	1998	-3.73	<.01
Age (years)	-0.132	0.01	1998	-9.61	<.01
Rearing SES (linear)	0.164	0.02	1998	8.53	<.01
Attained SES (linear)	0.251	0.02	1998	14.42	<.01
Attained SES (quadratic)	0.001	0.00	1998	0.75	.45
Symbol Digit					
Intercept	45.836	0.23	3778	203.21	<.01
Sex	-0.549	0.01	3115	-46.45	<.01
Age (years)	0.907	0.24	3115	3.85	<.01
Rearing SES (linear)	0.108	0.01	3115	7.91	<.01
Attained SES (linear)	0.230	0.01	3115	18.59	<.01
Attained SES (quadratic)	-0.002	0.00	3115	-1.31	.19
Digits Forward					
Intercept	49.525	0.20	3942	242.54	<.01
Sex	0.223	0.24	3571	0.93	0.35
Age (years)	-0.050	0.01	3571	-4.13	<.01
Rearing SES (linear)	0.088	0.01	3571	6.55	<.01
Attained SES (linear)	0.149	0.01	3571	11.85	<.01
Attained SES (quadratic)	0.002	0.00	3571	1.42	0.15
Digits Backward					
Intercept	48.973	0.19	4430	259.63	<.01
Sex	0.322	0.22	3939	1.44	0.15
Age (years)	-0.130	0.01	3939	-11.87	<.01
Rearing SES (linear)	0.088	0.01	3939	7.34	<.01
Attained SES (linear)	0.151	0.01	3939	13.06	<.01
Attained SES (quadratic)	0.002	0.00	3939	1.58	.11
Block Design					
Intercept	46.086	0.45	1141	102.77	<.01
Sex	0.693	0.44	906	1.57	0.12
Age (years)	-0.374	0.02	906	-19.19	<.01
Rearing SES (linear)	0.121	0.03	906	4.27	<.01
Attained SES (linear)	0.194	0.03	906	7.58	<.01
Attained SES (quadratic)	0.001	0.00	906	0.37	.71

Note. Analyses centered age on 60 years and both rearing SES (t-scored) and attained SES (t-scored) are centered on 50. Sex is centered on Men. Mixed Effects regression models account for pair dependencies. Attained SES in this table corresponds to household-level Attained SES

Table S3

Fit Statistics and Power for Attained SES moderation of cognitive performance: adjusted for mean-level sex effects

Model	Estimated Parameters	-2LL	df	AIC	Sample-adjusted BIC	$\Delta\chi^2$	Δdf	p-value
Synonyms N=4,307								
Full ACE Bivariate Moderation Model	28	121073.6	16475	88131.0	14917.8	115.0	6	1.83E-22
ACE Bivariate with no moderation effects	22	121188.6	16481	88232.8	14958.1			
ACE Bivariate with only genetic moderation effects	24	121102.4	16479	88150.6	14920.5	86.2	2	1.91E-19
ACE Bivariate with only common environment moderation effects	24	121130.4	16479	88178.1	14934.3	58.2	2	2.30E-13
ACE Bivariate with only unique environment moderation effects	24	121094.4	16479	88143.8	14917.1	94.2	2	3.51E-21
AE Bivariate with moderation effects	23	121145.1	16480	88193.2	14940.0	--	--	--
CE Bivariate with moderation effects	23	121144.4	16480	88192.5	14939.7	--	--	--
Only unique moderation*	25	121081.8	16478	88132.8	14913.4	106.8	3	5.36E-23
Only common moderation	25	121116.6	16478	88160.6	14930.8	72.0	3	1.59E-15
Just Unique A moderation	23	121106.2	16480	88152.1	14919.5	82.5	1	1.06E-19
Just Unique C moderation	23	121131.4	16480	88177.2	14932.0	57.2	1	3.94E-14
Just Unique E moderation	23	121095.7	16480	88143.2	14915.0	92.9	1	5.50E-22
Digits Forward N=7,860								
Full ACE Bivariate Moderation Model	28	147385.9	20028	18235.5	18031.9	36.2	6	2.52E-06
ACE Bivariate with no moderation effects	22	147422.1	20034	18237.0	18060.7			
ACE Bivariate with only genetic moderation effects	24	147403.9	20032	18233.4	18039.3	18.2	2	1.12E-04
ACE Bivariate with only common environment moderation effects	24	147409.2	20032	18236.1	--	12.9	2	1.58E-03
ACE Bivariate with only unique environment moderation effects	24	147397.3	20032	18230.1	18053.7	24.8	2	4.12E-06
AE Bivariate with moderation effects	23	147449.0	20033	18253.2	18066.7	--	--	--
CE Bivariate with moderation effects	23	147436.5	20033	18247.0	18285.2	--	--	--
Only unique moderation	25	147395.3	20031	18231.9	18052.9	26.8	3	6.48E-06
Only common moderation	25	147401.4	20031	18235.0	18042.4	20.6	3	1.27E-04
Just Unique A moderation	23	147411.1	20033	18234.3	18054.7	10.9	1	9.62E-04
Just Unique C moderation	23	147416.8	20033	18237.1	--	5.2	1	2.26E-02
Just Unique E moderation*	23	147397.7	20033	18227.6	18051.3	24.3	1	8.24E-07
Digits Backward N=8,722								
Full ACE Bivariate Moderation Model	28	153923.0	20890	112143.0	18235.5	64.2	6	6.28E-12
ACE Bivariate with no moderation effects	22	153987.2	20896	112195.2	18237.0			
ACE Bivariate with only genetic moderation effects	24	153939.4	20894	112151.4	18233.4	47.9	2	3.97E-11
ACE Bivariate with only common environment moderation effects	24	153972.4	20894	112184.4	18236.1	14.9	2	5.81E-04

Model	Estimated Parameters	-2LL	df	AIC	Sample-adjusted BIC	$\Delta\chi^2$	Δdf	p-value
ACE Bivariate with only unique environment moderation effects	24	153957.8	20894	112169.8	18230.1	29.4	2	4.13E-07
AE Bivariate with moderation effects	23	154002.2	20895	112212.2	18253.2	--	--	--
CE Bivariate with moderation effects	23	153997.1	20895	112207.1	18247.0	--	--	--
Only unique moderation	25	153960.1	20893	112174.1	18231.9	27.2	3	5.35E-06
Only common moderation*	25	153933.5	20893	112147.5	18235.0	53.8	3	1.24E-11
Just Unique A moderation	23	153974.7	20895	112184.7	18234.3	12.6	1	3.86E-04
Just Unique C moderation	23	153977.9	20895	112187.9	18237.1	9.3	1	2.29E-03
Just Unique E moderation	23	153962.9	20895	112172.9	18227.6	24.3	1	8.24E-07
Block Design **N**=2,148								
Full ACE Bivariate Moderation Model	28	105858.1	14316	77226.1	19117.2	31.2	6	2.32E-05
ACE Bivariate with no moderation effects	22	105889.4	14322	77245.4	19132.7			
ACE Bivariate with only genetic moderation effects*	24	105870.0	14320	77230.0	19114.3	19.4	2	6.13E-05
ACE Bivariate with only common environment moderation effects	24	105877.1	14320	77237.1	19130.8	12.2	2	2.24E-03
ACE Bivariate with only unique environment moderation effects	24	105888.3	14320	77248.3	19123.5	1.0	2	6.07E-01
AE Bivariate with moderation effects	23	105948.3	14321	77306.3	19143.0	--	--	--
CE Bivariate with moderation effects	23	105935.6	14321	77293.6	19140.4	--	--	--
Only unique moderation	25	105878.3	14319	77240.3	19127.4	11.0	3	1.17E-02
Only common moderation	25	105867.0	14319	77229.0	19114.1	22.3	3	5.65E-05
Just Unique A moderation	23	105882.7	14321	77240.7	19129.2	6.6	1	1.02E-02
Just Unique C moderation	23	105880.4	14321	77238.4	19130.8	8.9	1	2.85E-03
Just Unique E moderation	23	105889.1	14321	77247.1	19123.3	0.3	1	5.84E-01
Symbol Digit N= 7,019								
Full AcE Bivariate Moderation Model*	24	142343.5	19191	103961.5	18031.9	79.7	4	2.02E-16
AcE Bivariate with no moderation effects	20	142423.2	19195	104033.2	18060.7			
AcE Bivariate with only genetic moderation effects	22	142369.2	19193	103983.2	18039.3	54.0	2	2.02E-16
AcE Bivariate with only common environment moderation effects	--	--	--	--	--	--	--	
AcE Bivariate with only unique environment moderation effects	22	142398.1	19193	104012.1	18053.7	25.1	2	1.88E-12
AE Bivariate with moderation effects	23	142418.6	19192	104034.6	18066.7	--	--	--
cE Bivariate with moderation effects	19	142877.7	19196	104485.7	18285.2	--	--	3.54E-06
Only unique moderation	22	142396.4	19193	104010.4	18052.9	26.8	2	--
Only common moderation	22	142375.5	19193	103989.5	13284.3	47.7	2	--
Just Unique A moderation	21	142405.6	19194	104017.6	13286.6	17.6	1	1.52E-06
Just Unique C moderation	--	--	--	--	13285.4	--	--	4.39E-11
Just Unique E moderation	21	142398.9	19194	104010.9	13289.8	24.3	1	2.73E-05

Table S4

Estimated parameters from Attained SES moderation of Cognitive Performance, best fitting model with confidence intervals

	Synonyms N= 4,307			**Digits Forward** N= 7,860			**Digits Backward** N= 8,722			**Block Design** N=2,148			**Symbol Digit** N= 7,019		
Estimated Model Parameters	Estimate	LL 2.5%	UL 2.5%	Estimate	LL 2.5%	UL 2.5%	Estimate	LL 2.5%	UL 2.5%	Estimate	LL 2.5%	UL 2.5%	Estimate	LL 2.5%	UL 2.5%
Cognitive Performance Common Variance Pathways															
A															
Genetic variance	4.55*	2.38	6.72	2.01	.23	3.79	-2.78*	-3.57	-1.99	4.23*	1.36	7.10	6.76*	5.92	7.60
SES moderation of **A**	-	-	-	-	-	-	-.18*	-.23	-.13	.26*	.16	.37	-.18*	-.23	-.14
Age moderation of **A**	.19	-1.18	1.56	-.38	-1.38	.62	-.03	-.64	.58	-.19	-1.01	.64	-1.13*	-1.60	-.67
Age sq moderation of **A***	-	-	-	-	-	-	-	-	-	-	-	-	.86*	.59	1.13
C															
shared environmental variance	3.90*	2.56	5.24	2.10*	.84	3.36	1.81*	1.07	2.55	3.04*	.82	5.26	-	-	-
SES moderation of **C**	-	-	-	-	-	-	-.05	-.11	. .001	-	-	-	-	-	-
Age moderation of **C**	1.36*	.53	2.18	.16	-.45	.77	.64*	.22	1.06	.82	-.39	2.02	-	-	-
E															
nonshared environmental variance	.25	-.20	.70	.19	-.17	.55	.10	-.20	.41	.61	.02	1.20	.18	-.19	.56
SES moderation of **E**	-	-	-	-	-	-	-.02	-.05	.01	-	-	-	.08*	.05	.12
Age moderation of **E**	-.02	-.36	.31	-.002	-.27	.27	.21	-.04	.46	.04	-.35	.43	-.59*	-.90	-.28
Age sq moderation of **E***	-	-	-	-	-	-	-	-	-	-	-	-	.42*	.23	.62
Cognitive Performance Unique Variance Pathways															
A															
Genetic variance	5.38*	4.20	6.57	5.02*	3.89	6.16	4.19*	2.50	5.87	5.44*	3.60	7.29	4.41*	3.25	5.57
SES moderation of **A**	-.06	-.13	.01	-	-	-	-	-	-	-.13	-.25	.00	.16*	.11	.21
Age moderation of **A**	.70	-.55	1.96	-.70	-1.44	.04	-1.32	-2.39	-.26	-.56	-1.50	.39	2.36*	1.54	3.18
Age sq moderation of **A***	-	-	-	-	-	-	-	-	-	-	-	-	.39	.04	.74

	Synonyms N= 4,307			**Digits Forward** N= 7,860			**Digits Backward** N= 8,722			**Block Design** N=2,148			**Symbol Digit** N= 7,019		
Estimated Model Parameters	Estimate	LL 2.5%	UL 2.5%	Estimate	LL 2.5%	UL 2.5%	Estimate	LL 2.5%	UL 2.5%	Estimate	LL 2.5%	UL 2.5%	Estimate	LL 2.5%	UL 2.5%
C *shared environmental variance*	.85	-1.07	2.77	2.59*	.88	4.31	2.33	.22	4.44	5.60*	4.03	7.16	-	-	-
SES moderation of **C**	-.08	-.16	-.01	-	-	-	-	-	-	-	-	-	-	-	-
Age moderation of **C**	-2.10*	-2.79	-1.42	.47	-.42	1.21	.89	.09	1.69	-2.69*	-3.70	-1.69	-	-	-
E *nonshared environmental variance*	6.21*	5.85	6.57	7.48*	7.23	7.73	7.63*	7.36	7.90	5.68*	5.26	6.11	6.02*	5.73	6.32
SES moderation of **E**	-.08*	-.12	-.05	.04*	.03	.06	-	-	-	-	-	-	-.03	-.05	0.000
Age moderation of **E**	.44*	.14	.75	.15	-.06	.36	.21	.02	.39	.57*	.30	.85	.16	-.04	.37
Age sq moderation of **E***	-	-	-	-	-	-	-	-	-	-	-	-	-.11	-.25	.03
Attained SES Unique Variance Pathways															
A *Genetic variance*	4.07*	3.05	5.09	4.08*	3.03	5.13	-3.92*	-4.96	-2.89	2.92*	1.61	4.22	4.70*	4.26	5.13
Age moderation of A	-1.02*	-1.48	-.56	-1.04*	-1.51	-.56	1.27*	.86	1.67	-1.73*	-2.18	-1.28	1.14*	.86	1.43
C *shared environmental variance*	4.67*	3.94	5.40	4.66*	3.91	5.40	4.63*	3.90	5.36	5.05*	4.45	5.65	3.87*	3.38	4.37
Age moderation of **C**	.97*	.60	1.34	.97*	.60	1.35	1.08*	.72	1.44	.94*	.52	1.35	-.75*	-1.13	-.37
E *nonshared environmental variance*	7.73*	7.53	7.93	7.73*	7.53	7.93	7.75*	7.56	7.94	7.82*	7.64	8.01	7.73*	7.57	7.90
Age moderation of **E**	-.20*	-.33	-.07	-.19*	-.32	-.07	-.17*	-.29	-.05	-.16	-.29	-.03	-.49*	-.61	-.36

Note. LL= Lower Limit Confidence Interval, UL= Upper Limit Confidence Interval. *< p=.01, a conservative *p*-value is noted given large sample sizes.

Table S5

Parameter estimates for household-level Attained SES moderation of Symbol Digit performance by region, adjusted for age moderation, and average effects of sex.

	Additive Genetic					Shared Environment					Nonshared Environment				
Region	a_{SES}	a_C	a_U	β_{XC}	β_{XU}	c_{SES}	c_C	c_U	β_{YC}	β_{YU}	e_{SES}	e_C	e_U	β_{ZC}	β_{ZU}
USA	2.93	1.71	7.81	.15	-.15	4.31	*0*	*0*	*0*	*0*	8.61	.93	6.05	.00	-.05
Scandinavia	4.55	7.22	4.57	-.20	.16	3.98	*0*	*0*	*0*	*0*	7.52	.56	5.85	.08	-.02
Full Sample	4.29	6.73	4.93	-.21	.15	4.10	*0*	*0*	*0*	*0*	7.77	.69	5.92	.08	-.02

Note. The parameter estimates follow from a bivariate GxE model (see Figure 1 of the main paper). Path estimates a_{SES}, c_{SES}, e_{SES} reflect genetic and environmental influences on attained SES, while a_C, a_U, e_C, e_U reflect genetic and environmental influences on cognitive performance. Paths subscripted with 'c', i.e., a_C, and e_C , indicate influences in common between attained SES and cognition. Paths subscripted with 'u', a_U and e_U, reflect influences unique to cognitive performance. Regression weights, β_{XC} and β_{ZC} reflect the moderating effect of attained SES on variance it shares in common with cognitive performance, while β_{XU} and β_{ZU} indicate the moderating effect of attained SES on variance unique to cognitive performance. In this case, due to evidence of non-additive genetic influences in Symbol Digit performance (Pahlen et al., 2018), shared environmental paths (c_C, c_U) and paths reflecting moderating effects of attained SES on shared environmental influences (β_{YC} and β_{YU}) are not estimated and thus fixed to zero. Regional differences are confounded with test type, as the U.S. samples used Digit Symbol and the Scandinavian samples used Symbol Digit.

Table S6

Testing for direction of moderation: subsample with complete household-level Attained SES and cognitive test data.

SES --> Cog	Full Model				No Moderation Model			
	Parameters	Log-likelihood	AIC	BIC	Parameters	Log-likelihood	AIC	BIC
Block Design	30	-15463.50	30986.99	31132.85	15	-15703.54	31437.08	31510.00
Digit Symbol	30	-50797.84	101655.68	101837.54	15	-51605.79	103241.57	103332.51
Digit Span - Forward	30	-58930.82	117921.63	118108.21	15	-59720.20	119470.40	119563.69
Digit Span - Backward	30	-65289.52	130639.03	130828.46	15	-66185.87	132401.75	132496.46
Synonyms	30	-32361.70	64783.40	64952.01	15	-32931.06	65892.13	65976.43

Cog --> SES	Full Model				No Moderation Model			
	Parameters	-2 Log-likelihood	AIC	BIC	Parameters	Log-likelihood	AIC	BIC
Block Design	30	-15913.38	31886.76	32032.61	15	-15703.54	31437.08	31510.00
Digit Symbol	30	-53239.99	106539.97	106721.84	15	-51605.79	103241.57	103332.51
Digit Span - Forward	30	-62204.17	124468.35	124654.93	15	-59720.20	119470.40	119563.69
Digit Span - Backward	30	-70046.63	140153.27	140342.69	15	-66185.87	132401.75	132496.46
Synonyms	30	-33753.55	67567.11	67735.71	15	-32931.06	65892.13	65976.43

Note. Pooled sample, adjusted for sex. AIC = Akaike information criterion; BIC = Bayesian information criterion; SES→COG = ACE Bivariate model where etiological influences in cognitive performance are linear functions of attained SES; COG→SES = ACE Bivariate model where etiological influences in attained SES are linear functions of cognitive performance

Table S7: *Twin Correlations and cross-trait correlations for attained SES and cognitive test scores by Birth Cohorts before and after 1940*

	Complete pairs **(incomplete pairs)**			**Within-Trait Twin Correlations**			**Cross-Trait Correlations between Attained SES & Cognitive Tests**		
Trait	MZ	SSDZ	OSDZ	MZ	SSDZ	OSDZ	MZ	SSDZ	OSDZ
Birth Cohort 1893 - 1939									
Attained SES	*1073*	*1337*	*516*	0.42	0.34	0.33	.	.	.
*Rearing SES**	*983*	*1228*	510				*0.28*	*0.36*	*0.31*
	(7)	(8)							
Synonyms (SYN)	*150*	*225*	*201*	0.73	0.23	0.35	0.36	0.22	0.29
	(65)	(110)	(39)						
Digits Forward (DF)	767	936	244	0.36	0.27	0.13	0.18	0.13	0.19
	(140)	(264)	(13)						
Digits Backward	791	950	258	0.37	0.21	0.28	0.22	0.14	0.12
(DB)	(145)	(276)	(16)						
Block Design (BD)	278	311	203	0.61	0.35	-0.14	0.27	0.13	0.07
	(63)	(121)	(39)						
Symbol Digit (SD)	748	815	356	0.60	0.37	0.37	0.21	0.20	0.21
	(184)	(344)	(83)						
Birth Cohort 1940 -1971									
Attained SES	1286	1286	476	0.36	0.26	0.21	.	.	.
*Rearing SES**	1366	1276	472				*0.22*	*0.25*	*0.26*
	(3)	(1)							
Synonyms (SYN)	718	728	.	0.60	0.41	.	0.27	0.19	.
	(3)	(12)							
Digits Forward (DF)	755	644	366	0.47	0.29	0.23	0.17	0.13	0.14
	(6)	(9)	(4)						
Digits Backward	879	745	447	0.40	0.22	0.22	0.14	0.11	0.15
(DB)	(51)	(38)	(29)						
Block Design (BD)	96	67	.	0.71	0.58	.	0.17	0.12	.
	(9)	(6)							
Symbol Digit (SD)	479	423	351	0.56	0.20	0.19	0.23	0.17	0.19
	(26)	(19)	(19)						

Note. Correlations estimated in Mx, restricting sample to pairs with complete data on Attained SES scores.
MZ= Monozygotic, SSDZ=Same-Sex Dizygotic, OSDZ=Opposite-Sex Dizygotic. Included incomplete twin pairs e.g. one twin without cognitive assessment in parentheses
*Rearing SES is correlated with attained SES. Correlations were fixed within pairs and allowed to vary between zygosities.

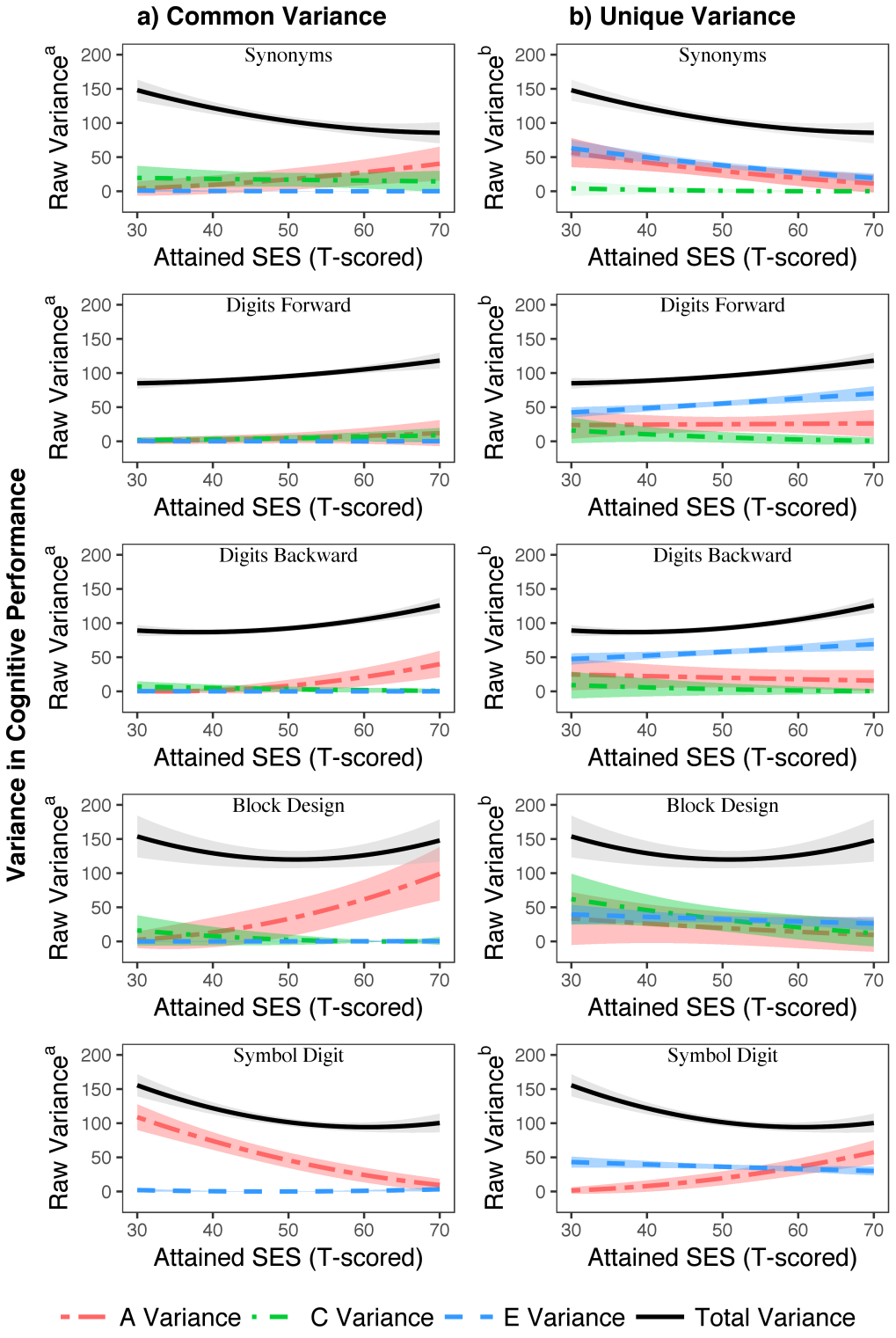

Figure S1. Raw Variances in cognitive performance for the Full Moderation Model with household-level Attained SES

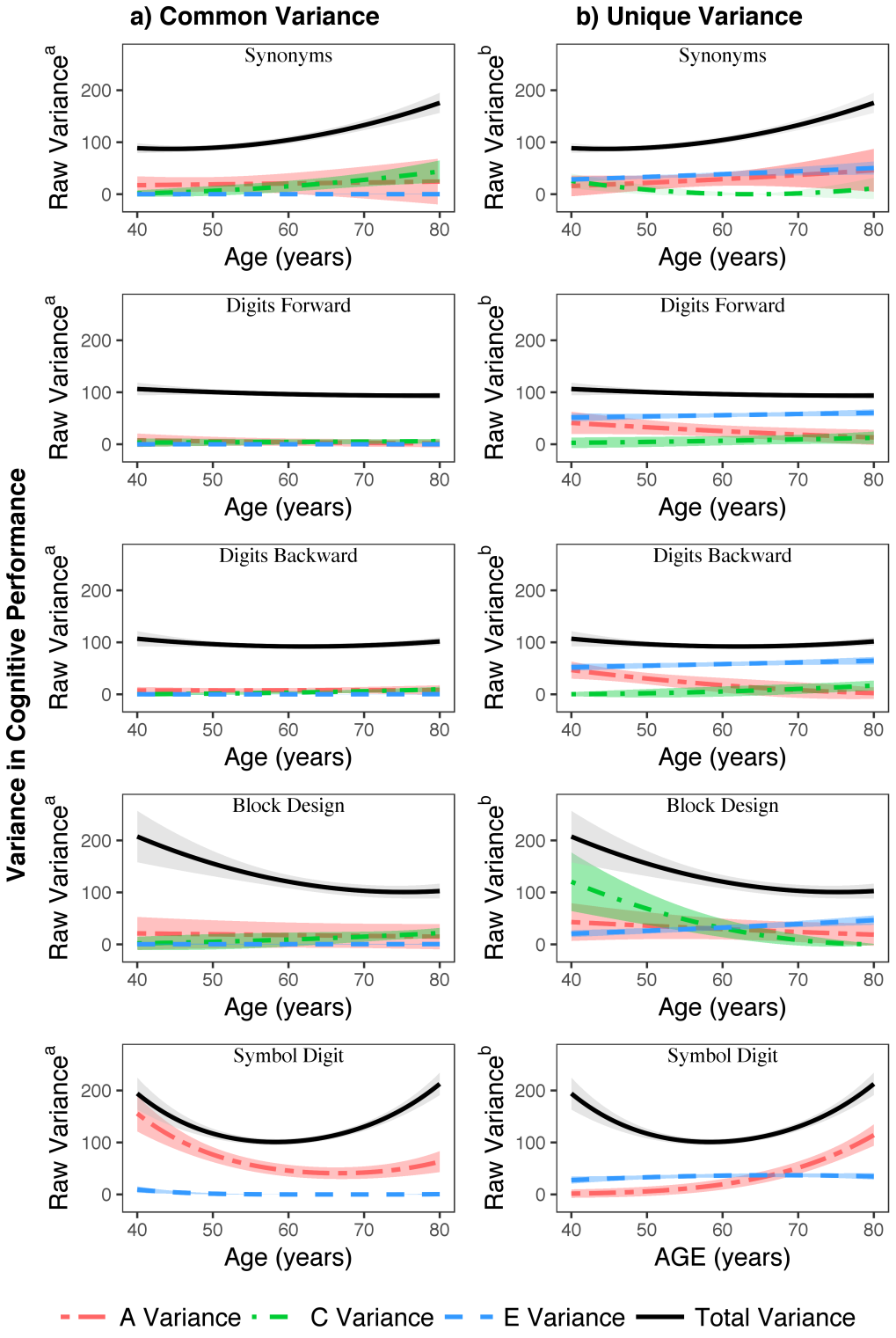

Figure S2. Raw Variances in cognitive performance by Age, adjusted for household-level Attained SES moderation. Age moderation for performance on Symbol Digit includes a nonlinear term.

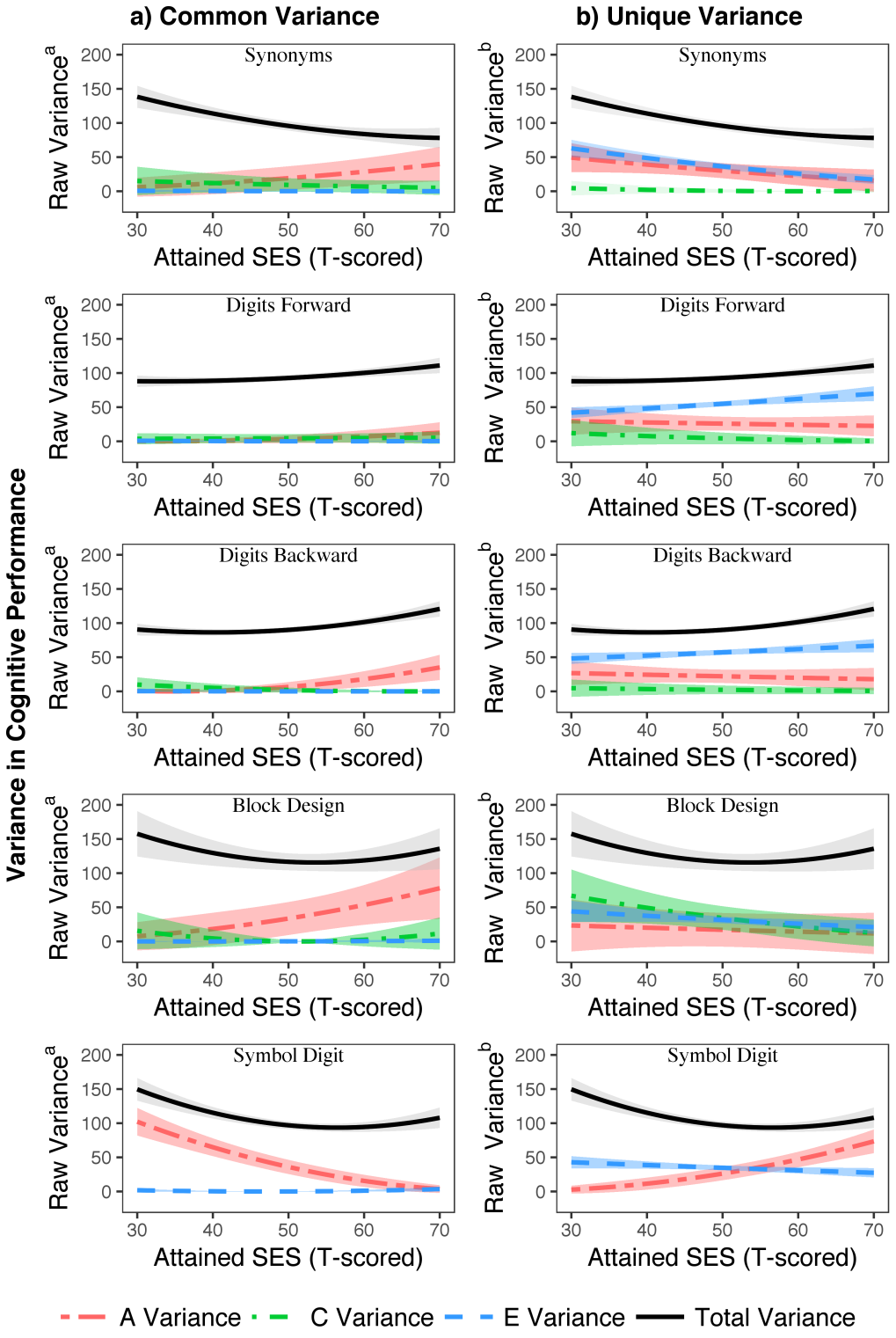

Figure S3. Raw Variances in cognitive performance by household-level attained SES, adjusted for rearing SES & Age moderation.

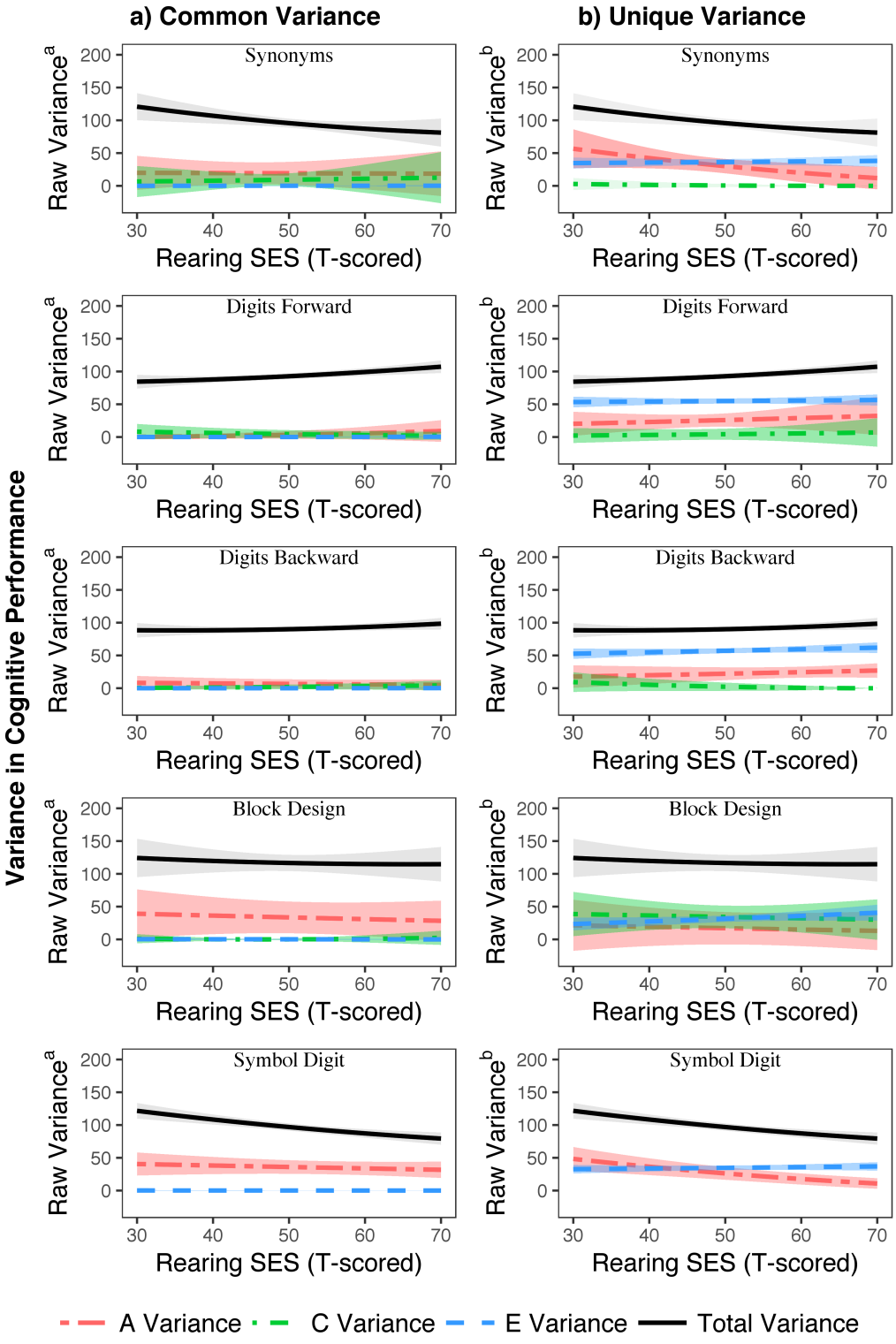

Figure S4. Raw Variances in cognitive performance by rearing SES in the full bivariate moderation model, adjusted for household level attained SES & Age moderation.

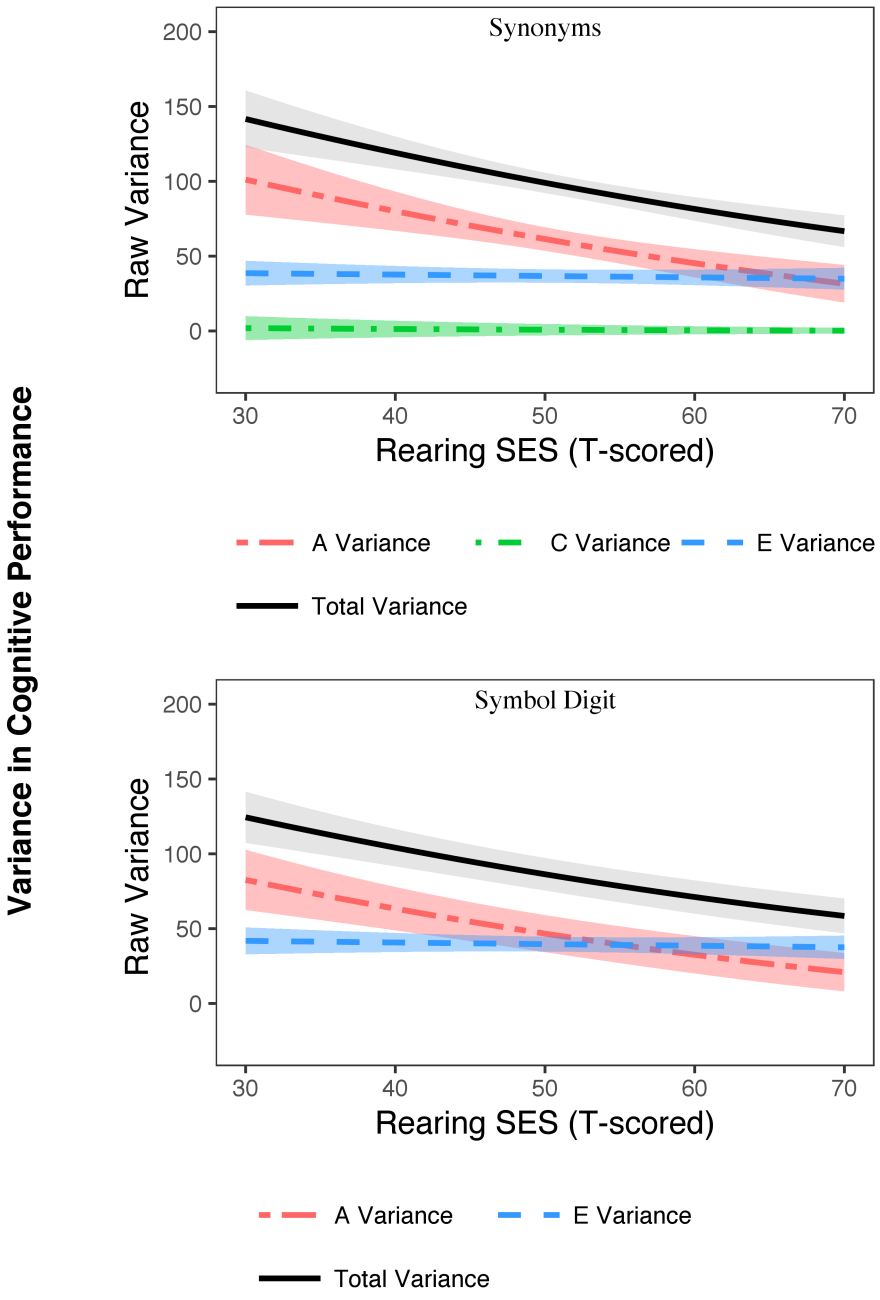

Figure S5. Raw Variances in cognitive performance moderated by rearing SES, univariate model adjusted for age moderation and mean-level sex effects.

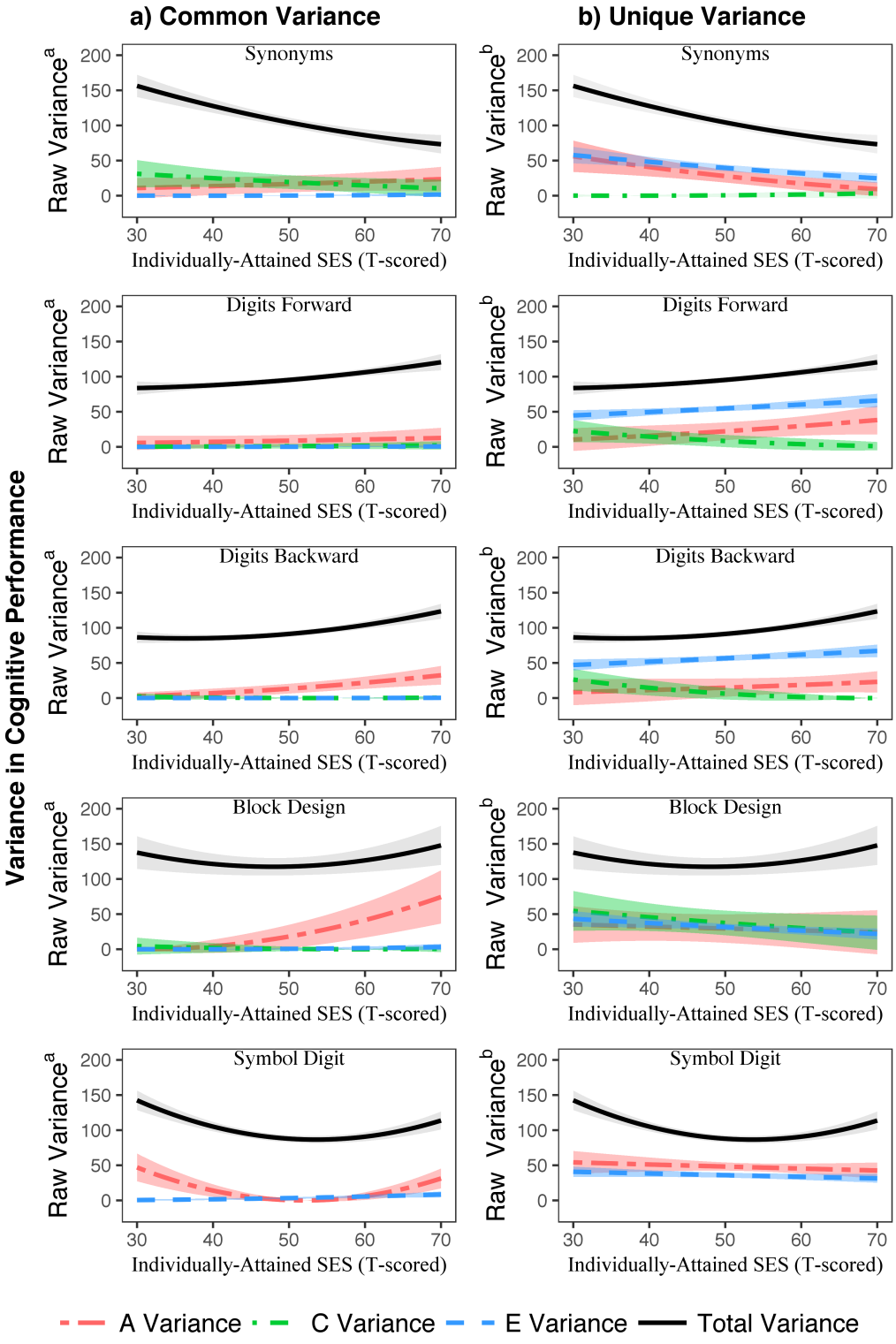

Figure S6. Raw Variances in cognitive performance for the Full Moderation Model with participant's individually-attained SES.

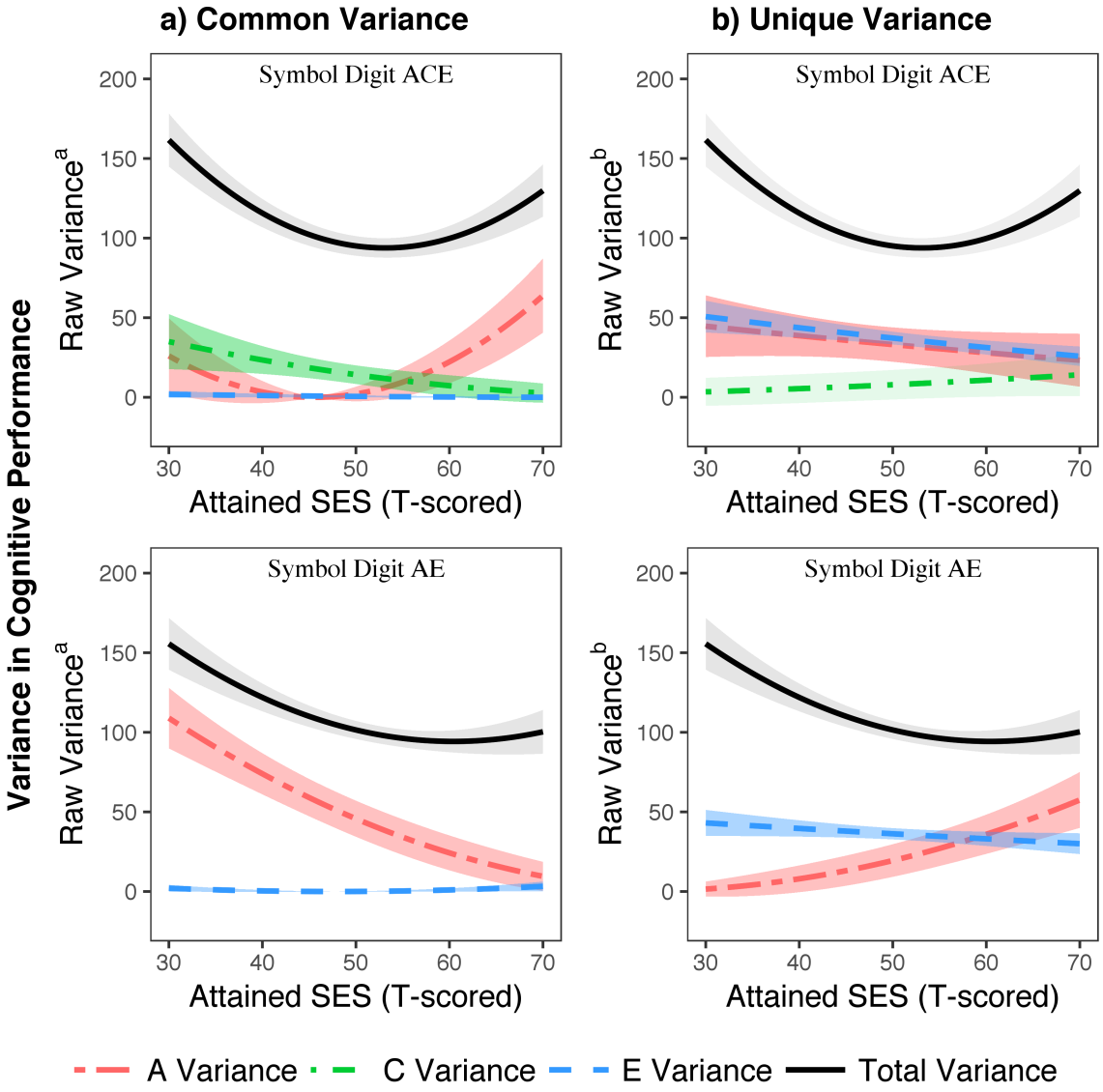

Figure S7: Full Bivariate Moderation model comparison for Symbol Digit, using an ACE model for Symbol Digit on the top row and the AE model (no C for cognitive) on the bottom row. Please note, estimates for the ACE model should be interpreted with caution, given analyses in a previous study with the same sample indicating possible dominance genetic effects (Pahlen et al., 2018)

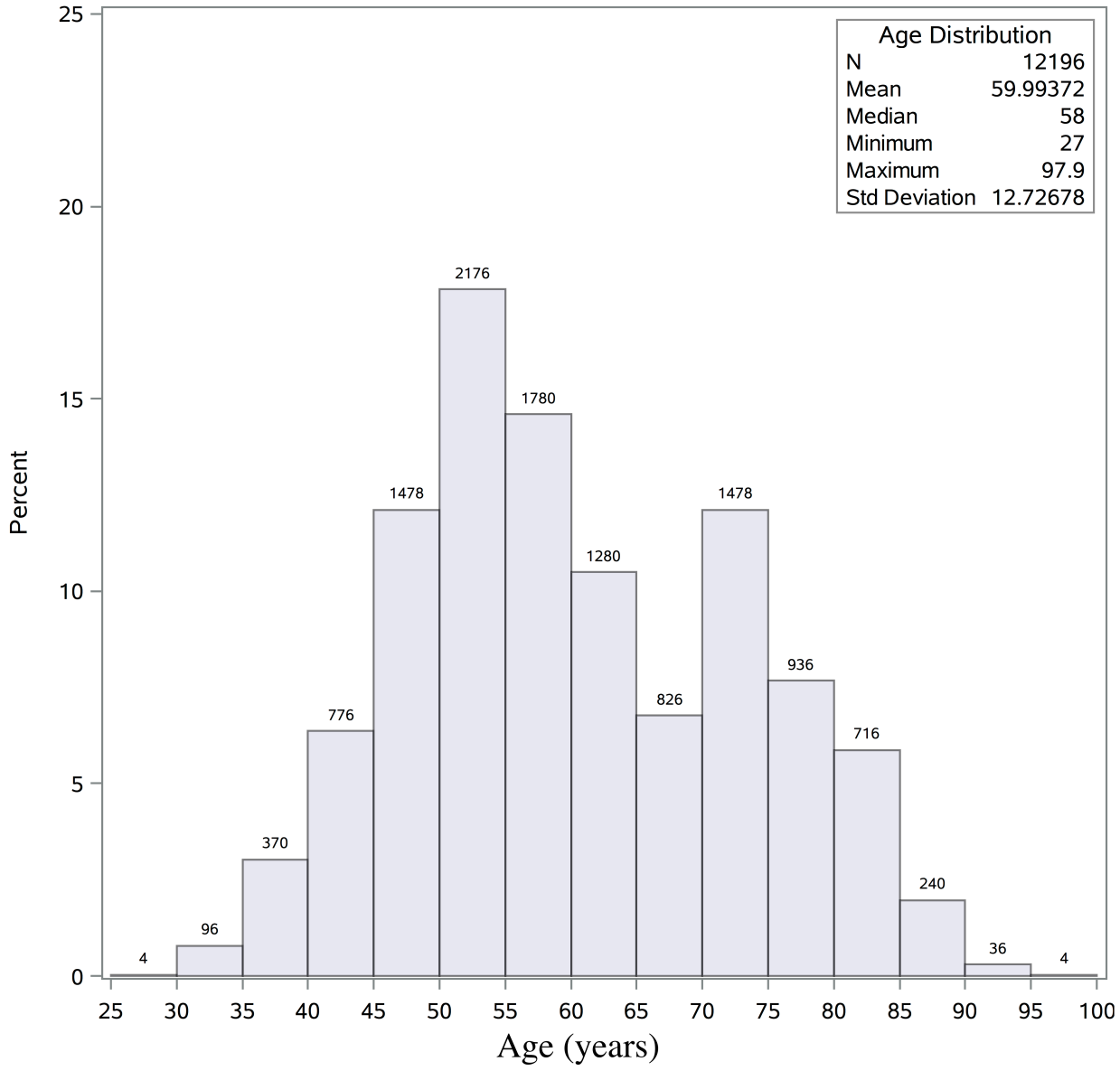

Figure S8: Distribution of participants' ages. Due to the composition of the cohort studies in IGEMS, age is correlated about .96 with birth year.

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