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CHAPTER 3

THE NATURE OF NURTURE: ON THE HIGH HERITABILITY OF CULTURAL DEPENDENT COGNITIVE ABILITIES

Abstract

Heritabilitity coefficients differ across cognitive abilities, but it is not clear why. We propose that these differences are in part the result of differences in gene-environment correlation. Specifically, we hypothesize that during development such correlations become larger for societally valued, hence culturally influenced, knowledge and skills ('crystallized abilities') than cognitive processing abilities ('fluid abilities'). In support of this hypothesis, we present the results from 23 twin studies (total N = 7852). In adults, but not in children, heritability coefficient correlated with cultural load; cultural loaded crystallized tests showing higher heritability coefficients than culture reduced fluid tests. The contra-intuitive finding that more heritable cognitive abilities are more culturally dependent sheds a new light on the longstanding nature-nurture debate.

3.1 The Nature-Nurture Debate in Intelligence

Whether individual differences in intelligence are more due to nature than to nurture is a longstanding philosophical debate, dating back to seventeenth century rationalists, who favoured nature, and empiricists, who favoured nurture (Fancher, 1996). The emergence of psychometrics and behavioural genetics in the twentieth century has made possible an empirical approach to this issue (in terms of individual differences) through the decomposition of variance in (psychometric) intelligence into genetic and environmental components (e.g. Plomin et al, 2008). On first sight, the results seem to favour nature: Numerous studies have shown that the genetic components of full scale IQ and general intelligence (*g*) explain more than half (up to 80%) of the variance (Plomin et al.). However, it is well known that genotype-environment interaction and covariance affect heritability coefficients (Purcell, 2002). While such effects are receiving increasing attention, there are few definite results. This is due in part to the lack of success in identifying the actual genes underlying intelligence (Deary, Johnson, & Houlihan, 2009; Plomin and Spinath, 2004). Thus from this perspective, the nature and nurture of intelligence remains poorly understood. We aim to elucidate the issue of genotype-environment covariance by considering the differential heritabilities of specific cognitive abilities. Our results disconfirm predictions from the mainstream theories of intelligence, i.e., Cattell's fluid-crystallized theory (Cattell, 1963; 1987) and Spearman and Jensen's *g* theory (Spearman, 1904; 1927; Jensen 1998).

Both fluid-crystallized and *g* theory account for differential heritabilities of cognitive abilities by positing a major source of individual differences in IQ, i.e., Gf (fluid intelligence) in fluid-crystallized theory, and *g* (general intelligence) in *g* theory, which is related to heritable biological capacities of the brain. Individual differences in cognitive processes, as measured by IQ tests, depend on this source, and thus on its underlying genetic factors. The more complex a cognitive processing test is, the larger its dependency on this source (as indicated by its factor loading on Gf or *g*), hence on genetic variable factors (as indicated by its heritability coefficient, h^2). Individual differences in acquired knowledge are heritable as well, because they are in part the result of individual differences in cognitive processing. However, as the acquisition of knowledge is susceptible to environmental influences, heritability of individual differences in knowledge is lower than individual differences in the underlying cognitive processes.

On the basis of fluid-crystallized or *g* theory, researchers categorize IQ subtests as fluid versus crystallized (e.g. Cattell, 1963; Ackerman, 1996) or culture-reduced versus culture-loaded (e.g. Rushton & Jensen, 2010a; Georgas, van de Vijver, Weiss, & Saklofske, 2003). Fluid tests minimize the role of individual differences in prior knowledge, whereas crystallized tests maximize it. Individual differences in fluid test scores reflect primarily individual differences in cognitive processes, such as reasoning and (working) memory. Individual differences in crystallized test scores reflect differences in knowledge and skills that are acquired during the lifespan, especially in educational settings. Because crystallized tests depend more strongly on (culture dependent) prior knowledge, they usually require more adjustments to adapt a test from one language group or culture to the next (Georgas et al.). In this sense, crystallized tests are typically more cultural loaded than fluid tests.

Fluid-crystallized and *g* theory predict relatively low heritabilities of cognitive undemanding, highly culture loaded, crystallized tests. Here, we formulate an alternative hypothesis based on the idea of dynamic gene-environment interplay (Dickens & Flynn, 2001; van der Maas et al., 2006; Dickens 2008). Consider the following. Heritability of IQ increases over the life span. Behaviour geneticists attribute this to increasing G-E covariance, which arises because more intelligent people are exposed to and seek out more cognitively stimulating environments (Scarr & McCartney, 1983; Dickens & Flynn, 2001). Assuming these environments foster societally valued knowledge and skills (i.e., crystallized abilities) rather than cognitive processing per se (fluid abilities) (Dickens & Flynn 2001; Dickens, 2008), we expect the increase in gene-environment covariance to be higher for crystallized abilities than fluid abilities. This ultimately results in higher heritabilities of crystallized abilities.

3.2 Empirical Data

3.2.1 Method

Consistent with Gf-Gc and *g* theories, several studies using the Wechsler scales (e.g. Wechsler, 1991, 1997) have shown that the subtests' *g* loadings and heritabilities correlate positively (Jensen, 1987; Rijsdijk et al., 2002, Pedersen et al., 1992). However, the degree to which these subtests were cognitive demanding, crystallized, or cultural loaded was not considered, nor were the effects of genotype-environment covariance. We re-examined these data in the light of the opposing predictions from Gf-Gc and *g* theories (crystallized abilities show lower heritability than fluid abilities) and the alternative hypothesis mentioned above (crystallized abilities show higher heritabilities than fluid abilities). Additionally, we conducted a comprehensive search of studies to locate all behaviour genetic studies that involved either Wechlser's Intelligence Scale for Children (WISC or its revisions) or Wechlser's Adult Intelligence Scale (WAIS or its revisions), and that contained sufficient information to compute subtests' heritabilities (h^2). These subtests comprise Vocabulary, Information, Arithmetic, Similarities, Verbal Comprehension, Digit Span, Picture Completion, Picture Arrangement, Block Design, Coding, and Object Assembly. Of these 11 subtests, the first 5 are often considered to be crystallized tests. We determined the degree to which these subtests are cultural loaded by considering alterations made to each subtest in adapting it to different cultures (languages). This degree was based on the average proportion of the number of items that had to be adjusted in each subtest of the WISC-III when it was adapted for use in thirteen different countries (Georgas et al., 2003). The 5 crystallized subtests were indeed the 5 most cultural loaded subtests (see Table 3.1). Since the Wechsler Verbal IQ (VIQ) and Performance IQ (PIQ) subscales also mapped well on cultural load (see Table 3.1), we also located studies that reported heritabilities of the Wechsler's VIQ and PIQ.

Below, we collate the results of 23 independent twin studies that used representative subject samples (combined N = 7852). Figure 3.1 shows the rank orders of the subtests according to their heritabilities. In all statistical analyses, we corrected mean heritabilities (see Table 3.2 and Table 3.3) and *g* loadings (see Table 3.4 and Table 3.5) for attenuation due to reliability (see Table 3.6 and 3.7).

Table 3.1, showing the cultural load of (both crystallized and fluid) cognitive abilities as measured by the subtests on the verbal intelligence scale (VIQ) and performance intelligence scale (PIQ) of the Wechsler Intelligence tests (e.g., Wechsler, 1991, 1997)

Subtest	Cultural load	Category	Scale
Vocabulary	0.35[1]	Crystallized	VIQ
Information	0.22[1]	Crystallized	VIQ
Comprehension	0.15[1]	Crystallized	VIQ
Similarities	0.09[1]	Crystallized	VIQ
Arithmetic	0.08[1]	Crystallized	VIQ
Picture Completion	0.03[1]	Fluid	PIQ
Picture Arrangement	0.02[1]	Fluid	PIQ
Block Design	0.01[1]	Fluid	PIQ
Coding	0.00[2]	Fluid	PIQ
Digit Span	0.00[1]	Fluid	VIQ
Object Assembly	0.00[1]	Fluid	PIQ

[1] see Table 18.1 in Georgas, van de Vijver, Weiss, & Saklofske (2003), [2] via e-mail correspondence with prof. dr. van de Vijver

3.2.2 Analyses

Wechsler Tests Analysis 1: Subtest scores

Our first analysis involved 6 child samples (WISC) and 4 adult samples (WAIS). We computed average heritabilities per subtests over the samples by weighting the heritabilities by the square root of the studies' sample size (twin pairs). In line with the finding that the heritability of IQ increases throughout development, a paired t-test showed that the WAIS subtests displayed higher heritabilities (mean = .56) than the WISC subtests (see Table 3.3) (mean = .43, t = 3.56, df = 10, p = .005). In line with the alternative hypothesis, in adults, but not in children, crystallized abilities were the most heritable (see Table 3.2): Two tailed tests showed that the WAIS heritabilities of crystallized tests (mean = .65) were higher than those of fluid tests (mean = .49) (t = -2.55, df = 8.38, p = .033) and that the correlation between heritabilities and cultural load was positive (r = .61, df = 9, p = .044; ρ = 0.60). In the WISC these effects were non-significant. Noteworthy, the most cultural loaded subtests had the highest *g* loadings (see Table 3.3) (WAIS: r = .82, $p < 0.01$; WISC: r = .81, $p < 0.01$). The correlations between *g* loading and heritability were not significant (see Table 3.8 and Table 3.9).

Wechsler tests Analysis 2: VIQ vs. PIQ scores

Our second analysis involved 12 samples (apart from the samples from the first analysis), of which 5 comprised children (WISC) and 7 comprised adults (WAIS). Corroborating the findings above, a one-sided paired Wilcoxon test showed that the WAIS, but not the WISC, displayed higher heritability for VIQ than PIQ (median of the WAIS VIQ-PIQ differences = 0.07, V = 19, p = 0.037; see Table 3.10 and Figure 3.2). Thus, the Wechsler data show that in adults, but not in children, highly cultural loaded, crystallized abilities are more heritable than cultural reduced, fluid abilities.

Minnesota Twin study

Our third analysis involved data from the Minnesota Twin study, in which 42 cognitive subtests from diverse batteries (see Table 3.11) were administered to 126 adult twin pairs raised apart. We computed intercorrelations among the subtests' *g* loadings, heritabilities, and two alternative operationalizations of cultural loading (see Table 3.12). We obtained a positive correlation between *g* loadings and heritabilities (r = 0.53, t = 3.93, df = 40, $p < 0.001$), but again the highest heritability coefficients and *g* loadings were clearly for the most cultural loaded subtests (see Figure 3.3).

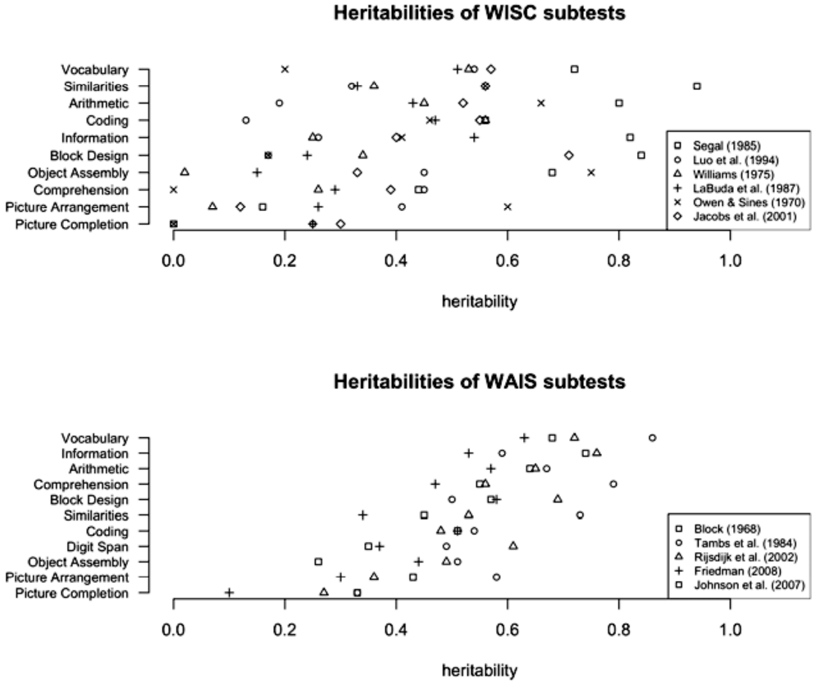

Figure 3.1 Heritabilities of the subscales of the Wechsler Intelligence Scale for Children (WISC; top) and the Wechsler Adult Intelligence Scale (WAIS; bottom)

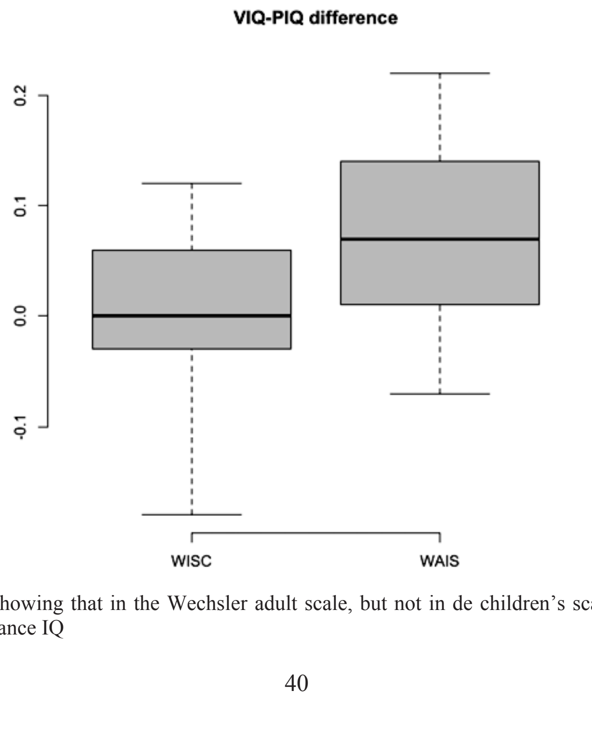

Figure 3.2 Boxplots showing that in the Wechsler adult scale, but not in de children's scale, Verbal IQ is more heritable than Performance IQ

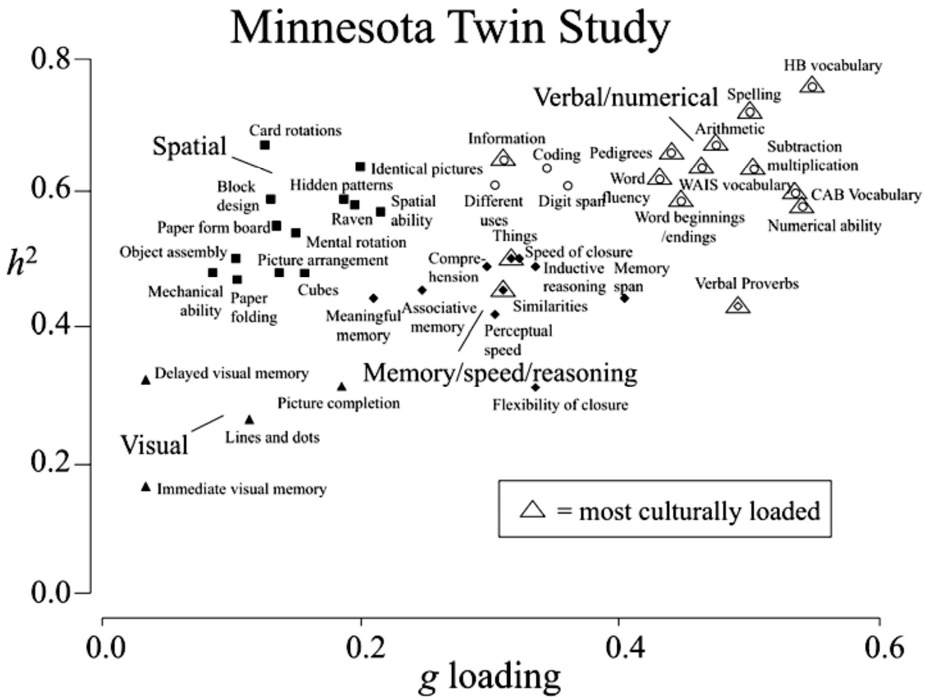

Figure 3.3 The relation between *g* loading, heritabilities (h^2) and cultural load in the Minnesota Twin Study, showing that culture loaded test are the most *g* loaded and the most heritable. An additional cluster analysis revealed that culture loaded verbal-scholastic tests were relatively highly heritable and *g* loaded. Complex, culture reduced spatial tests were also relatively highly heritable, but less *g* loaded. Culture reduced, memory, processing speed and reasoning tests tended to be moderately heritable, and varied substantially in *g* loading. Their *g* loadings were lower than those of the verbal-scholastic tests. Culture reduced visual processing tests were lowly heritable and *g* loaded.

3.3 Conclusions and Discussion

In sum, in contrast to the prediction from fluid-crystallized and *g* theory, we found in a wide range of samples that in adults, but not in children, highly culturally loaded tests displayed the largest heritability. They were also the most highly *g* loaded, which does not sit well with the notion that *g* loading reflects mainly cognitive demand. Our results, which support the differential increase in gene-environment correlation hypothesis, are hard to understand without considering the role education and experience. We hypothesize the following. Because the acquisition of knowledge depends on cognitive processing, individuals, who develop relatively high levels of cognitive processing, tend to achieve relatively high levels of knowledge. High achievers are more likely to end up in cognitive demanding environments that encourage and facilitate the further development of a wide range of knowledge and skills. These environments, e.g. higher educational systems, are largely determined by societal demands. These demands thus influence the magnitude of interactions among cognitive processes and knowledge, hence their intercorrelations, and so their *g* loadings. With respect to the nature-nurture debate, we conclude that the G-E covariance implies - contra-intuitively - that a high heritability of one cognitive ability relative to another implies that it depends relatively more on nurture.

Table 3.2 Heritabilities of the Wechsler's Intelligence Scale for Children (WISC) subtests

Subtest	Segal (1985) n = 103	Luo et al. (1994) n = 283	Williams (1975) n = 100	LaBuda et al. (1987) n = 143	Owen & Sines (1970) n = 42	Jacobs et al. (2001) n = 451	Weighted Average	Corrected for attenuation
Vocabulary	0.72	0.54	0.53	0.51	0.20	0.57	0.5511	0.5855
Information	0.82	0.26	0.25	0.54	0.41	0.40	0.4081	0.4421
Comprehension	0.44	0.45	0.26	0.29	0.00	0.39	0.3708	0.4209
Similarities	0.94	0.32	0.36	0.33	0.56	0.56	0.4872	0.5374
Arithmetic	0.80	0.19	0.45	0.43	0.66	0.52	0.4500	0.5056
Picture Completion	0.00	0.25	-0.12	0.25	0.00	0.30	0.2048	0.2331
Picture Arrangement	0.16	0.41	0.07	0.26	0.60	0.12	0.2282	0.2652
Block Design	0.84	0.17	0.34	0.24	0.17	0.71	0.4726	0.5114
Coding	0.56	0.13	0.56	0.47	0.46	0.55	0.4323	0.5179
Digit Span	-	0.15	0.13	0.44	0.16	0.26	0.2378	0.2765
Object Assembly	0.68	0.45	0.02	0.15	0.75	0.33	0.3575	0.4280

Table 3.3 Heritabilities of the Wechsler's Adult Intelligence Scale (WAIS) subtests

Subtest	Block (1968) n = 120	Tambs et al. (1984) n = 80	Rijsdijk et al. (2002) n =194	Friedman (2008) n = 293	Weighted Average	Corrected for attenuation
Vocabulary	0.68	0.86	0.72	0.63	0.6909	0.7117
Information	0.74	0.59	0.76	0.53	0.6386	0.6695
Comprehension	0.55	0.79	0.56	0.47	0.5467	0.6000
Similarities	0.45	0.73	0.53	0.34	0.4583	0.4971
Arithmetic	0.64	0.67	0.65	0.57	0.6165	0.6647
Picture Completion	0.33	0.33	0.27	0.10	0.2150	0.2388
Picture Arrangement	0.43	0.58	0.36	0.30	0.3723	0.4410
Block Design	0.57	0.50	0.69	0.58	0.6000	0.6442
Coding	0.51	0.54	0.48	0.51	0.5050	0.5554
Digit Span	0.35	0.49	0.61	0.37	0.4483	0.4920
Object Assembly	0.26	0.51	0.49	0.44	0.4308	0.5122

Table 3.4 Reliabilities of the Wechsler's Intelligence Scale for Children (WISC) subtests

Subtest	WISC US	WISC-R US	WISC-III US	WISC III-UK	WISC III-NL	Average
Vocabulary	0.86	0.86	0.86	0.89	0.96	0.8860
Information	0.76	0.85	0.85	0.85	0.95	0.8520
Comprehension	0.68	0.77	0.77	0.73	0.93	0.7760
Similarities	0.75	0.81	0.81	0.81	0.93	0.8220
Arithmetic	0.75	0.77	0.77	0.74	0.93	0.7920
Picture Completion	0.64	0.77	0.77	0.81	0.87	0.7720
Picture Arrangement	0.72	0.73	0.73	0.64	0.88	0.7400
Block Design	0.86	0.85	0.85	0.77	0.94	0.8540
Coding	0.60	0.72	-	0.77	-	0.6967
Digit Span	0.56	0.78	-	0.73	0.89	0.7400
Object Assembly	0.66	0.70	0.70	0.66	0.77	0.6980

Table 3.5 Reliabilities of the Wechsler's Adult Intelligence Scale (WAIS) subtests

Subtest	WAIS US	WAIS-R US	WAIS-III US	WAIS III-NL	Average
Vocabulary	0.95	0.96	0.93	0.93	0.9425
Information	0.91	0.89	0.92	0.92	0.9100
Comprehension	0.78	0.84	0.85	0.85	0.8300
Similarities	0.86	0.84	0.84	0.86	0.8500
Arithmetic	0.82	0.84	0.88	0.90	0.8600
Picture Completion	0.83	0.81	0.82	0.78	0.8100
Picture Arrangement	0.67	0.74	0.72	0.72	0.7125
Block Design	0.84	0.87	0.89	0.87	0.8675
Coding	-	0.82	0.82	0.84	0.8267
Digit Span	0.68	0.83	0.91	0.90	0.8300
Object Assembly	0.68	0.68	0.73	0.74	0.7075

Table 3.6 Loadings on the first principal factor ('*g* loadings') of the Wechsler's Intelligence Scale for Children (WISC) subtests

Subtest	WAIS US	WAIS-R US	WAIS-III US	WISC-III UK	WISC-III NL	Average	Corrected for attenuation
Vocabulary	0.81	0.82	0.82	0.78	0.78	0.8775	0.9039
Information	0.79	0.79	0.80	0.76	0.75	0.8500	0.8910
Comprehension	0.69	0.72	0.70	0.65	0.65	0.8100	0.8891
Similarities	0.72	0.79	0.80	0.78	0.75	0.8200	0.8894
Arithmetic	0.67	0.64	0.70	0.60	0.69	0.7400	0.7980
Picture Completion	0.49	0.58	0.60	0.50	0.49	0.6300	0.7000
Picture Arrangement	0.58	0.56	0.52	0.42	0.50	0.6325	0.7493
Block Design	0.59	0.67	0.66	0.54	0.57	0.6700	0.7193
Coding	0.44	0.40	0.33	0.26	0.34	0.5500	0.6049
Digit Span	0.51	0.45	0.45	0.42	0.43	0.5775	0.6339
Object Assembly	0.47	0.56	0.58	0.40	0.47	0.5500	0.6539

Table 3.7 Loadings on the first principal factor ('*g* loadings') of the Wechsler's Adult Intelligence Scale (WAIS) subtests

Subtest	WAIS US	WAIS-R US	WAIS-III US	WAIS-III NL	Average	Corrected for attenuation
Vocabulary	0.88	0.88	0.88	0.87	0.8775	0.9039
Information	0.86	0.84	0.84	0.86	0.8500	0.8910
Comprehension	0.80	0.80	0.82	0.82	0.8100	0.8891
Similarities	0.79	0.80	0.84	0.85	0.8200	0.8894
Arithmetic	0.77	0.74	0.72	0.73	0.7400	0.7980
Picture Completion	0.73	0.67	0.60	0.52	0.6300	0.7000
Picture Arrangement	0.69	0.62	0.64	0.58	0.6325	0.7493
Block Design	0.73	0.67	0.64	0.64	0.6700	0.7193
Coding	0.58	0.58	0.51	0.53	0.5500	0.6049
Digit Span	0.63	0.60	0.52	0.56	0.5775	0.6339
Object Assembly	0.52	0.55	0.58	0.55	0.5500	0.6539

Table 3.8 Correlations among heritabilities, *g* loadings and cultural load in the WISC

	Heritability	Corrected Heritability	*g* loading	Corrected *g* loading	Cultural load
Heritability	1.00				
Corrected heritability	0.99*	1.00			
g loading	0.57	0.48	1.00		
Corrected *g* loading	0.54	0.45	0.99*	1.00	
Cultural load	0.55	0.47	0.81*	0.79*	1.00

* significant α = .05

Table 3.9 Correlations among heritabilities, *g* loadings and cultural load in the WAIS

	Heritability	Corrected Heritability	*g* loading	Corrected *g* loading	Cultural load
Heritability	1.00				
Corrected heritability	0.99*	1.00			
g loading	0.60	0.53	1.00		
Corrected *g* loading	0.50	0.46	0.98*	1.00	
Cultural load	0.63*	0.57	0.87*	0.82*	1.00

* significant α = .05

Table 3.10 Heritabilities of the Wechsler VIQ and PIQ scales

Study	Test	n	VIQ	PIQ	VIQ-PIQ difference
Alarcon et al. (2000)	WISC	1110	0.74	0.68	0.06
Edmonds et al. (2008)	WISC	240	0.85	0.73	0.12
Gosso (unpublished)	WISC	359	0.7	0.73	-0.03
Hoekstra et al (2007)	WISC	115*	0.46	0.64	-0.18
van der Sluis et al. (2008)	WISC	385	0.78	0.78	0,00
Betjemann et al. (2010)	WAIS	142	0.66	0.66	0,00
Gosso (unpublished)	WAIS	580	0.78	0.71	0.07
Hoekstra et al (2007)	WAIS	115*	0.84	0.74	0.10
Malykh et al. (2005)	WAIS	160	0.86	0.84	0.02
Rijsdijk et al. (1998)	WAIS	416	0.64	0.46	0.18
Vandenberg (1968)	WAIS	-	0.63	0.41	0.22
van der Sluis et al. (2008)	WAIS	360	0.68	0.75	-0.07

* longitudinal study

Table 3.11 Characteristics of the Comprehensive Ability Battery (CAB), Hawaii Battery (HB) and Wechsler Adults Intelligence Scale Revised (WAIS-R) subtests used in the Minnesota Twin Study

Subtest	Battery	Name	Origin	Cultural load 1	Cultural load 2	Reliability	Kind	*g* loading	Corrected *g* loading	Heritability	Corrected Heritability
1	CAB	Numerical Ability	Hakstian & Cattell (1978)	0	1	0.79	test-retest	0.5418	0.6096	0.58	0.6526
2	CAB	Spatial Ability	Hakstian & Cattell (1978)	0	0	0.86	test-retest	0.2160	0.2329	0.57	0.6146
3	CAB	Memory Span	Hakstian & Cattell (1978)	0	0	0.96	split-half	0.4049	0.4132	0.44	0.4491
4	CAB	Flexibility of Closure	Hakstian & Cattell (1978)	0	0	0.79	split-half	0.3364	0.3785	0.31	0.3488
5	CAB	Mechanical Ability	Hakstian & Cattell (1978)	0	0	0.72	split-half	0.0863	0.1018	0.48	0.5657
6	CAB	Speed of Closure	Hakstian & Cattell (1978)	0	0	0.71	test-retest	0.3257	0.3865	0.50	0.5934
7	CAB	Perceptual Speed	Hakstian & Cattell (1978)	0	0	0.64	test-retest	0.3058	0.3823	0.42	0.5250
8	CAB	Word Fluency	Hakstian & Cattell (1978)	0	1	0.78	separately timed parts	0.4640	0.5254	0.64	0.7247
9	CAB	Inductive Reasoning	Hakstian & Cattell (1978)	0	0	0.74	split-half	0.3348	0.3892	0.49	0.5696
10	CAB	Associative Memory	Hakstian & Cattell (1978)	0	0	0.79	split-half	0.2470	0.2779	0.46	0.5175
11	CAB	Meaningful Memory	Hakstian & Cattell (1978)	0	0	0.84	split-half	0.2127	0.2321	0.44	0.4801
12	CAB	Verbal-Vocabulary	Hakstian & Cattell (1978)	1	1	0.78	split-half	0.5366	0.6076	0.60	0.6794
13	CAB	Verbal-Proverbs	Hakstian & Cattell (1978)	1	1	0.78	split-half	0.4930	0.5582	0.43	0.4869
14	CAB	Spelling	Hakstian & Cattell (1978)	1	1	0.78	split-half	0.5006	0.5669	0.72	0.8152
15	HB	Card Rotations	Wilson et. al (1975)	0	0	0.88	internal consistency	0.1267	0.1351	0.67	0.7142
16	HB	Mental Rotation	Wilson et. al (1975)	0	0	0.88	internal consistency	0.1501	0.1600	0.54	0.5756
17	HB	Paper Form Board	Wilson et. al (1975)	0	0	0.84	internal consistency	0.1353	0.1476	0.55	0.6001
18	HB	Hidden Patterns	Wilson et. al (1975)	0	0	0.92	internal consistency	0.1875	0.1955	0.59	0.6151
19	HB	Cubes	Ekström et al. (1976)	0	0	0.84	internal consistency	0.1580	0.1724	0.48	0.5237
20	HB	Paper Folding	Ekström et al. (1976)	0	0	0.84	internal consistency	0.1055	0.1151	0.47	0.5128
21	HB	Raven	Wilson et. al (1975)	0	0	0.86	internal consistency	0.1952	0.2104	0.58	0.6254

Table 3.11 (Continued)

22	HB	HB Vocabulary	Wilson et. al (1975)	1	1	0.96	internal consistency	0.5491	0.5604	0.76	0.7757
23	HB	Subtraction/ Multiplication	Wilson et. al (1975)	0	1	0.96	internal consistency	0.5035	0.5139	0.64	0.6532
24	HB	Word Beginnings/ Endings	Wilson et. al (1975)	0	1	0.71	internal consistency	0.4471	0.5306	0.59	0.7002
25	HB	Pedigrees	Wilson et. al (1975)	1	1	0.72	internal consistency	0.4394	0.5179	0.66	0.7778
26	HB	Things Categories	Wilson et. al (1975)	0	1	0.74	internal consistency	0.3174	0.3689	0.51	0.5929
27	HB	Different Uses	Ekström et al. (1976)	1	1	0.76	internal consistency	0.3031	0.3477	0.61	0.6997
28	HB	Immediate Visual Memory	Wilson et. al (1975)	0	0	0.58	internal consistency	0.0335	0.0439	0.16	0.2101
29	HB	Delayed Visual Memory	Wilson et. al (1975)	0	0	0.62	internal consistency	0.0335	0.0425	0.32	0.4064
30	HB	Lines and Dots	Wilson et. al (1975)	0	0	0.89	internal consistency	0.1133	0.1201	0.26	0.2756
31	HB	Identical Pictures	Ekström et al. (1976)	0	0	0.87	internal consistency	0.2008	0.2153	0.64	0.6862
32	WAIS-R	Information	Wechsler (1981)	1	1	0.89	split-half	0.3120	0.3307	0.65	0.6890
33	WAIS-R	Comprehension	Wechsler (1981)	1	1	0.84	split-half	0.2960	0.3230	0.49	0.5346
34	WAIS-R	Vocabulary	Wechsler (1981)	1	1	0.96	split-half	0.4304	0.4393	0.62	0.6328
35	WAIS-R	Coding	Wechsler (1981)	0	0	0.82	split-half	0.3451	0.3810	0.64	0.7068
36	WAIS-R	Arithmetic	Wechsler (1981)	1	1	0.84	split-half	0.4754	0.5188	0.67	0.7310
37	WAIS-R	Similarities	Wechsler (1981)	1	1	0.84	split-half	0.3120	0.3404	0.45	0.4910
38	WAIS-R	Digit Span	Wechsler (1981)	0	0	0.83	test-retest	0.3615	0.3969	0.61	0.6696
39	WAIS-R	Picture Completion	Wechsler (1981)	0	0	0.81	split-half	0.1864	0.2071	0.31	0.3444
40	WAIS-R	Block Design	Wechsler (1981)	0	0	0.87	split-half	0.1311	0.1406	0.59	0.6325
41	WAIS-R	Picture Arrangement	Wechsler (1981)	0	0	0.74	split-half	0.1384	0.1608	0.48	0.5580
42	WAIS-R	Object Assembly	Wechsler (1981)	0	0	0.68	split-half	0.1039	0.1260	0.50	0.6063

Table 3.12 Correlations among heritabilities, *g* loadings and cultural load in the Minnesota Twin Study

	Heritability	Corrected Heritability	*g* loading	Corrected *g* loading	Cultural load 1	Cultural load 2
Heritability	1.00					
Corrected heritability	0.98*	1.00				
g loading	0.52*	0.52*	1.00			
Corrected *g* loading	0.50*	0.52*	0.99*	1.00		
Cultural load 1	0.37*	0.36*	0.53*	0.52*	1.00	
Cultural load 2	0.46*	0.48*	0.76*	0.75*	0.76*	1.00

* significant at $\alpha = .05$