PERGAMON

Personality and Individual Differences 30 (2001) 857–871

PERSONALITY AND INDIVIDUAL DIFFERENCES

www.elsevier.com/locate/paid

Some evidence for the existence of a general factor of semantic memory and its components

Paul Irwing *, Tommy Cammock, Richard Lynn

School of Psychology and Communication, University of Ulster at Coleraine, Cromore Road, Co. Londonderry BT52 1SA, Northern Ireland, UK

Received 24 September 1999; received in revised form 17 February 2000

Abstract

This paper is concerned with the issues of the factorial structure of long-term semantic memory, with what are the major domains of long-term memories for different kinds of information and knowledge, and whether these are positively intercorrelated to form a general factor of long-term semantic memory. The methodology of the study consisted of the construction of a test of general knowledge, which endeavoured to cover all major areas or domains of general knowledge in western cultures. This was administered to 509 females and 209 males, mean age 20.9 years, most of whom (638) were undergraduate students. Nineteen measures conforming to primary domains of general knowledge were subjected to confirmatory factor analyses, using LISREL 8.30. A model with six first-order factors (Physical Health and Recreation, Current Affairs, Fashion, Family, Arts and Science) showed a good fit to the data (SRMR = 0.047). In a subsequent higher-order factor analysis, the six first-order factors loaded substantially (range 0.54–0.90) on a single second-order factor (SRMR = 0.050). Thus, all domains of general knowledge tested in the study were positively intercorrelated and explicable in terms of a strong general factor of long-term semantic memory ability. The six first-order factors are probably expressions of interests.

Keywords: Long-term memory; IQ; General knowledge; Individual differences; Structural equations modelling

1. Introduction

This paper is concerned with the questions of whether there is a general factor of long-term memory and, if so, what are its components. The essence of the problem is whether long-term

* Corresponding author. Tel.: +44-1265-324660.
E-mail address: fp.irwing@ulst.ac.uk (P. Irwing).

0191-8869/01/$ - see front matter
PII: S0191-8869(00)00078-7

memories for different domains of information are positively intercorrelated to form a general factor of long-term memory. The view that this is not the case was advanced in the early 19th century by the German psychologist J. F. Herbart (1816), who wrote that "Strength of memory is usually limited in every man to particular kinds of objects ... He who easily remembers the technical expressions of a science that interests him has often a bad memory for the novelties of a town". This hypothesis can be tested by measuring the strength of memories in different domains and ascertaining whether they are positively intercorrelated, have zero intercorrelations or even, as Herbart suggested, have negative intercorrelations. This is the issue with which we are concerned in the present paper.

The problem is analysed within the theoretical framework of the hierarchical factor model of intelligence. This model has its origin in the work of Spearman (1904) who posited the existence of a factor of general intelligence and a number of specific abilities. The model was elaborated by Burt (1949) and Vernon (1950), who posited a three-level hierarchical structure of intelligence consisting of a large number of primary abilities at the first and lowest level, two second-order abilities at the second level and a single factor of general intelligence at the third and highest level. This model is widely accepted in contemporary differential psychology. The most thorough recent exposition of the model is that presented by Carroll (1993), who analysed and integrated the large research literature and concluded that there are eight reasonably well-established second-order factors. There is, however, no clear long-term memory ability factor in Carroll's hierarchical model. In Carroll's model, general information, which is stored in long-term memory, is grouped with the second-order Gc (crystallized intelligence) factor (p. 599), but Carroll also has another second-order factor, which he designates "Broad Retrieval Ability" and describes it as "the ready retrieval of concepts or items from long-term memory" (p. 625). Broad Retrieval Ability is conceptually and empirically distinct from short-term memory typically measured by digit span tests.

Memory has been studied by experimental as well as by differential psychologists. Both groups of researchers have reached a consensus that there are two broad kinds of memory consisting of short- and long-term memory. Experimental psychologists follow the work of Tulving (1972) in also distinguishing two kinds of long-term memory designated semantic memory and episodic memory. Semantic memory consists of general knowledge and is the same concept as that measured in differential psychology by tests of general knowledge or general information. Episodic memory consists of long-term memories of personal experiences and is sometimes designated autobiographical memory. It is difficult for differential psychologists to measure because the memories are unique to each individual. In experimental psychology there is also the concept of procedural memory consisting of memories for procedures. A useful recent review of these distinctions and the research supporting them has been provided by Bors and MacLeod (1996). In terms of these distinctions made in experimental psychology, general knowledge as measured in differential psychology should be designated "semantic memory".

Despite Carroll's conclusion that Broad Retrieval Ability is a second-order factor, this is probably the least well substantiated of the second-order factors. Carroll observes that "It is possible that there are several varieties of this factor" (p. 625) and that they may not be sufficiently well intercorrelated to justify the inference of a single factor. He concludes there is "no adequate study of individual differences in the types of memories that different persons are likely to retain over long periods of time" (p. 303) and that the hypothesis proposed in 1816 by Herbart

has still not been adequately confirmed or rejected. This is the problem addressed in the study to be reported.

2. Method

2.1. Subjects

The sample consisted of 718 subjects, comprising 638 undergraduate students, 33 secondary school pupils, 41 full-time employees, two persons who were unemployed and four subjects for whom data was missing. There were 509 female and 209 male subjects ranging in age from 11 to 57 years (mean = 20.9, SD = 5.29). Two indicators of socio-economic status were the father's education and occupational level. With regard to education, 441 fathers had completed secondary school to 16 years of age, 98 to age 18, 47 graduated from non-university tertiary educational institutions, and 117 from university, while 15 subjects provided no information. Ninety-one of the fathers were described as professional, 246 minor professional, 100 white collar, 69 skilled and 194 as semi-skilled, with 18 subjects failing to answer.

2.2. Procedure

During a single session, subjects were administered a battery of measures, including the General Knowledge Test (GKT), in groups ranging in size from 5 to 40. Only the GKT and demographic data were relevant to the current study. A strict protocol was followed in all testing sessions; including the use of a standardized set of instructions and a 1-h time limit to complete the GKT.

2.3. Measures

2.3.1. General Knowledge Test

The test consisted of 216 items[1], which were developed by the authors, in collaboration with one subject matter expert. General knowledge was construed as culturally valued knowledge, communicated by a range of non-specialist media. Ephemera or knowledge confined solely to one medium, such as "television soaps", were explicitly excluded by this conceptualization, as was information so specialist as to require extensive training for it to be acquired. Eighteen domains of general knowledge were initially identified as conforming with this definition, viz: History of Science; Politics; Sport; History; Classical Music; Art; Literature; General Science; Geography; Cookery; Medicine; Games; Discovery and Exploration; Biology; Film; Fashion; Finance; and Popular Music. Example items are shown in Table 1.

Twelve items were selected for each domain, in conformity with our conceptualization of general knowledge. Items were chosen which required a one or two word answer, which was unambiguous. The test was vetted and revised by each of the authors in turn until there was a consensus as to which items were to be included, and their respective answers. Each correct answer was awarded a score of one. In nine cases, there were two answers deemed to be equally acceptable, e.g. Newton

[1] The general knowledge test, with answers, is available from the first author.

Table 1
Example items for each domain of general knowledge[a]

History of Science
1. Who discovered the double helix structure of DNA?
8. Which British chemist was the originator of the modern atomic theory of matter?

Politics
18. Who was the leader of the Khmer Rouge and became premier of Cambodia in 1975?
24. Who has ruled Cuba since 1959?

Sport
28. Where were the 1996 Olympic games held?
35. What in golf describes a score of one under par on a particular hole?

History
43. Which king of England was executed in 1649?
46. Which Italian wrote an account of his visit to China about 1275?

Classical Music
51. Who composed The Ring?
58. Who composed Il Barbiere di Seviglia?

Art
61. Who painted the ceiling of the Sistine chapel?
67. Who painted the Laughing Cavalier?

Literature
82. Who wrote ''Utopia''?
83. Who wrote ''Don Quixote''?

General Science
90. What are the chemical constituents of steel?
92. Who formulated the law that the energy of a quantity of matter is equal to the product of the mass times the square of the velocity of light?

Geography
97. Which country lies west of the Bering Strait?
100. Which is the longest river in Asia?

Cookery
110. What is parmesan?
111. What are croutons made of?

Medicine
123. What disease is caused by insufficient production of insulin?
130. What is the commonest cause of cirrhosis of the liver?

Games
134. In what game can a piece be crowned?
142. What card game has only one player?

(*continued on next page*)

Table 1 (*continued*)

Discovery and Exploration
147. Who was the first to reach the South pole?
148. Who was the first to fly the Atlantic?
Biology
157. What lizard changes colour to match its surroundings?
165. What is the largest sea bird?
Film
171. Who played Dr Zhivago in "Dr Zhivago"?
174. Who played the Godfather in "The Godfather"?
Fashion
181. Which Italian designer was shot in Miami in 1997?
186. Which British model started the "superwaif" trend?
Finance
195. Who is the president of Microsoft?
202. What is the currency of Russia?
Popular Music
210. Who wrote and sang "Thriller"?
211. Which American had a big hit with "Like a Virgin"?

[a] Numbers denote the item order in the general knowledge test.

or Leibniz as the inventor of calculus. For a further five items (17, 38, 40, 47 and 88), half marks were awarded for a partial answer, e.g. either hydrogen or oxygen in response to the question, "What are the chemical constituents of water?"

3. Results

The analysis proceeded in four stages: principal components analysis of each domain of general knowledge, exploratory factor analysis of the resulting 19 composite scores of general knowledge, followed by first- and second-order confirmatory factor analyses.

3.1. Principal components analyses

Although factor analysis is commonly applied to dichotomous items, this procedure is problematic. Use of dichotomous items generally attenuates the magnitude of Pearson's coefficient of correlation (Kim & Mueller, 1978; Gorsuch, 1974), and may lead to artefacts in which items of similar difficulty form spurious factors (Gorsuch, 1974). These difficulties are compounded by large numbers of items. For example, Nunnally (1978) argues that for factor analysis a ratio of 10 times the number of subjects to variables is essential. In this instance, that would require a sample of 2160, whereas the current sample comprised 718 subjects.

Because of these considerations, a two-step approach was adopted. Since the GKT was composed of well-defined domains, one could be reasonably confident that the items for each domain were homogenous and unifactorial. Under these circumstances, a preferred first step was to apply principal components analysis to each domain, using LISREL 8.30.

The initial principal components analyses suggested that removal of the two worst items within each domain would lead to acceptable measures for each domain of general knowledge, with the exception of popular music. In the latter case, for the first principal component, half the items loaded positively and half negatively, which suggested two components. Principal components analysis was applied to the revised measures of each of the resulting 19 domains of general knowledge, with the results shown in Table 2.

The item content of the two components of Popular Music suggested that the first component should retain the label ''Popular Music'', and the second component be denoted ''Jazz and Blues''. Across the 19 domains of general knowledge, the first principal component accounted for from 31.9 to 65% of the variance. With one exception (item 61 = 0.24), all factor loadings were in the range 0.38–0.92. Scree tests and, where indicated (see below), varimax rotations showed that, after the first component in each domain of general knowledge, there were no further interpretable components.

3.2. Exploratory factor analysis

The subsequent analyses reported in this paper were based on unit weighted composite scores for the 19 separate domains of general knowledge. Unit weighted composite scores are preferable to factor regression scores unless the sample size is very large (Cohen, 1990).

The 19 composite measures of general knowledge were subjected to maximum likelihood extraction (Jöreskog & Lawley, 1968) followed by direct oblimin rotation. Both Kaiser's (1961) criterion to retain factors with unrotated eigenvalues greater than one and a scree test (Cattell, 1966) pointed to a five factor solution. However, the five-factor solution (see Table 3) did not satisfy the criterion of interpretability, which requires that all factors are conceptually cohesive (Carroll, 1993, p. 86). Factor 1 included science, which does not readily fit with politics and finance. Equally, science does not rationally cohere with the recreations of sport and games, as required by Factor 3. In consequence, it was decided to use confirmatory factor analysis to finalize the factor structure, since this provides more precise tests of model fit (Jöreskog, 1993; Kline, 1993).

3.3. Confirmatory factor analysis

It was considered justified to use the same data set for exploratory and confirmatory analyses since there were substantive differences between the models tested (see below). Subsequent models were tested with LISREL 8.30, using polychoric correlations and weighted least squares estimation, as recommended for ordinal data (Jöreskog, 1990). Since our sample size was on the margins of acceptability for use of asymptotic distribution free (ADF) estimation procedures (Hoogland & Boomsma, 1998), and recent Monte Carlo simulations suggest that maximum likelihood-based fit statistics are preferable to those obtained from ADF (Hu & Bentler, 1998), all confirmatory factor analyses were repeated using maximum likelihood estimation. The 19 general knowledge composites were normalized, prior to maximum likelihood analysis, in order to produce correct

Table 2
Principal components analyses of 19 domains of general knowledge

Factors																					
History of Science		Politics		Sport		History		Classical Music		Art		Literature		General Science		Geography		Cookery			
Item	λ[a]	Item	λ	Item	λ	Item	λ	Item	λ	Item	λ	Item	λ	Item	λ	Item	λ	Item	λ		
1	0.77	13	0.76	25	0.67	37	0.70	50	0.71	61	0.24	73	0.72	85	0.54	97	0.82	109	0.53		
3	0.55	14	0.44	28	0.68	38	0.62	51	0.86	62	0.77	74	0.69	87	0.63	98	0.72	110	0.73		
4	0.59	16	0.64	29	0.57	39	0.58	52	0.87	63	0.69	75	0.86	88	0.61	99	0.69	111	0.79		
6	0.65	17	0.61	30	0.67	41	0.59	53	0.84	64	0.81	76	0.60	90	0.69	100	0.76	112	0.44		
7	0.71	18	0.80	31	0.68	42	0.69	54	0.84	65	0.61	78	0.51	91	0.66	101	0.63	113	0.71		
8	0.73	19	0.75	32	0.62	43	0.72	55	0.78	66	0.64	80	0.79	92	0.74	103	0.67	116	0.54		
9	0.66	21	0.56	33	0.45	44	0.63	56	0.80	67	0.77	81	0.81	93	0.67	104	0.78	117	0.59		
10	0.73	22	0.77	34	0.57	45	0.70	58	0.91	68	0.69	82	0.88	94	0.56	106	0.77	118	0.49		
11	0.57	23	0.77	35	0.70	46	0.75	59	0.85	70	0.68	83	0.80	95	0.46	107	0.84	119	0.63		
12	0.68	24	0.82	36	0.60	48	0.61	60	0.63	72	0.58	84	0.77	96	0.56	108	0.71	120	0.45		
Percent variance	44.5		49.1		39.0		43.4		65.0		44.4		56.4		38.0		54.8		36.0		

Factors Medicine		Games		Discovery and Exploration		Biology		Film		Fashion		Finance		Popular Music		Jazz	
Item	λ[a]	Item	λ	Item	λ	Item	λ	Item	λ	Item	λ	Item	λ	Item	λ	Item	λ
121	0.65	133	0.61	145	0.72	157	0.68	169	0.75	181	0.77	193	0.69	205	0.75	206	0.76
122	0.58	134	0.70	146	0.65	158	0.63	170	0.58	182	0.71	194	0.63	207	0.71	208	0.76
123	0.75	135	0.48	147	0.75	159	0.60	171	0.80	184	0.51	195	0.73	210	0.79	209	0.90
124	0.67	136	0.51	148	0.74	161	0.61	172	0.58	186	0.74	196	0.57	211	0.92	213	0.61
125	0.60	139	0.51	149	0.74	162	0.53	174	0.76	187	0.71	197	0.64	212	0.38	214	0.83
127	0.59	140	0.60	151	0.60	163	0.46	175	0.76	188	0.69	198	0.67	216	0.67	215	0.62
128	0.73	141	0.59	153	0.70	164	0.52	176	0.76	189	0.61	199	0.53				
129	0.52	142	0.67	154	0.69	165	0.67	177	0.69	190	0.60	200	0.53				
130	0.74	143	0.42	155	0.74	167	0.65	178	0.68	191	0.64	201	0.69				
132	0.62	144	0.50	156	0.62	168	0.63	180	0.58	192	0.39	202	0.70				
Percent variance	42.0		31.9		48.6		36.2		48.9		41.5		41.2		52.0		56.9

[a] Factor loading.

Table 3
Loadings for five-factor model of general knowledge[a]

Domains of general knowledge	Factors				
	1	2	3	4	5
Politics	0.68				
History	0.65				
Finance	0.61	−0.20			
Geography	0.43				0.22
Discovery and Exploration	0.39				0.31
History of Science	0.38		0.28		
Fashion		−0.82			
Popular Music		−0.55			
Film		−0.40			0.35
Cookery			0.77		
Medicine			0.62		
Games				−0.76	
Sport	0.33			−0.47	
Biology			0.30	−0.43	
General Science	0.28		0.34	−0.35	
Classical Music					0.62
Literature	0.21				0.55
Art					0.44
Jazz and Blues					0.33

[a] Blanks represent parameters < 0.20.

parameter estimates and chi-squares (Jöreskog, Sörbom, du Toit & du Toit, 1999). ADF and maximum likelihood solutions were very similar, but we report the latter, because of their marginal superiority, both theoretically and in terms of obtained fit statistics.

Following the current consensus, multiple indices were used to evaluate the fit of confirmatory factor models (Bollen, 1989; Marsh, Balla & Hau, 1996). Specifically, in conformity with recent advice (Hu & Bentler, 1998; Marsh et al., 1996), we examined the Standardized Root-Mean-Square Residual (SRMR: Jöreskog & Sörbom, 1981; Bentler, 1995), the Non-Normed Fit Index (NNFI: Bentler & Bonett, 1980), and the Root Mean Square Error of Approximation (RMSEA: Browne & Cudeck, 1993). A model was considered to fit the data if: (a) the NNFI was ≥ 0.90 (Marsh et al., 1996); (b) the RMSEA was close to 0.06 (Hu & Bentler, 1998); and (c) the SRMR was ≤ 0.05 (Spence, 1997).

3.4. First-order factor analyses

The five-factor exploratory solution (Table 3) was subjected to confirmatory factor analysis, with the modification that each item was allowed to load on only one factor. This model was very restrictive in comparison to the exploratory solution, in which the loadings of all items on all factors were estimated. The five-factor model of general knowledge failed to meet the pre-specified criteria of fit (see Table 4). Detailed assessment of fit revealed a very large modification index (MI = 87.1) for the loading of Film on the Arts factor. A modification index of this magnitude

Table 4
Fit indices for first- and second-order confirmatory factor analyses[a]

Factor models	x^2	df	SRMR	NNFI	HNNFI	RMSEA
1. First-order five-factor model	632.3	142	0.053	0.88		0.072
2. First-order five-factor model + cross factor loading	559.3	142	0.049	0.89		0.066
3. First-order six-factor model	487.9	137	0.047	0.91		0.061
4. Higher-order one-factor model	567.5	146	0.050	0.90	0.97	0.065

[a] SRMR = Standardized Root-Mean-Square Residual; NNFI = Non-Normed Fit Index; HNNFI = Higher-order Non-Normed Fit Index; RMSEA = Root-Mean-Square Error of Approximation.

indicates that allowing the factor loading would lead to a substantial increment in fit. Since film is commonly regarded as an art, the model was re-specified accordingly (see Bollen, 1989 for a discussion of re-specification).

The new model incorporating the loading of Film on Arts still marginally failed to meet the criteria of fit for the NNFI and RMSEA (see Table 4). More importantly, an examination of modification indices strongly indicated a correlated error between History of Science and General Science (MI = 44.6). The presence of a correlated error may be indicative of an omitted latent variable. In this instance, a Science factor on which History of Science and General Science loaded would provide a coherent new factor, and improve the interpretability of factors 1 and 3. Consequently, a six-factor model of general knowledge, specifying a new Science factor, was estimated. This model fitted according to our pre-specified criteria (see Table 4) and was, therefore, accepted.

The standardized factor loadings and average extracted variance for the six-factor model of general knowledge are shown in Table 5, and the inter-factor correlations, reliabilities (Werts, Rock, Linn & Jöreskog, 1978), means and standard deviations in Table 6. The factor loadings were satisfactory (Table 5), with 18 loadings at >0.4 and the remaining two loadings at >0.35, while factor reliabilities ranged from moderate to good (0.64–0.84). The average extracted variances were generally adequate, with the exception of the Arts factor, which at 0.27 was substantially below the desirable threshold of 0.5 suggested by Dillon and Goldstein (1984, p. 482). The mean scores and reliabilities for the Arts and Science factors were somewhat low, but this may be an artefact of the sample.

The nature of each factor was determined according to which domains of general knowledge were related to the factor, and the magnitude of the factor loadings. Factor one comprised politics, finance, discovery and exploration, geography, and history. Since these topics form the subject matter, directly or indirectly, of broadsheet newspapers, and current affairs programmes, the factor was denoted Current Affairs. The second fact was labelled Fashion, since film, fashion, and popular music are all features of the fashion milieu. The third factor comprised cookery and medicine (health). This was labelled Family, because these areas of knowledge are related to the traditional family roles of women. Factors four and five correspond unambiguously to the traditional spheres of arts and science, and were labelled accordingly. Finally, Physical Health and Recreation seemed an appropriate label for a domain comprising sport, games and biology.

Table 5
Standardized confirmatory loadings and average extracted variance for six-factor model of general knowledge, with standardized total effects of broad retrieval ability[a]

Factors and composites	Factors						G_m
	1	2	3	4	5	6	
1. *Current Affairs*							
Politics	0.77						0.67
History	0.69						0.58
Finance	0.78						0.69
Geography	0.62						0.47
Discovery and Exploration	0.69						0.56
2. *Fashion*							
Fashion		0.93					0.51
Popular Music		0.46					0.24
Film		0.42			0.38		0.54
3. *Domestic*							
Cookery			0.70				0.46
Medicine			0.78				0.51
4. *Physical Health and Recreation*							
Games				0.65			0.58
Sport				0.58			0.51
Biology				0.74			0.65
5. *Arts*							
Classical Music					0.52		0.32
Literature					0.63		0.48
Art					0.57		0.44
Jazz and Blues					0.37		0.22
6. *Science*							
General Science						0.78	0.68
History of Science						0.65	0.56
Factor variance	0.51	0.46	0.55	0.44	0.27	0.52	0.28

[a] Blanks represent parameters fixed to zero.

3.5. Second-order factor analysis

The high correlations between the six first-order factors of general knowledge (see Table 6) point to the existence of at least one second-order factor. This indicates the desirability of testing for a single second-order factor on which each of the first-order factors might be expected to load. This model is shown in Fig. 1. The second-order factor model attained a good fit according to specified criteria for the SRMR and NNFI (see Table 4). The marginal failure to meet the fit criterion for RMSEA may not be important given that, at small sample size, this index tends to

Table 6
Means, standard deviations and inter-factor correlation matrix for first-order factors of general knowledge[a]

	M	*SD*	1	2	3	4	5	6
1. Current Affairs	9.3	7.2	0.84					
2. Fashion	13.5	4.5	0.48	0.69				
3. Family	12.1	3.9	0.51	0.44	0.71			
4. Physical Health and Recreation	16.4	4.8	0.80	0.57	0.59	0.70		
5. Arts	5.4	4.2	0.82	0.48	0.54	0.68	0.64	
6. Science	5.7	3.1	0.80	0.37	0.68	0.81	0.73	0.68

[a] Scale totals are the unit-weighted sum of item scores. Estimates of internal consistency (cf Werts et al., 1978) are on the diagonal.

over-reject substantially true-population models (Hu & Bentler, 1998, p. 447). A rescaled NNFI was also calculated to reflect the fit solely of the higher portion of the second-order factor model (Marsh, 1991). At 0.97, the higher-order NNFI confirmed that a single higher-order factor provided a good fit to the data (Hu & Bentler, 1998).

A notable feature of the second-order factor model shown in Fig. 1 is the tendency for first-order factors to load highly on the second-order factor, with four out of six loadings >0.85. In contrast, loadings on the first-order factors were mostly moderate, with substantial variance (range = 0.14–0.86) in the specific composites unexplained by the factor. The comparative strengths of the first- and second-order factors is also indicated by the second-order factor having an average extracted variance in the first-order factors of 0.64, whereas the corresponding figures for the first-order factors range from 0.27 to 0.52 (see Table 5). Overall, the second-order factor explains a moderate 28% of the variance in the composites, though only three of the standardized total effects fall below a threshold of 0.4 (see Table 5). One possible interpretation of these findings may be that, while specific components of general knowledge are subject to the vagaries of personal interest, the first-order factors are relatively pure indicators of long-term semantic memory ability. The resultant reliability of the second-order factor was good (0.91: Werts et al., 1978), which suggests that the current scale represents a promising measure of long-term semantic memory ability. Given the problems of sampling variability, we would advise that the full 216-item version of the scale be used for further testing, prior to any major revisions.

4. Discussion

The most important features of the results are that all the domains of general knowledge tested in the study are positively intercorrelated and explicable in terms of a general long-term semantic memory factor and six lower-order long-term memory domain factors. This disconfirms the hypothesis proposed in the early 19th century by Herbart to the effect that different domains of memory are independent or even negatively intercorrelated. As noted in the Introduction, it is unclear how this factor fits into the hierarchical model of abilities proposed by Carroll (1993). The present study does not throw any light on this issue. We can, however, make some reasonable conjectures from other research. First, it is quite well established that general knowledge is highly correlated with *g*. This is clear from factor analyses of the Wechsler tests in which the Information

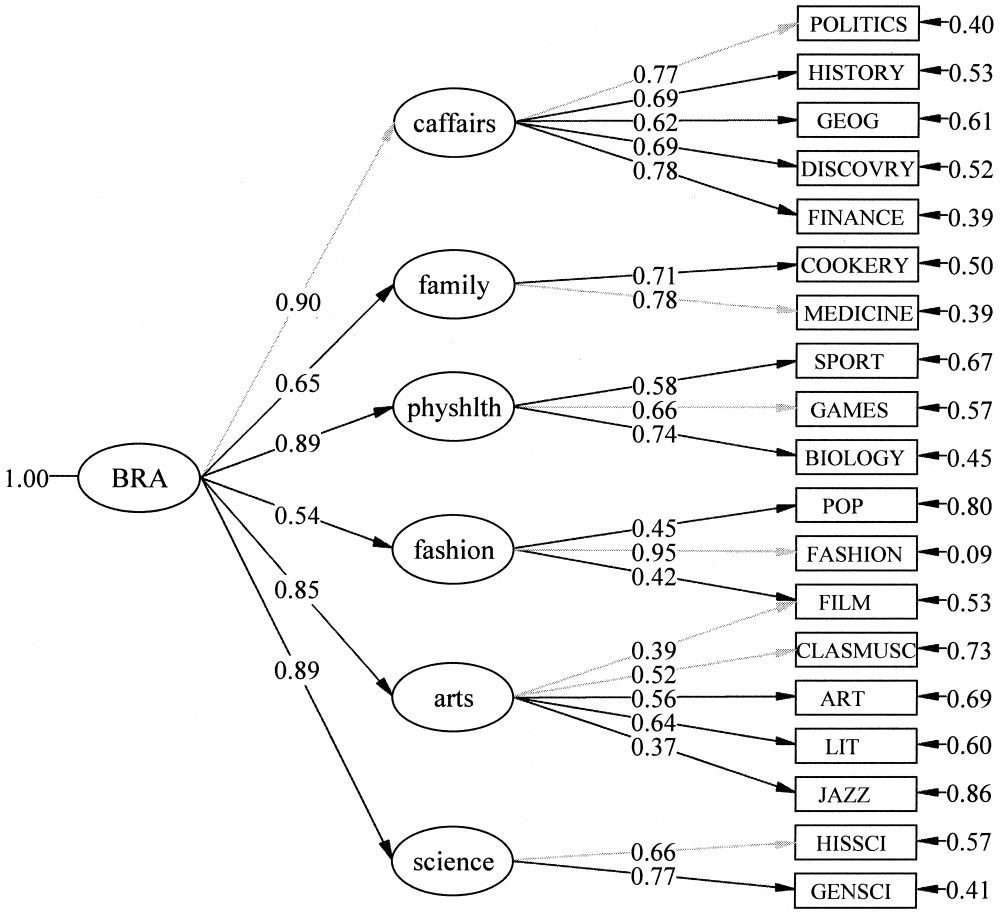

Fig. 1. Second-order confirmatory factor model of general knowledge test. (Ellipses enclose factors, boxes enclose indicators. Long unidirectional arrows represent factor loadings, short arrows unexplained variance, grey and black signify free and fixed parameters, respectively. DISCOVRY = discovery and exploration; GEOG = geography; CLASMUS = classical music; LIT = literature; GENSCI = general science; HISSCI = history of science; caffairs = current affairs; physhlth = physical health and recreation; SEMMEM = semantic memory .).

subtest regularly appears as a good measure of *g* (Jensen, 1998). Secondly, a number of factorial studies have found that general knowledge is a component of the second-order Gc factor or general verbal ability, as Carroll (1993) has shown, but it may also be a component of what Carroll designates Broad Retrieval Ability consisting of the ability to retrieve information from long-term memory. There is a need for conceptual clarification of this point and it may be desirable to posit a general long-term semantic memory factor at the second-order level in hierarchical models of intelligence of the kind proposed by Carroll. This factor would embrace the six first-order factors found in the present study and possibly some others.

We have to acknowledge some possible limitations of the study. First, the questions have a common format of the same kind as that of the information tests in the Wechsler tests. There are alternative formats such as multiple choice or asking for a number of items belonging to specified

categories, such as ''name as many Nobel prize winners as you can think of'', which are designated measures of fluency and which is a component of Carroll's Broad Retrieval Ability. Tests of these kinds could produce different factorial structures. Secondly, there may be further domains of general knowledge unmeasured in the present study.

The explanation for the general factor of long-term semantic memory found in this study is probably that there is some neurophysiological process or processes responsible for the retention of general information in long-term memory. It was proposed by Hebb (1949) that the development of transmission across synapses might be one of these processes and this view is still in favour among memory theorists such as Baddeley (1999). The presence of individual differences in the efficiency of such a process or processes would explain why all domains of long-term semantic memory are positively intercorrelated. We are constantly exposed to information most of which we quickly forget. The existence of individual differences in the retention mechanism would explain the presence of the general factor. The six first-order factors are probably expressions of interests. Different individuals have different interests in current affairs, the arts, science, etc. and acquire and retain information about the domains in which they are interested. This is the point originally made by Herbart when he noted that the scientist remembers a lot of information about science, but little about other things in which he is not interested. Herbart was half right in so far as he proposed that the strength of memories for different domains of knowledge is determined by interests, but the existence of the general factor of long-term semantic memory shows that he was also half wrong and that it is meaningful to speak of some people having ''good memories'' and others having ''poor memories''.

Appendix A

Correlation matrix for general knowledge subscales.

Scale	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. History of Science																		
2. Politics	0.49																	
3. Sport	0.32	0.45																
4. History	0.47	0.62	0.38															
5. Classical Music	0.35	0.33	0.14	0.31														
6. Art	0.43	0.48	0.29	0.42	0.39													
7. Literature	0.41	0.45	0.33	0.43	0.52	0.44												
8. General Science	0.55	0.44	0.38	0.39	0.37	0.31	0.42											
9. Geography	0.33	0.36	0.37	0.32	0.40	0.32	0.42	0.44										
10. Cookery	0.30	0.31	0.14	0.19	0.29	0.32	0.26	0.36	0.29									
11. Medicine	0.31	0.29	0.17	0.20	0.33	0.40	0.33	0.46	0.24	0.51								
12. Games	0.24	0.33	0.48	0.30	0.27	0.32	0.34	0.42	0.30	0.28	0.32							
13. Discovery and Exploration	0.44	0.55	0.36	0.51	0.40	0.40	0.49	0.46	0.52	.26	0.32	0.42						
14. Biology	0.37	0.43	0.38	0.38	0.28	0.49	0.46	0.55	0.40	0.36	0.41	0.52	0.53					
15. Film	0.37	0.43	0.30	0.38	0.39	0.56	0.43	0.30	0.14	0.30	0.28	0.37	0.43	0.41				
16. Fashion	0.25	0.36	0.34	0.26	0.21	0.50	0.36	0.28	0.14	0.35	0.35	0.35	0.41	0.42	0.59			
17. Finance	0.42	0.64	0.47	0.56	0.36	0.41	0.43	0.48	0.38	0.31	0.27	0.38	0.56	0.49	0.43	0.42		
18. Popular Music	0.08	0.13	0.21	0.08	−0.01	0.11	0.13	0.10	0.02	0.16	0.13	0.17	0.11	0.20	0.29	0.45	0.20	
19. Jazz	0.26	0.30	0.29	0.28	0.32	0.24	0.31	0.32	0.32	0.15	0.07	0.31	0.32	0.25	0.37	0.29	0.27	−0.14

References

Baddeley, A. D. (1999). *Essentials of memory*. Hove, UK: Psychology Press.

Bentler, P. M. (1995). *EQS structural equations program manual*. Encino, CA: Multivariate Software.

Bentler, P. M., & Bonett, D. G. (1980). Significance tests and goodness-of-fit in the analysis of covariance structures. *Psychological Bulletin, 88*, 588–600.

Bollen, K. A. (1989). *Structural equations with latent variables*. New York: Wiley.

Bors, D. A., & MacLeod, C. M. (1996). Individual differences in memory. In E. L. Bjork, & R. A. Bjork, *Memory* (pp. 412–441). San Diego, CA: Academic Press.

Browne, M. W., & Cudeck, R. (1993). Alternative ways of assessing model fit. In K. A. Bollen, & J. S. Long, *Testing structural equation models* (pp. 256–293). London: Sage.

Burt, C. L. (1949). The structure of the mind. *British Journal of Educational Psychology, 57*, 176–199.

Carroll, J. B. (1993). *Human cognitive abilities*. Cambridge: Cambridge University Press.

Cattell, R. B. (1966). The scree test for the number of factors. *Multivariate Behavioral Research, 1*, 245–276.

Cohen, J. (1990). Things I have learned (so far). *American Psychologist, 45*, 1304–1312.

Dillon, W. R., & Goldstein, M. (1984). *Multivariate analysis: methods and applications*. New York: Wiley.

Gorsuch, R. L. (1974). *Factor analysis*. London: Saunders.

Hebb, D. O. (1949). *The organisation of behavior*. New York: Wiley.

Herbart, J. F. (1816). *Lehrbuch zur psychologie* (*textbook of psychology*). (M. K. Smith, Trans.). New York: Applebaum, 1891.

Hoogland, J. J., & Boomsma, A. (1998). Robustness studies in covariance modeling: an overview and a meta-analysis. *Sociological Methods and Research, 26*, 329–367.

Hu, L., & Bentler, P. M. (1998). Fit indices in covariance structure modeling: sensitivity to underparametrized model misspecification. *Psychological Methods, 3*, 424–453.

Jensen, A. R. (1998). *The g factor*. Westport, CT: Praeger.

Jöreskog, K. G. (1990). New developments in LISREL: analysis of ordinal variable using polychoric correlations and weighted least squares. *Quality and Quantity, 24*, 387–404.

Jöreskog, K. G. (1993). Testing structural equation models. In K. A. Bollen, & J. S. Long, *Testing structural equation models* (pp. 294–316). London: Sage.

Jöreskog, K. G., & Lawley, D. N. (1968). New methods in maximum likelihood factor analysis. *British Journal of Mathematical and Statistical Psychology, 21*, 85–96.

Jöreskog, K. G., & Sörbom, D. (1981). *LISREL V: analysis of linear structural relationships by the method of maximum likelihood*. Chicago, IL: National Educational Resources.

Jöreskog, K. G., Sörbom, D., du Toit, S., & du Toit, M. (1999). *LISREL 8: new statistical features*. Chicago, IL: Scientific Software International Inc.

Kaiser, H. (1961). A note on Guttman's lower bound for the number of common factors. *Multivariate Behavioral Research, 1*, 249–276.

Kim, J. O., & Mueller, C. W. (1978). *Factor analysis: statistical methods and practical issues*. London: Sage.

Kline, P. (1993). *The handbook of psychological testing*. London: Routledge.

Marsh, H. W. (1991). Multidimensional students' evaluations of teaching effectiveness: a test of alternative higher-order structures. *Journal of Educational Psychology, 83*, 285–296.

Marsh, H. W., Balla, J. R., & Hau, K.-T. (1996). An evaluation of incremental fit indices: a clarification of mathematical and empirical properties. In G. A. Marcoulides, & R. E. Schumacker, *Advanced structural equation modeling: issues and techniques* (pp. 315–335). Mahwah, NJ: Erlbaum.

Nunnally, J. O. (1978). *Psychometric theory*. New York, NJ: McGraw-Hill.

Spearman, C. (1904). General intelligence, objectively determined and measured. *American Journal of Psychology, 15*, 201–293.

Spence, S. H. (1997). Structure of anxiety symptoms among children: a confirmatory factor–analytic study. *Journal of Abnormal Psychology, 106*, 280–297.

Tulving, E. (1972). Episodic and semantic memory. In E. Tulving, & W. Donaldson, *Organization of memory*. New York: Academic Press.

Vernon, P. E. (1950). *The structure of human abilities*. London: Methuen.
Werts, C. E., Rock, D. R., Linn, R. L., & Jöreskog, K. G. (1978). A general method of estimating the reliability of a composite. *Educational and Psychological Measurement, 38*, 933–938.