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Gender differences in latent cognitive abilities and education links with g in Italian elders

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ABSTRACT

The process of ageing induces researchers to study the psychological characteristics of elders, particularly general intelligence or *g*. The *g* factor can be extracted from a correlation matrix of a battery of cognitive tests and is a significant predictor of success in life. One of the most important questions in intelligence research is if there are gender differences in latent cognitive abilities and different relationships between education and g in males and females. Analysis with structural equation models was applied on 1,168 volunteer normal, healthy older adults aged 65–84 years from the Italian standardization sample for old age of the WAIS-R. The results suggested that there are no gender differences in latent cognitive abilities, while education showed a significant relationship with intelligence, both for males and females.

The increasing proportion of elders in the Italian population is a well known trend, growing from about 18% in 2001 to around 20% in 2010, and estimated to reach approximately 33% by 2050 (ISTAT, 2001, 2008; Zenezini, 2009). Consequently, many researchers in Italy are studying the process of ageing and the health, socio-economical, and psychological problems that affect elders. One of the most important aspects of the ageing process is its effect on intelligence, particularly its impact on general intelligence or *g* and its components, that is, fluid and crystallized intelligence (Horn & Cattell, 1967).

It is necessary to establish valid measurement models for tests of intelligence before analyzing structural relationships between intelligence and other constructs. As noted by Anderson and Gerbing (1982, p. 453), "proper specification of the measurement model is necessary before meaning can be assigned to the analysis of the structural model." Therefore, it is not possible to study the effects of ageing on intelligence in Italy if the structural validity of tests used to measure intelligence has not been established. Given that the Wechsler Adult Intelligence Scale–Revised (WAIS-R; Orsini & Laicardi, 1997, 2003) is the version of the Wechsler scale currently used with adults in Italy, its measurement model must be validated prior to investigate its structural relationship with age and other variables.

Fortunately, the Italian WAIS-R has been tested with both exploratory factor analytic (EFA) and confirmatory factor analytic (CFA) methods on data obtained from normative samples as well as with independent samples of adults (Balsamo, Romanelli, & Saggino, 2010; Laicardi, Frustaci, & Lauriola, 1996; Orsini & Laicardi, 1997, 2003). Using the normative sample, Orsini and Laicardi (1997, 2003) found three factors for ages 16–54 years, two factors for ages 55–64, and one factor for ages 65–84 years. The three-factor solution was composed of verbal comprehension (VC), perceptual organization (PO), and memory/freedom from distractibility (M/FD) factors whereas the two-factor solution contained the VC and PO factors. A similar three-factor solution was found for an independent sample of 180 young adults aged 19–35 years (Laicardi et al., 1996), and a one-factor solution was found in a sample of 523 older adults aged 65–100 years (Balsamo et al., 2010). Another sample of 400 older adults aged 65–100 years replicated the one-factor structure for ages 65–74 years but found three factors at ages 75–100 years (Saggino, Balsamo, Grieco, Cerbone, & Raviele, 2004).

Given these inconsistent factor analytic results, Pezzuti, Barbaranelli, and Orsini (2012) reanalyzed the data from the 2,284 adults in the WAIS-R Italian normative sample aged 16–74 years. Participants were separated into four age groups (16–24 years, 25–44 years, 45–64 years, and 65–74 years), and CFA solutions for each age group were computed. Although a three-factor solution was superior for all four age groups, the picture arrangement subtest was allowed to cross-load on the VC factor for ages 16–24 and 65–74 years. The preferred model for age 45–64 years did not allow picture arrangement to cross-load and placed the digit symbol subtest on the M/FD factor. It

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should be noted that preferred models were selected by Pezzuti et al. (2012) because of significant chi-square difference tests. However, excessive power associated with large sample sizes and multiple comparisons may have made practical fit criteria more appropriate (Gignac, 2007). In fact, differences in fit index values were generally small, indicative of non-meaningful changes in model fit among the various three-factor solutions (Chen, 2007). Thus, there remains some doubt about the factor structure of the Italian WAIS-R.

Previous research has also demonstrated that measurement models for the WAIS-R are affected by variation of language and culture of samples (Crawford, Gray, & Allan, 1995; Roivainen, 2013). Although a two factor solution was found in some samples, others were best described by a three factor model (Leckliter, Matarazzo, & Silverstein, 1986). Generally, the Digit Span and Arithmetic subtests loaded highest on the third factor (M/FD) with, in some cases, the digit symbol subtest (Leckliter et al., 1986; Orsini & Laicardi, 1997, 2003; Pezzuti et al., 2012). Thus, before any structural analysis on the general factor of intelligence, it is necessary to establish the best measurement model for a given sample with confirmatory factor analyses (CFAs).

Beyond the structural validity of any specific cognitive test, one of the most important topics in research about intelligence is the question of sex differences. Some researchers have demonstrated the existence of gender differences in general intelligence that favor men (Irwing, 2012; Lynn, 1997, 1999; Mackintosh, 1998; Nyborg, 2003). Furthermore, general intelligence is generally positively correlated with brain size, and men tend to have larger brains (McDaniel, 2005; Rushton & Ankney, 2009). In contrast, other researchers found no significant gender difference in general intelligence (e.g., Burgaleta et al., 2012; Colom, García, Juan-Espinosa, & Abad, 2002; Colom, Juan-Espinosa, Abad, & García, 2000; Crawford et al., 1995; Flynn & Rossi-Casé, 2011; Halpern & LaMay, 2000; Jensen, 1998; Saggino et al., 2014).

Specific gender differences have been more evident for some latent cognitive factors, for example, superior working memory (WM) and PO factor scores for men (Dolan et al., 2006). Alternatively, males have displayed better performance in mathematical achievement, WM, manipulation of visual images, spatial reasoning, and mechanical reasoning while females have demonstrated superiority in reading and writing achievement, long term memory retrieval, acquisition and use of verbal information, and perceptual speed (Flores-Mendoza et al., 2013; Halpern & LaMay, 2000; Kaufman, Kaufman, Liu, & Johnson, 2009; van der Sluis et al., 2006).

Education has also been found to be a source of variability in cognitive performance (Ardila & Rosselli, 1989; Youngjohn, Larrabee, & Crook, 1993). For example, the portion of total variance accounted for by g dropped from 51% to 37% over the ages of 25 to 64 years, when education was partialled out and education was more strongly related to g than was age (.29 versus -.13 loading value, respectively; Birren & Morrison, 1961). Studies with other intelligence tests have found that an increase in education level was associated with better performance on intelligence tests (Brinch & Galloway, 2012; Kaufman & Lichtenberger, 2006; Kaufman et al., 2009; Paolo & Ryan, 1994; Portin, Saarijärvi, Joukamaa, & Salokangas, 1995).

In short, there remains considerable uncertainty regarding sex and education differences on intelligence. The plain of our work is the following:

1. To apply confirmatory factor analyses to different hierarchical formative models (Bollen & Lennox, 1991; Diamantopoulos, Riefler, & Roth, 2008) to identify the model which has the best goodness-of-fit-to data from the Italian standardization sample for old age of the Wechsler Adult Intelligence Scale–Revised (Orsini & Laicardi, 2003);
2. To test with a multigroup confirmatory factor analysis the measurement invariance between males and females in relation to the effects of g and first-order factors of intelligence on WAIS-R subtests (Saggino et al., 2014);
3. To test the effect of the exogenous variable education on g for both males and females with a multiple indicators multiple causes model (Keith, Reynolds, Patel, & Ridley, 2008).

1. Method

1.1. Participants

The Italian standardization sample for old age of the Wechsler Adult Intelligence Scale (WAIS–R), which is the version of the Wechsler scale currently used with adults in Italy, included 1,168 volunteer, normal, healthy older adults from 65 to 84 years (584 men and 584 females). Their mean years of education was 6.0 years ($SD = 3.6$). More information about this sample is reported in Orsini and Laicardi (2003).

1.2. Analyses

1.2.1. Confirmatory factor analyses to select the best hierarchical formative model

We applied CFA to the WAIS-R data from the 1,168 participants to identify the factorial structure of the WAIS-R among this older Italian sample. In particular, we tested the five models, whose path diagrams are shown in Fig. 1, that have obtained confirmation in prior research (Pezzuti et al., 2012):

1. Model 1 consists of two first-order factors, VC and PO, and a second-order general factor. VC includes the information, digit span, vocabulary, arithmetic, comprehension, and similarities subtests, while PO includes the picture completion, picture arrangement, block design, object assembly, and digit symbol subtests;
2. Model 2 has three first-order factors: VC, PO, and M/FD and the second-order g factor. VC includes information, vocabulary, comprehension, and similarities subtests; PO includes picture completion, picture arrangement, block design, object assembly, and digit symbol subtests; and M/FD includes digit span and arithmetic subtests;
3. Model 3 contains the same three first-order factor as model 2, but the digit symbol subtest is included in the M/FD factor instead of the PO factor;
4. Model 4 contains the same three first-order factors as model 2, but the picture arrangement subtest is included in the VC factor in addition to the PO factor;
5. Model 5 is the same as model 4, but the digit symbol subtest is included in the M/FD factor instead of the PO factor.

1.2.2. Test of measurement invariance between males and females

Previous research confirmed the measurement invariance in g between males and females (Saggino et al., 2014). However the invariance of first-order factors of intelligence (VC, PO, and M/FD) was not tested. Therefore, we tested the measurement invariance both for g and for first-order factors with a multigroup confirmatory analysis (MGCFA) on the bi-factor model illustrated in Fig. 2.

Measurement invariance (Meredith, 1993; Mullen, 1995) tests the invariance of the factorial pattern (configural invariance), of factor loadings (metric invariance), of intercepts (scalar invariance), and of residual variance (strict factorial invariance). Partial measurement invariance tests the configural, metric, scalar and strict factorial invariance when some parameters vary between groups.

1.2.3. Test of education effects on g in males and females

To test the effects of the exogenous variable education on g in both males and females, we performed an analysis with a MIMIC model. Fig. 3 shows the path diagram of the MIMIC model. Education is the school attendance (centered, in years) of each individual (Keith et al., 2008). School attendance has been shown to be linked with IQ scores (Ceci, 1991).

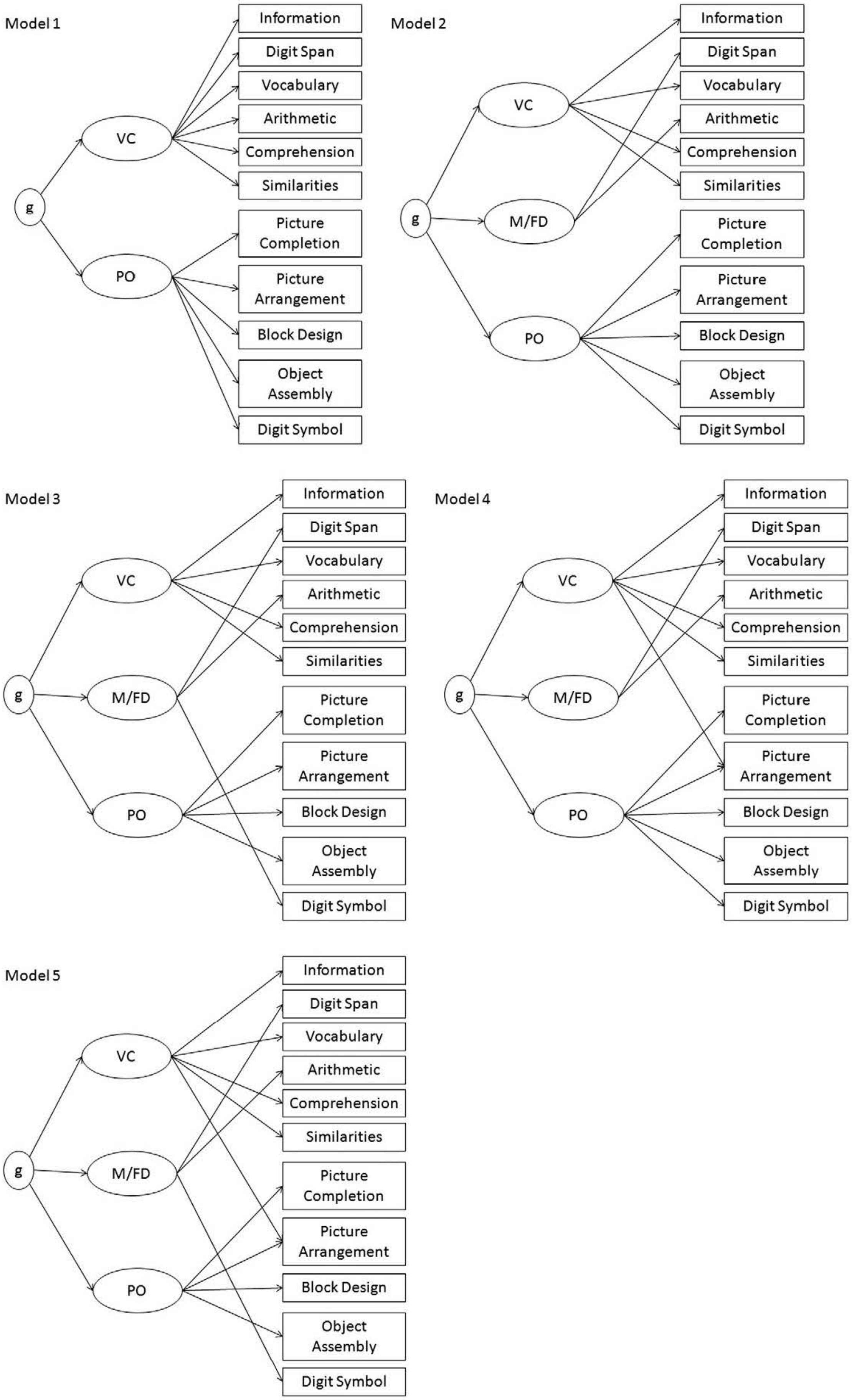

Fig. 1. Models used in CFAs to test structural validity of the WAIS–R.

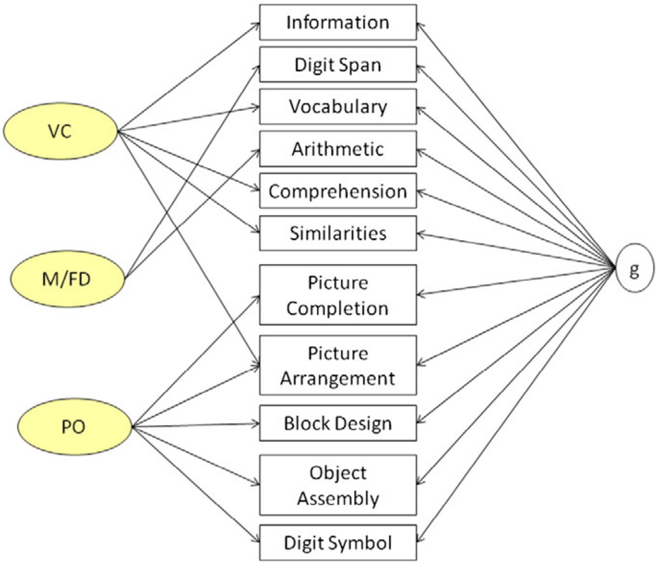

Fig. 2. Bi-factor model used to test measurement invariance between genders.

All analyses were conducted with M-plus 7.0 (Muthén & Muthén, 1998–2012). We used the maximum likelihood extraction method. Fit of the models to the empirical data was judged with the χ^2, the comparative fit index (CFI), the Tucker—Lewis fit index (TLI), the root mean square error of approximation (RMSEA), the 90% confidence interval for RMSEA, and the standardized root mean residual (SRMR). Because χ^2 is always significant with large samples, CFI, TLI, RMSEA with confidence interval, and SRMR were used to compare the fit of the competing models. A good model should have CFI $\geq .95$, TLI $\geq .95$, RMSEA $\leq .06$, an inferior limit of the 90% RMSEA confidence interval $\leq .08$, and SRMR $\leq .05$, while an acceptable model should have CFI and TLI $\geq .90$ and RMSEA and SRMR $\leq .08$ (Browne & Cudeck, 1993; Hu & Bentler, 1999). Marsh, Hau, and Wen (2004) suggested use of TLI rather than SRMR to test model fit because TLI is less affected by sample size.

2. Results and discussion

2.1. *Confirmatory factor analyses to select the best hierarchical formative model*

As illustrated by the results in Table 1, model 4 best fits the data.

This three-factor structure of the WAIS-R allowed the picture arrangement subtest to load on both VC and PO factors. Our results are similar to those obtained by Crawford, Allan, Stephen, Parker, and Besson (1989), Burgess, Flint, and Adshead (1992), Laicardi et al. (1996), and Pezzuti et al. (2012).

2.2. *Test of measurement invariance between males and females*

Table 2 shows descriptive statistics (mean and SD) for each WAIS-R subtest and full score IQ (FSIQ) partitioned on the basis of gender and years of schooling of subjects.

We tested measurement invariance between genders of the bi-factor model shown in Fig. 2.

We calculated the differences between the CFI values of the configural, metric, scalar, and strict invariance models. If the difference between CFIs (ΔCFI) was lower than −.01, then the between-group invariance of CFA models was confirmed (Cheung & Rensvold, 2002). The metric model was compared to the configural model to test invariance of factor loadings; the scalar model was compared with the metric model to test intercepts invariance; and the strict model was compared to the scalar model to test the residual variances' invariance. Table 3 shows the goodness-of-fit-indexes for each model and the ΔCFI values.

The ΔCFI between the metric and the configural models was lower than −.01 (−.007), thus confirming metric invariance, while the ΔCFI between the scalar and the metric model was about −.01. If the intercept of the arithmetic subtest was set free then the ΔCFI was lower than −.01 (−.006), indicating partial scalar invariance. Comparing the strict invariance model with the partial scalar model, we obtained a value of ΔCFI lower than −.01 (−.008). Therefore, the measurement invariance of g and the first-order factors (VC, PO and M/FD) was confirmed (Saggino et al., 2014), indicating that the WAIS–R structure

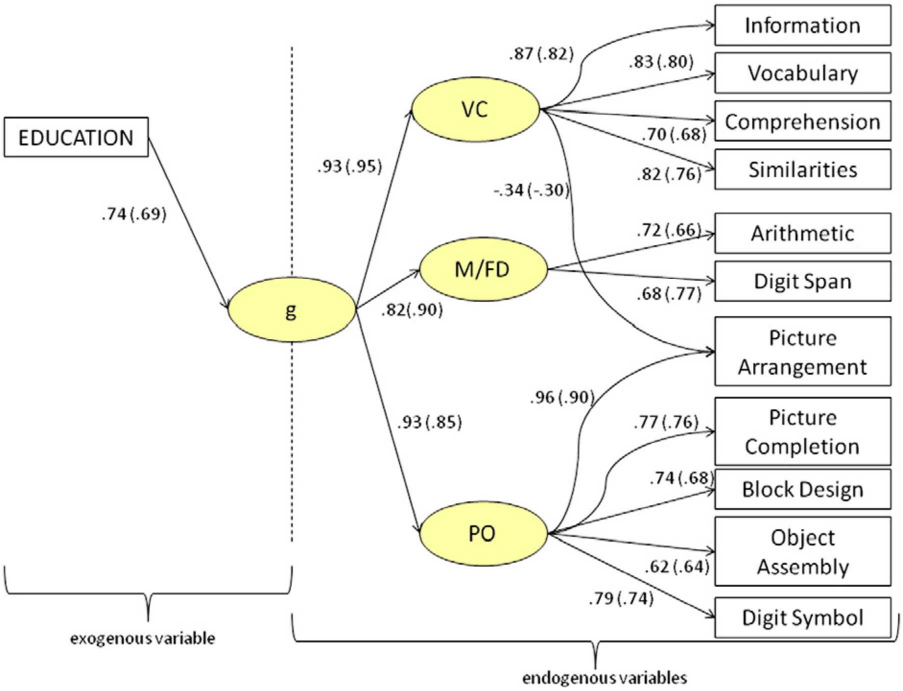

Fig. 3. MIMIC model for testing the effects of the exogenous variable education on *g* and the effects of *g* on first-order factors CV, PO, and M/FD and on WAIS-R subtest scores (endogenous variables). Standardized coefficients for both females and males (in parentheses) are reported. All coefficients are significant ($p < .01$).

Table 1
Goodness-of-fit indexes for CFA Models 1–5 and the MIMIC Model.

Models	χ^2	df	CFI	TLI	RMSEA	90% C.I. RMSEA	SRMR
Model 1 (VC & PO)	724.301	34	.911	.883	.118	.110–.126	.053
Model 2 (VC, PO, & M/FD)	546.215	41	.934	.911	.103	.095–.110	.043
Model 3 (VC, PO, & M/FD)	668.387	41	.918	.890	.114	.107–.122	.048
Model 4 (VC, PO, & M/FD)	484.846	40	.942	.920	.098	.090–.105	.040
Model 5 (VC, PO, & M/FD)	609.907	40	.926	.898	.110	.103–.118	.047

Note: VC is verbal comprehension factor; PO is perceptual organization factor; and M/FD is memory/freedom from distractibility factor.

was equivalent between men and women in this sample of older Italian adults.

2.3. Test of education effects on g in males and females

Fig. 3 shows the standardized coefficients of the path between the endogenous variables (WAIS-R subtests and first-order factors) and the exogenous variable education, for both females and males (males in parentheses). All coefficients were significant. In particular, the standardized path coefficient from education to *g* was .74 for females and .69 for males. The difference between the coefficients is not significant ($Z = 1.666$, $p = 0.096$). Therefore the effect of the exogenous variables education on *g* is the same between males and females. The goodness-of-fit indexes of the MIMIC model are fair ($\chi^2 = 407.621$ df $= 95$; RMSEA $= .075$ (90% RMSEA .068–.083); CFI $= .955$; TLI $= .938$).

The MIMIC model confirms the significant effect of *g* on the three first-order factors (VC, PO, and M/FD). In addition, the first-order factors have significant effects on their corresponding WAIS-R subtests. In particular, the standardized coefficient of the path from VC to the picture arrangement scale is negative. Therefore, an increase of one standard deviation of VC would decrease the score on the picture arrangement subtest by .34 standard deviations for females and .30 standard deviations for males.

Several conclusions emerge from our study. First, our findings show that in the Italian sample of elder adults who participated in the Italian standardization of the WAIS-R, Wechsler's scales can be considered a measure of three first-order constructs of intelligence which are VC, PO, and M/FD, with the picture arrangement subtest loading both on VC and PO. Second, the multigroup confirmatory factor analysis confirmed measurement invariance of *g* (Saggino et al., 2014) and, in addition, of the first-order factors between male and female Italian elders. Third, the MIMIC model confirmed the relationship of education with *g* in Italian elders. Therefore, our results agree with the experimental findings of previous research wherein gender and education effects on *g* were tested for adults where education showed a stronger effect on intelligence than gender (Kaufman et al., 2009; Paolo & Ryan, 1994; Portin et al., 1995).

The link between education and IQ is clearly demonstrated by much research and, in particular, the relationships between grade attained, school attendance, early school termination, late school onset, and IQ (Ceci, 1991). According to Ceci (1991, p. 711), “the high correlations between IQ and schooling are difficult to account for on the basis of genetic solution or any other explanation (e.g., motivational differences or parental socioeconomic status), because these mechanisms appear farfetched in many of the studies that were reviewed.” Therefore, schooling can improve individual cognitive skills because it furnishes relevant information, it trains people to concentrate on problems, and it inculcates modes of cognition that are valued on intelligence tests (Ceci, 1991). An alternative view is that people with higher IQs are more successful in school and persist in the educational system, thereby reversing the direction of the education–IQ relationship. True experiments, which would be impossible to conduct, would be required to authoritatively determine the causal relationship of education and IQ. However, natural experiments have shown that schooling affected IQ (Brinch & Galloway, 2012; Cahan & Cohen, 1989). Recent research has shown that a large proportion of the variance in school achievement is independent of intelligence (Haworth, Asbury, Dale, & Plomin, 2011), that standardized tests of achievement and intelligence measure are separate but highly related constructs (Kaufman, Reynolds, Liu, Kaufman, & McGrew, 2012), and that early intelligence and later achievement are partially independent (Ritchie & Bates, 2013). Additionally, it is probably not reasonable to posit such a radical genotype by environment interaction (Manuck & McCaffery, 2014). Consequently, the bioecological model of intelligence (Scullin, Peters, Williams, & Ceci, 2000) appears to be the most reasonable explanation for the current results.

A limit of our study is that the relation between education and *g* might have been affected by the combined effects of gender and social and cultural behavior of individuals within the standardized sample of older adults. It will be necessary to study the effect of education in samples containing different age ranges to test how education affects *g* from youth to old age. Only in this way will it be possible to compare the kind and size of education effects in elders to those of younger adults.

Another potential limit is that gender effects on *g* might also vary in relation to sample characteristics. Therefore, it is important that future

Table 2
Mean and standard deviations (SD) of subtests scores and full scale IQ score (FSIQ) for different years of schooling and gender characteristics of Italian standardization sample for old age of the WAIS-R.

	Years of schooling								Gender			
	<5 Years		5 Years		8 Years		>8 Years		Females		Males	
WAIS-R subtests and IQ	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Information	7.80	1.97	9.71	2.48	11.47	2.45	13.55	2.47	9.21	2.89	10.84	2.76
Digit span	8.32	2.62	9.91	2.68	11.05	2.60	12.32	2.33	9.68	2.84	10.35	2.91
Vocabulary	8.27	2.41	9.21	2.64	11.49	2.43	13.84	2.06	9.73	3.05	10.20	3.03
Arithmetic	8.59	2.69	9.75	2.72	10.93	2.67	12.76	3.01	9.17	2.81	10.92	2.94
Comprehension	8.35	2.60	9.35	2.57	11.22	2.86	13.05	2.91	9.49	2.95	10.31	3.12
Similarities	8.41	2.48	9.51	2.59	11.15	2.87	13.50	2.57	9.79	3.03	10.26	3.04
Picture completion	8.04	2.40	9.77	2.58	11.30	2.72	12.67	3.13	9.46	3.02	10.50	2.91
Picture arrangement	8.61	2.17	9.76	3.04	10.85	2.78	11.92	2.80	9.59	2.78	10.28	3.07
Block design	8.31	2.46	9.79	2.63	10.88	2.76	12.36	2.75	9.42	2.88	10.44	2.83
Object assembly	8.56	3.00	9.75	2.75	10.93	2.75	11.93	2.86	9.45	3.07	10.43	2.88
Digit symbol	7.84	2.25	10.19	2.84	11.43	2.47	12.66	2.37	9.66	3.02	10.60	2.91
FSIQ	88.08	9.95	97.96	11.76	108.13	12.31	119.50	11.97	96.67	14.83	103.32	14.46

Table 3
Goodness-of-fit indexes for testing measurement invariance between males and females with multigroup confirmatory analysis.

Model	χ^2	df	RMSEA	TLI	CFI	ΔCFI
1. Configural invariance	287.266	66	0.076	0.942	0.965	
2. Metric invariance	352.062	89	0.071	0.949	0.958	**−0.007**
3. Scalar invariance	420.008	92	0.078	0.938	0.948	−0.010
3a. Excluding arithmetic intercept	391.816	91	0.075	0.942	0.952	**−0.006**
4. Strict invariance	452.675	101	0.077	0.939	0.944	**−0.008**

Note: model 3a is compared with model 2. ΔCFIs lower than −.01 are in bold types.

researchers try to disentangle the combination of cultural, social, and educative effects from the genetic characteristics of people to obtain a pure measure of the effects of individual genetic characteristics on *g*. There is research that shows that external factors such as stress (McEwen, 2010), skin massages (Guzzetta et al., 2009), or poverty (Mani, Mullainathan, Shafir, & Zhao, 2013) can affect cognitive functions.

3. Conclusions

In conclusion, the results of the present study suggest that the strength of the relation between education and *g* is equivalent for both males and females. In addition, these results confirm that the measure of intelligence in older Italian adults obtained with the WAIS-R is structured into three first-order factors (verbal comprehension, perceptual organization, and memory/freedom from distractibility) and one higher-order general factor, as shown in previous literature.

References

Anderson, J., & Gerbing, O. (1982). Some methods for respecifying measurement models to obtain unidimensional construct measurement. *Journal of Marketing Research*, *19*, 453–460.

Ardila, A., & Rosselli, M. (1989). Neuropsychological characteristics of normal aging. *Developmental Neuropsychology*, *5*, 307–320.

Balsamo, M., Romanelli, R., & Saggino, A. (2010). The de-differentiation hypothesis in normal elderly persons 1, 2. *Perceptual and Motor Skills*, *110*, 85–88.

Birren, J.E., & Morrison, D.F. (1961). Analysis of WAIS subtests in relation to age and education. *Journal of Gerontology*, *16*, 363–369.

Bollen, K., & Lennox, R. (1991). Conventional wisdom on measurement: A structural equation perspective. *Psychological Bulletin*, *110*, 305–314.

Brinch, C.N., & Galloway, T.A. (2012). Schooling in adolescence raises IQ scores. *Proceedings of the National Academy of Sciences*, *109*, 425–430.

Browne, M.W., & Cudeck, R. (1993). Alternative ways of assessing model fit. In K.A. Bollen, & J.S. Long (Eds.), *Testing structural equation models* (pp. 136–162). Newbury Park, CA: Sage.

Burgaleta, M., Head, K., Álvarez-Linera, J., Martínez, K., Escorial, S., Haier, R., et al. (2012). Sex differences in brain volume are related to specific skills, not to general intelligence. *Intelligence*, *40*, 60–68.

Burgess, A., Flint, J., & Adshead, H. (1992). Factor structure of the Wechsler Adult Intelligence Scale-Revised (WAIS-R): A clinical sample. *British Journal of Clinical Psychology*, *31*, 336–338.

Cahan, S., & Cohen, N. (1989). Age vs. schooling effects on intelligence development. *Child Development*, *60*, 1239–1249. http://dx.doi.org/10.2307/1130797.

Ceci, S.J. (1991). How much does schooling influence general intelligence and its cognitive components? A reassessment of the evidence. *Developmental Psychology*, *27*, 703–722.

Chen, F.F. (2007). Sensitivity of goodness of fit indexes to lack of measurement invariance. *Structural Equation Modeling*, *14*, 464–504.

Cheung, G. W., & Rensvold, R. B. (2002). Evaluating goodness-of-fit indexes for testing measurement invariance. *Structural Equation Modeling*, *9*, 233–255.

Colom, R., Juan-Espinosa, M., Abad, F.J., & García, L.F. (2000). Negligible sex differences in general intelligence. *Intelligence*, *28*, 57–68.

Colom, R., García, L.F., Juan-Espinosa, M., & Abad, G.J. (2002). Null sex differences in general intelligence: Evidence from the WAIS-III. *The Spanish Journal of Psychology*, *28*, 29–35.

Crawford, J.R., Allan, K.M., Stephen, D.W., Parker, D.M., & Besson, J.A.O. (1989). The Wechsler Adult Intelligence Scale—Revised (WAIS-R): Factor structure in a U.K. sample. *Personality and Individual Differences*, *10*, 1209–1212.

Crawford, J.R., Gray, C.D., & Allan, K.M. (1995). The WAIS-R (UK): Basic psychometric properties in an adult UK sample. *British Journal of Clinical Psychology*, *34*, 237–250.

Diamantopoulos, A., Riefler, P., & Roth, K.P. (2008). Advancing formative measurement models. *Journal of Business Research*, *61*, 1203–1218.

Dolan, C.V., Colom, R., Abad, F.J., Wicherts, J.M., Hessen, D.J., & van der Sluis, S. (2006). Multi-group covariance and mean structure modeling of the relationship between the WAIS – III common factors and sex and educational attainment in Spain. *Intelligence*, *34*, 193–210.

Flores-Mendoza, C., Widaman, K.F., Rindermann, H., Primi, R., Mansur-Alves, M., & Pena, C.C. (2013). Cognitive sex differences in reasoning tasks: Evidence from Brazilian samples of educational settings. *Intelligence*, *41*, 70–84.

Flynn, J.R., & Rossi-Casé, L. (2011). Modern women match men on Raven's Progressive Matrices. *Personality and Individual Differences*, *50*, 799–803.

Gignac, G.E. (2007). Multi-factor modeling in individual differences research: Some recommendations and suggestions. *Personality and Individual Differences*, *42*, 37–48.

Guzzetta, A., Baldini, S., Bancale, A., Baroncelli, L., Ciucci, F., Ghirri, P., et al. (2009). Massage accelerates brain development and the maturation of visual function. *Journal of Neuroscience*, *6*, 6042–6051.

Halpern, D.G., & LaMay, M.L. (2000). The smarter sex: A critical review of sex differences in intelligence. *Educational Psychology Review*, *12*, 229–246.

Haworth, C.M.A., Asbury, K., Dale, P.S., & Plomin, R. (2011). Added value measures in education show genetic as well as environmental influence. *PLoS One*, *6*(2), e16006.

Horn, J.L., & Cattell, R.B. (1967). Age differences in fluid and crystallized intelligence. *Acta Psychologica*, *26*, 107–129.

Hu, L., & Bentler, P. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling*, *6*, 1–55.

Irwing, P. (2012). Sex differences in *g*: An analysis of the US standardization sample of the WAIS-III. *Personality and Individual Differences*, *53*, 126–131.

ISTAT (2001). XIV Censimento della popolazione e delle abitazioni. www.istat.it

ISTAT (2008). Previsioni demografiche. 1° Gennaio 2007–1° Gennaio 2051. www.istat.it

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

Kaufman, A.S., Kaufman, J.C., Liu, X., & Johnson, C.J. (2009). How do educational attainment and gender relate to fluid intelligence, crystallized intelligence and academic skills at ages 22–90 years? *Archives of Clinical Neuropsychology*, *24*, 153–163.

Kaufman, A.S., & Lichtenberger, E.O. (2006). *Assessing adolescent and adult intelligence*. New York, NY: Wiley.

Kaufman, S.B., Reynolds, M.R., Liu, X., Kaufman, A.S., & McGrew, K.S. (2012). Are cognitive *g* and academic achievement *g* one and the same *g*? Exploration on the Woodcock-Johnson and Kaufman tests. *Intelligence*, *40*, 123–138. http://dx.doi.org/10.1016/j.intell.2012.01.009.

Keith, T.Z., Reynolds, M.R., Patel, P.G., & Ridley, K. (2008). Sex differences in latent cognitive abilities ages 6 to 59: Evidence from the Woodcock – Johnson III test of cognitive abilities. *Intelligence*, *36*, 502–525.

Laicardi, C., Frustaci, A., & Lauriola, M. (1996). Factor structure of the WAIS-R Italian version compared with American and British solutions. *Psychological Reports*, *79*, 1171–1177.

Leckliter, I.N., Matarazzo, J.D., & Silverstein, A.B. (1986). A literature review of factor analytic studies of the WAIS-R. *Journal of Clinical Psychology*, *42*, 332–342.

Lynn, R. (1997). Sex differences in intelligence: Data from a Scottish standardization of the WAIS-R. In H. Nyborg (Ed.), *The scientific study of general intelligence: Tribute to Arthur Jensen*. Risskov, Denmark: University of Aarhus.

Lynn, R. (1999). Sex differences in intelligence and brain size: A developmental theory. *Intelligence*, *27*, 1–12.

Mackintosh, N.J. (1998). *IQ and human intelligence*. New York, NY: Oxford University Press.

Mani, A., Mullainathan, S., Shafir, E., & Zhao, J. (2013). Poverty impedes cognitive function. *Science*, *341*, 976–980.

Manuck, S.B., & McCaffery, J.M. (2014). Gene-environment interaction. *Annual Review of Psychology*, *65*, 41–70. http://dx.doi.org/10.1146/annurev-psych-010213-115100.

Marsh, H.W., Hau, K., & Wen, Z. (2004). In search of golden rules: Comment on hypothesis-testing approaches to setting cut-off values for fit indexes and dangers in overgeneralization Hu and Bentler's (1999) findings. *Structural Equation Modeling*, *11*, 320–341.

McDaniel, M.A. (2005). Big-brained people are smarter: A meta-analysis of the relationship between in vivo brain volume and intelligence. *Intelligence*, *33*, 337–346.

McEwen, B.S. (2010). Stress, sex, and neural adaptation to a changing environment: Mechanisms of neuronal remodeling. *Annals of the New York Academy of Sciences*, *1204*, 38–59.

Meredith, W. (1993). Measurement invariance, factor analysis and factorial invariance. *Pychometrika*, *58*, 525–543.

Mullen, M. (1995). Diagnosing measurement equivalence in cross-national research: A structural equation approach. *Journal of Applied Psychology*, *73*, 574–584.

Muthén, L.K., & Muthén, B.O. (1998–2012). *Mplus user's guide* (7th ed.). Los Angeles, CA: Muthén & Muthén.

Nyborg, H. (2003). *The scientific study of general intelligence: Tribute to Arthur Jensen*. Risskov, Denmark: University of Aarhus.

Orsini, A., & Laicardi, C. (1997). *WAIS-R. Contributo alla taratura italiana [WAIS-R. Contribution to the Italian standardization]*. Firenze: Organizzazioni Speciali.

Orsini, A., & Laicardi, C. (2003). *WAIS-R e terza età [WAIS-R and third age]*. Firenze: Organizzazioni Speciali.

Paolo, A.M., & Ryan, J.J. (1994). Factor structure of the WAIS-R by educational level: An examination of elderly persons. *Archives for Clinical Neuropsychology*, *9*, 259–264.

Pezzuti, L., Barbaranelli, C., & Orsini, A. (2012). Structure of the Wechsler Adult Intelligence Scale– Revised in the Italian normal standardisation sample. *Journal of Cognitive Psychology*, *24*, 229–241.

Portin, R., Saarijärvi, S., Joukamaa, M., & Salokangas, R.K.R. (1995). Education, gender and cognitive performance in a 62-year-old normal population: Results from the Turva Project. *Psychological Medicine*, *25*, 1295–1298.

Ritchie, S.J., & Bates, T.C. (2013). Enduring links from childhood mathematics and reading achievement to adult socioeconomic status. *Psychological Science*, *24*, 1301–1308. http://dx.doi.org/10.1177/0956797612466268.

Roivainen, E. (2013). Are cross-national differences in IQ profiles stable? A comparison of Finnish and U.S. WAIS norms. *International Journal of Testing*, *13*, 140–151.

Rushton, J.P., & Ankney, C.D. (2009). Whole brain size and general mental ability: A review. *International Journal of Neuroscience*, *119*, 692–732.

Saggino, A., Balsamo, M., Grieco, A., Cerbone, M.R., & Raviele, N.N. (2004). Corsi's block-tapping task: Standardization and location in factor space with the WAIS-R for two normal samples of older adults 1. *Perceptual and Motor Skills*, *98*, 840–848.

Saggino, A., Pezzuti, L., Tommasi, M., Cianci, L., Colom, R., & Orsini, A. (2014). Null sex differences in general intelligence among elderly. *Personality and Individual Differences*, *63*, 53–57.

Scullin, M.H., Peters, E., Williams, W.M., & Ceci, S.J. (2000). The role of IQ and education in predicting later labor market outcomes: Implications for affirmative action. *Psychology, Public Policy, and Law*, *6*, 63–89. http://dx.doi.org/10.1037/11076-8971.6.1.63.

van der Sluis, S., Posthuma, D., Dolan, C.V., de Geus, E., Colom, R., & Boomsma, D.I. (2006). Sex differences on the Dutch WAIS – III. *Intelligence*, *34*, 273–289.

Youngjohn, J.R., Larrabee, G.J., & Crook, T.H. (1993). New age- and education corrected norms for the Benton Visual Retention Test. *Clinical Neuropsychologist*, *7*, 155–160.

Zenezini, M. (2009). Invecchiamento della popolazione, crescita, occupazione [Ageing of population, growth and employment]. *Studi e Note di Economia*, *3*, 431–468.