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Intellect and Cognitive Performance in the Lothian Birth Cohort 1936

Sophie von Stumm[a] & Ian J. Deary[b]

[a]Department of Psychology, Goldsmiths University of London, London, UK

[b]Centre for Cognitive Ageing and Cognitive Epidemiology, Department of Psychology, University of Edinburgh, Scotland, UK.

*Corresponding author:
Sophie von Stumm
E-mail address: s.vonstumm@gold.ac.uk

Abstract

Investment personality traits are thought positively to affect cognitive performance in old age, even after controlling for prior cognitive ability. In the Lothian Birth Cohort 1936 (*N* = 1091), a cross-lagged model tested for reciprocal effects of the investment trait Intellect on verbal fluency, an indicator of crystallized intelligence, at the ages of 70 and 73 years, while adjusting for general IQ at ages of 11 and 70 years. Intellect at 70 was weakly associated with contemporaneous verbal fluency but had no significant effects on fluency at age 73. Conversely, verbal fluency at 70 was significantly, positively related to Intellect at age 73. The results suggest that better verbal fluency precedes intellectual investment in old age, rather than the other way around.

Words: 122

Keywords: investment; cognitive aging; intelligence; personality; childhood IQ

The investment theory of cognitive development proposes that personality traits determine *when*, *where* and *how* people invest their cognitive ability, thereby affecting lifespan cognitive development (Ackerman, 1996; Cattell, 1943). Thus, individual differences in knowledge or crystallized ability are thought to be accounted for by differences in general mental ability *and* by differences in typical levels of investment (cf. Ackerman, 1996; Horn & Cattell, 1982). Accordingly, investment traits refer to the tendency to seek out, engage in, enjoy, and continuously pursue opportunities for effortful cognitive activity (von Stumm, Chamorro-Premuzic, & Ackerman, 2011). Investment traits may enhance cognitive performance through two pathways: first, investment traits encourage cognitive activity engagement, which in turn “exercises” the brain (Bielak, 2010; Sharp, Reynolds, Pedersen, & Gatz, 2010; von Stumm, 2012). Second, investment traits may help in constructing even mundane everyday experiences (e.g., shopping or laundry) in a cognitively stimulating manner that contributes to mental flexibility (cf. Stine-Morrow, 2007).

To date, it remains unclear if positive effects of investment traits on cognitive change (i.e., differential preservation) are explained by alternative factors, in particular by prior cognitive ability (i.e., preserved differentiation; Salthouse, 2006). In other words, the association of investment traits with cognitive performance may only be a spurious one that is entirely due to more intelligent people also applying their intelligence more often rather than those who invest becoming smarter. In this context, the findings of three previous longitudinal studies are inconsistent, all of which reported data from participants of the Scottish Mental Surveys who were tested on IQ at the age of 11 in the first half of the 20th century (Deary, Whalley & Starr, 2009). In the Lothian Birth Cohort 1921, Gow and colleagues (2005) found that IQ at age 11 significantly predicted Intellect at age 81 as well as IQ at age 79. Intellect is an investment trait from the Five Factor Model of personality that refers to intellectual curiosity, including a preference for abstract thinking, ideas and imagination (Goldberg, 1992). Gow et al. (2005) reported that IQ at age 79 and Intellect at age 81 were no longer associated after adjusting for childhood IQ. They concluded that the association between old age cognition and investment was entirely caused by the confounding variable of childhood IQ. Analyzing different data from the same cohort, von Stumm and Deary (2011) found that higher Typical Intellectual Engagement at age 81 significantly contributed to better verbal fluency from age 79 to 87, even after adjusting for childhood and late adulthood IQ. Typical Intellectual Engagement is an investment trait that captures people's desire to solve and be absorbed by intellectual problems (Goff & Ackerman, 1992). While it resembles the Intellect scale, Typical Intellectual Engagement emphasizes intellectual pursuits, such as reading books or watching educational TV, to a greater extent. In a third study, Hogan and colleagues (2012) reported on data from the Aberdeen Birth Cohort 1936, showing that Openness to Experience was related to better cognitive performance from age 64 to age 68 years after adjusting for childhood IQ. The study also included a short measure of Typical Intellectual Engagement, which had no consistent effect on cognition. Openness to Experience is an alternative to Intellect as the fifth personality dimension from the Five Factor Model and spans six trait aspects, for example intellectual curiosity, imagination and aesthetic awareness (Costa & McCrae, 1992).

The discrepancies of previous findings may on the one hand result from employing using different investment trait scales. That said, Intellect, Openness to Experience and Typical Intellectual Engagement assess an overlapping construct space, partially comprising identical items, and are positively inter-correlated (Ferguson, 1999; Gow et al., 2005; Mussel, 2010; see also von Stumm, 2010). Another explanation for the inconsistency of earlier results may lie with the type of cognitive performance measure that the studies included. Initially, investment traits were hypothesized to specifically augment crystallized ability but not general mental capacity (Ackerman, 1996). Thus, the long-term positive effects of investment on cognition may not detectable when using omnibus IQ tests or measures that are more representative of fluid than crystallized intelligence (Ackerman, 1996; Cattell, 1943). For example, Gow et al. (2005) reported on an omnibus IQ measure; Hogan et al. (2012) used reading ability, inductive reasoning, memory and speed of processing; and von Stumm and Deary (2011) included a verbal fluency measure. Out of those measures, reading ability (i.e., word recognition and correct pronunciation) and verbal fluency (i.e., ability to retrieve vocabulary through associations) are the most likely to assess crystallized intelligence (e.g., Johnson & Bouchard, 2005; McGrew, 2009).

Beyond the inconsistencies in measures, the three previous studies also assessed investment only at one time point. Therefore, they could not address whether investment and verbal fluency have reciprocal effects on one another over time, or if they are largely independent entities. If the investment theory of differential preservation was accurate, one would expect to find long-term and concurrent positive effects of investment on crystallized ability. To this end, we report in the present study on members of the Lothian Birth Cohort 1936, who were tested on IQ test at the age of 11 and who were followed-up twice at the ages of 70 and 73 years. At both occasions, they completed Goldberg’s (1992) Intellect scale and measures of verbal fluency, which plausibly reflect positive effects of investment if such effects are meaningful after adjusting for childhood IQ. Path models tested associations between Intellect and verbal fluency at the ages of 70 and 73 years, after controlling for differences in childhood and late adulthood IQ (i.e., age 11 and 70) to rule out the possibility that changes in investment and verbal fluency are driven by the same cause (e.g., prior cognitive ability and general cognitive decline; von Stumm & Deary, 2011). It was predicted that (a) Intellect and verbal fluency were highly stable from age 70 to age 73, (b) Intellect at age 70 significantly predicted verbal fluency at age 73, and (c) the associations between

Intellect and verbal fluency were robust after adjusting for IQ at age 11 and 70. Thus, verbal fluency and Intellect were expected to have reciprocal effects on each other over time.

Methods

Sample

The Lothian Birth Cohort 1936 included 1091 relatively healthy participants (548 men and 543 women), most of whom completed the Moray House Test in 1947 during the Scottish Mental Survey at a mean age of 10.9 years (*SD* = 0.3). They were first followed up at a mean age of 69.5 years old (SD = 0.8; herein age 70), and second time at a mean age of 72.5 (SD = 0.7; *N* = 866; herein age 73). The recruitment and testing of the sample has been described in detail elsewhere (Deary et al., 2007; Deary, Gow, Pattie, & Starr, 2011). Only variables relevant to the current analysis are reported here in detail.

Measures

Moray House Test. The test consists of 71 items with a maximum score of 76. The test includes a variety of item types (e.g., following directions; word classifications; analogies; and reasoning) and was validated in 1932 in 1,000 children against the Stanford Revision of the Binet Scale with *r* = .80 (Scottish Council for Research in Education, 1933).

Verbal fluency (Lezak, Howieson, & Loring, 2004). The participant is asked to name as many words as possible beginning with the letters C, F, and L, and is given one minute for each letter. Proper names are not allowed and repeated words are scored only once.

Intellect (International Personality Item Pool (IPIP); Goldberg, 2001). The IPIP assesses Intellect with 10 items on a 5-point scale ranging from very inaccurate to very accurate. Intellect refers to intellectual curiosity and quick thinking (Goldberg, 1982). The items were in sentence fragment form (e.g., “I have a rich vocabulary”) and so “I” was added to make them simpler to read.

Analysis

All measures were corrected for age in days at time of testing, using the standardized residuals. The factorial invariance of verbal fluency and Intellect was tested across over time by fitting increasingly restrictive equality constraints on the respective factor model parameters. Verbal fluency was specified by three observed indicator variables and Intellect by ten at the ages of 70 and 73 years, respectively. A first model established restricted the factor loadings to be equal at both times; a second model constrained the residual variances of the observed indicator variables to also be equal over time; and in a third model, equality constraints were added to the intercepts associated with age 70 and age 73 (Horn & McArdle, 1992). The constrained models were compared to unconstrained factor models of verbal fluency and Intellect respectively, suggesting that the factors were invariant over time (*p*-value for $\chi^2_{difference} > .001$, in all cases)[1]. Subsequently, the observed indicators of verbal fluency and Intellect were added to form unit-weighted composite scores at age 70 and age 73, respectively. After calculating the study variables’ correlations, path models were fitted (Figure 1). First, stability coefficients of Intellect and verbal fluency at age 70 and 73 were tested, as well as their cross-lagged association. Verbal fluency and Intellect were allowed free contemporaneous correlations at the ages 70 and age 73, respectively. Second, IQ at age 11 was modeled to predict IQ at age 70, which in turn had direct effects on Intellect and verbal fluency at age 70, to test if changes in Intellect and verbal fluency are driven by the same cause. Expanding the second model, IQ at age 11 was specified to have direct effects on Intellect and Verbal Fluency at age 70 and 73. In a fourth and final model, IQ at age 70 also

[1] Details on χ^2 values are available from the first author upon request.

had direct paths on verbal fluency and Intellect at age 73 to test if their respective associations childhood IQ were unchanged, after adjusting for IQ at age 70. Models were fitted using Full Information Maximum Likelihood estimation (FIML; Arbuckle, 1996) under the assumption of data missing at random to the complete sample (N = 1091), as well as to a subsample omitting all cases with any missing data (N = 715), and to a further subsample omitting all cases with missing data and a Mini Mental State Exam (MMSE) score of 24 and below (N = 706). This latter subsample excludes participants likely to be suffering from cognitive impairments. Model fit was assessed with the χ^2 (df) test, the Comparative Fit Index (CFI), the Tucker-Lewis Index (TLI), and the Root-mean-square error of approximation (RMSEA). CFI and TLI indicate an adequate model fit at values of .90 and .95 or above (Hu & Bentler, 1999). RMSEA values of .08 and below are considered acceptable (Browne & Cudeck, 1993).

Results

The study variables' correlations were positive and of moderate to large magnitude (see Table 1, also for descriptives). IQ at age 11 and 70 had almost identical correlations with verbal fluency and Intellect at age 70 and 73. In line with our hypothesis, verbal fluency and Intellect showed significant contemporaneous and cross-lagged inter-correlations.

In the first model (χ^2 (0) = 0; CFI = 1.000; TLI = N/A; RMSEA = N/A), Intellect and verbal fluency were significantly correlated at age 70 (r = .25, p < .001) but not at age 73 (r = .05; p > .05). Both variables had high stability coefficients from 70 to 73 years (r = .80 for verbal fluency, and r = .73 for Intellect). Verbal fluency at 70 had a significant positive effect on Intellect at 73 but Intellect at 70 was only marginally related to verbal fluency at 73. The second model had a comparatively poor fit (χ^2 (6) = 58.53; CFI = .980; TLI = .929; and RMSEA = .090; CI (90%) from .070 to .111), which was significantly improved in the third model, when direct paths between IQ at age 11 and Intellect and verbal fluency at age 73 were added (χ^2 (2) = 5.74; CFI = .999; TLI = .985; RMSEA = .041; CI (90%) from .000 to .083). IQ at 11 was highly predictive of IQ at age 70, accounting for 48% of its variance. In addition, IQ at age 11 had significant direct effects on Intellect (.20/ .06) and verbal fluency (.18/ .08) at age 70 and 73 ($p < .05$, in all cases). In the fourth model (χ^2 (0) = 0; CFI = 1.000; TLI = N/A; RMSEA = N/A), which also allowed for direct effects of IQ at age 70 on verbal fluency and Intellect at age 73, IQ at age 11 was no longer significantly associated with the variables at age 73 ($p > .05$ in both cases; Figure 2). Instead, IQ at age 70 was significantly associated with verbal fluency at the ages of 70 and 73, and with Intellect at age 70 ($p < .05$, in all cases) but not at age 73 ($p > .05$). IQ at age 70 partially mediated the effects of IQ at age 11 on verbal fluency and Intellect at age 70 (Sobel's test significant at $p < .001$ for verbal fluency and $p < .01$ for Intellect), but not on verbal fluency and Intellect at age 73 (Sobel's test significance at $p = .09$). Verbal fluency at age 70 had a significant effect on Intellect at age 73, whereas Intellect at age 70 was not significantly associated with verbal fluency at age 73. The corresponding coefficients were both small and not significantly different. Overall, the model accounted for 66% and 58% of the variance in verbal fluency and Intellect at age 73, respectively. The model parameters changed negligibly when omitting cases with missing data points, as well as those with a lower than 24 MMSE score.

Discussion

The current study contributes to understanding the role of investment personality traits for cognitive development in old age. In line with our hypotheses, Intellect and verbal fluency were highly stable between the ages of 70 and 73 years. Similarly, as we already showed in this sample elsewhere, IQ at age 11 was a strong predictor of IQ at age 70 (e.g., Gow et al., 2011). Beyond that, childhood IQ had significant direct effects on Intellect and verbal fluency at age 70 and 73. However, after including IQ at age 70 in the model, the association of childhood IQ with verbal fluency and Intellect at age 73 became non-significant, contradicting our hypotheses. That is, IQ at age 11 was associated with verbal fluency and Intellect at age 70 beyond IQ at age 70 but these effects did not persist for age 73. By comparison, IQ at age 70 was significantly related to verbal fluency and Intellect at both ages of 70 and 73 years.

Somewhat rejecting our hypotheses, Intellect was associated with concurrent verbal fluency at the age of 70 years but the effect did not extend to age 73. That is, Intellect was significantly associated with verbal fluency, after adjusting for general IQ in childhood and at age 70, but not in the long-term. Conversely, better verbal fluency at age 70 was significantly associated with higher Intellect at age 73, even though the effect size was small. This finding suggests that it is better verbal fluency that precedes investment tendencies, perhaps because people with higher verbal abilities are more capable to follow intellectual pursuits (e.g., reading books, theatre). Thus, cognitive development in old age appears to be more in line with preserved differentiation rather than differential preservation.

On the one hand, our results are in line with Gow et al.'s (2005) conclusions that the investment-cognition link in old age is largely accounted for by childhood IQ. In fact, the associations of IQ at age 11 with Intellect and verbal fluency at age 70 and 73 were considerably greater than the cross-lagged effects between the latter. On the other hand, our findings contradict von Stumm and Deary's (2011) report of a significant positive effect of investment on verbal fluency. They had examined a later and longer period of ageing from age 79 to age 87, and also used a different investment trait measure, namely Typical Intellectual Engagement, which may constitute a more precise measure of investment than Intellect, at least if it is assessed in its entirety (Hogan et al., 2012). That said, it is also possible that we failed to detect a significant contribution of Intellect on verbal fluency in old age because we lacked data for more sophisticated statistical models (i.e., latent growth curve with a third assessment wave).

In conclusion, Intellect and verbal fluency marginally influenced each other’s development in old age but they comprised weakly associated entities that are highly stable. Their contemporaneous correlation reduced after adjusting for childhood IQ, which influenced verbal fluency and Intellect at age 70 and 73 but not their (weak) cross-lagged relations. Thus, a predisposition to seek out and engage in cognitively stimulating activity was associated with better concurrent cognitive ability but had no enduring effects on cognitive performance three years later.

References

Ackerman, P. L. (1996). A theory of adult intellectual development: Process, personality, interests, and knowledge. *Intelligence, 22*, 227-257.

Bielak, A. A. M. (2010). How can we not ‘lose it’ if we still don’t understand how to ‘use it’? Unanswered questions about the influence of activity participation on cognitive performance in older age: A mini-review. *Gerontology, 56,* 507–519.

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

Cattell, R. B. (1943). The measurement of adult intelligence. *Psychological Bulletin, 40,* 153-193.

Costa, P. T., & McCrae, R. R. (1992). *Revised NEO Personality Inventory (NEO-PI-R) and NEO Five-Factor Inventory (NEO-FFI): Professional manual*. Odessa, FL: Psychological Assessment Resources.

Deary, I. J., Gow, A. J., Taylor, M. D., Corley, J., Brett, C., Wilson, V., Campbell, H., Whalley, L. J., Porteous, D. J., & Starr, J. M. (2007). The Lothian Birth Cohort 1936: a study to examine influences on cognitive ageing from age 11 to age 70 and beyond. *BMC Geriatrics, 7,* 28-40.

Deary, I. J., Gow, A., Pattie, A., & Starr, J. (2011). Cohort Profile: The Lothian Birth Cohorts of 1921 and 1936. *International Journal of Epidemiology,* doi: 10.1093/ije/dyr19.

Ferguson, E. (1999). A facet and factor analysis of typical intellectual engagement (TIE): Associations with locus of control and the five-factor model of personality. *Social Behavior and Personality, 27,* 545-561.

Goldberg, L. R. (1992). The development of markers for the Big-Five Factor Structure. *Psychological Assessment, 4,* 26–42.

Goldberg, L. R. (2001). International Personality Item Pool. *Web address can be obtained from authors.*

Gow, A. J., Whiteman, M. C., Pattie, A. & Deary, I. J. (2005). The personality-intelligence interface: insights from an ageing cohort. *Personality and Individual Differences, 39,* 751-761.

Gow, A. J., Johnson, W., Pattie, A., Brett, C. E., Roberts, B., Starr, J. M. & Deary, I. J. (2011). Stability and change in intelligence from age 11 to ages 70, 79 and 87: the Lothian Birth Cohorts of 1921 and 1936. *Psychology and Aging, 26,* 232-240.

Hogan, M. J., Staff, R. T., Bunting, B. P., Deary, I. J., Whalley, L. J. (2012). Openness to Experience and Activity Engagement Facilitate the Maintenance of Verbal Ability in Older Adults. *Psychology and Aging, in press*.

Horn, J. L., & Cattell, R. B. (1982). Whimsy and misunderstandings of Gf-Gc theory: A comment on Gilford. *Psychological Bulletin, 91,* 623-633.

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

Johnson, W., & Bouchard Jr., T. J. (2005). Constructive Replication of the Visual-Perceptual-Image Rotation (VPR) Model in Thurstone's (1941) Battery of 60 Tests of Mental Ability. *Intelligence, 33,* 417−430.

Johnson, W., Gow, A. J., Corley, J., Redmond, P., Henderson, R., Murray, C., Starr, J., & Deary, I. J. (2012). Can We Spot Deleterious Ageing in Two Waves of Data? The Lothian Birth Cohort 1936 from Ages 70 to 73. *Longitudinal and Life Course Studies, in press.*

Lezak, M., Howieson, K., & Loring, D. W. (2004). *Neuropsychological testing.* Oxford, UK: Oxford University Press.

McGrew, K. (2009). Editorial. CHC theory and the human cognitive abilities project. Standing on the shoulders of the giants of psychometric intelligence research. *Intelligence, 37,* 1-10.

Mussel, P. (2010). Epistemic curiosity and related constructs: Lacking evidence of discriminant validity. *Personality and Individual Differences, 49,* 506-510.

Salthouse, T. A. (2006). Mental exercise and mental aging: Evaluating the validity of the use it or lose it hypothesis. *Perspectives on Psychological Science, 1,* 68-87.

Scottish Council for Research in Education (1933). *The intelligence of Scottish children: A national survey of an age-group.* London: University of London Press, Ltd.

Sharp, E. S., Reynolds, C. A., Pedersen, N. L., Gatz, M. (2010). Personality and cognitive aging: Is openness protective? *Psychology and Aging, 25,* 60-73.

Stine-Morrow, E. A. L. (2007). The Dumbledore Hypothesis of cognitive aging. *Current Directions in Psychological Science, 16,* 300-304.

von Stumm, S. (2010). *Intelligence, investment and intellect: Re-examining intelligence-personality associations.* Doctoral Thesis, Goldsmiths University of London.

von Stumm, S. (2012). Investment Trait, Activity Engagement, and Age: Independent Effects on Cognitive Ability. *Journal of Aging Research,* doi:10.1155/2012/949837.

von Stumm, S., Chamorro-Premuzic, T., Ackerman, P. L. (2011). Re-visiting intelligence-personality associations: Vindicating intellectual investment (p. 217-241). In T. Chamorro-Premuzic, S. von Stumm, & A. Furnham (eds.), *Handbook of Individual Differences*. Chichester, UK: Wiley-Blackwell.

von Stumm, S., & Deary, I. J. (2011). Typical Intellectual Engagement and Cognition in the Ninth Decade of Life: the Lothian Birth Cohort 1921. *Psychology and Aging, 98,* 87-91.

Table 1

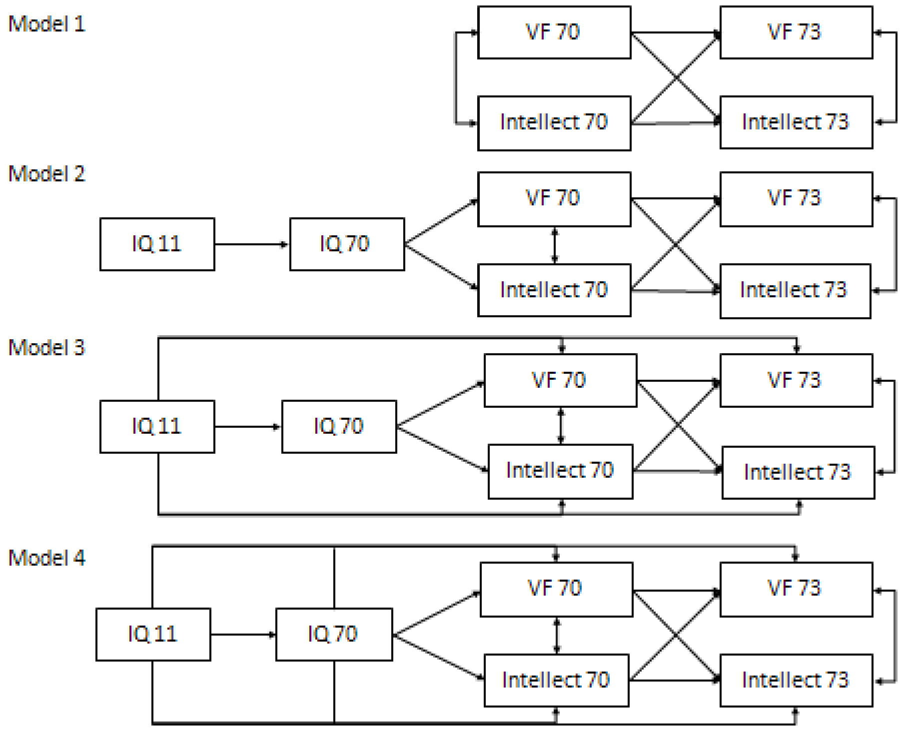
Descriptives and correlations among study measures

		N	Min	Max	M	SD	α	1	2	3	4	5
1	IQ at 11	1028	1	74	49.00	11.80	-	-				
2	IQ at 70	1079	9	76	64.23	8.80	-	.69	-			
3	Verbal fluency 70	1087	10	83	42.42	12.54	.88	.38	.41	-		
4	Verbal fluency 73	865	6	90	43.18	12.94	.89	.38	.39	.81	-	
5	Intellect 70	948	5	40	23.83	5.68	.74	.29	.26	.24	.24	-
6	Intellect 73	852	5	40	23.74	5.93	.78	.28	.27	.28	.27	.76

Note. α refers to the internal consistency coefficient. IQ scores were not recorded on item level; thus, no concurrent α can be computed for them. All correlations are significant at $p < .001$.

Figure 1

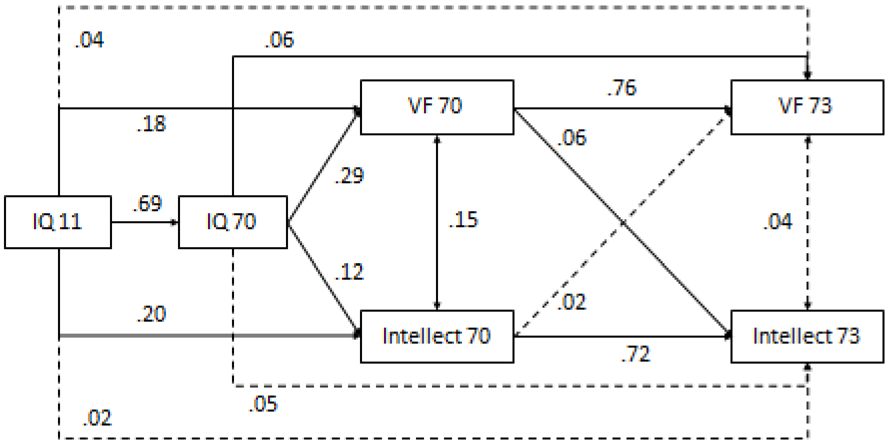
Models of childhood IQ, verbal fluency and Intellect from age 11 to 73



Key: VF = Verbal Fluency.

Figure 2

Fully adjusted model of investment and cognition in the Lothian Birth Cohort 1936 across the ages of 11 to 73 years



Note. Error terms have been omitted to sustain graphical clarity. Non-significant paths are dashed ($p > .05$).

Key: VF = Verbal Fluency.