Intelligence 61 (2017) 78–84

Contents lists available at ScienceDirect

Intelligence

Midlife level and 15-year changes in general cognitive ability in a sample of men: The role of education, early adult ability, BMI, and pulse pressure

Michael Rönnlund [a,*], Anna Sundström [a,b], Sara Pudas [c]

[a] Department of Psychology, Umeå University, Sweden
[b] Centre of Demographic and Ageing Research, Umeå University, Sweden
[c] Umeå Center of Functional Brain Imaging, Umeå University, Sweden

A R T I C L E I N F O

Article history:
Received 27 May 2016
Received in revised form 31 December 2016
Accepted 24 January 2017
Available online 31 January 2017

Keywords:
g factor
Early cognitive ability
Midlife
Longitudinal
BMI
Pulse pressure

A B S T R A C T

The objective of the study was to examine determinants of midlife level and long-term changes in a general cognitive ability (*g*) factor. The data were from a Swedish sample of men ($n = 262$; $M = 49.9$ years, $SD = 4.0$) for which cognitive (conscript) test scores at age 18 were retrieved. In midlife the men completed a battery of cognitive tests that was re-administered at five-year intervals up to 15 years after the baseline assessment. Second-order latent growth curve models were used to examine predictors of midlife level and longitudinal changes in a *g* factor reflecting four cognitive measures (WAIS-R Block Design, vocabulary, action recall, and word fluency). The results showed education (years of schooling) to be related to ability level (intercept) before ($\beta = 0.71$), but not after ($\beta = 0.09$), adjustment of an early adult (age 18) *g* factor (reflecting three different cognitive measures) that was highly predictive of midlife *g* level (adjusted $\beta = 0.89$). Neither education nor *g* at age 18 (or midlife *g* level) was related to long-term changes in *g*, though. Conversely, baseline age, BMI, and pulse pressure were unrelated to midlife ability level, but higher baseline age, higher BMI and higher pulse pressure in midlife were predictive of cognitive decline. Thus, whereas higher levels of initial ability or educational attainment do not appear to buffer against onset of age-related decline in *g* in midlife and young-old age, maintenance of lower levels of pulse pressure and body weight could possibly have such an effect. However, further research is required to evaluate the mechanisms behind the observed relationships of the targeted variables and cognitive decline.

1. Introduction

Longitudinal data from large-scale population-based studies demonstrate relatively stable mean levels of cognitive functioning from early adulthood until around age 60, after which a fairly generalized pattern of decline is observed. Such trajectories were observed for spatial ability (Rönnlund & Nilsson, 2006a; Schaie, 1994), numeric ability, verbal meaning (Schaie, 1994), episodic memory (Rönnlund, Nyberg, Bäckman, & Nilsson, 2005), and for a general ability (*g*) factor (Hertzog & Schaie, 1988). However, significant between-person heterogeneity in longitudinal change (e.g. Christensen et al., 1999; Hertzog & Schaie, 1988; Lövdén et al., 2004), indicate that the mean level patterns need not apply to the individual. A major goal of cognitive aging research is to identify factors that account for such interindividual differences in age-related cognitive change.

A long-standing issue in cognitive aging research is whether age is kinder to the initially more able. An early study by Owens (1959) addressed this issue based on 30-year longitudinal data for Army Alpha test in a sample of 127 men (20 years of age at baseline). A comparison across five levels of initial performance revealed no differences in cognitive change. Whereas several subsequent studies confirmed a lack of relationship between initial ability level and rate of cognitive change in advanced age (e.g. Christensen et al., 2001; Eisdorfer, 1963; Salthouse, 2012), others instead suggested that a higher initial ability level attenuates decline, for example in Raven's matrices (e.g. Bourne, Fox, Deary, & Whalley, 2007) and verbal ability (Deary, McLennan, & Starr, 1998). Thus, the evidence concerning the relation between initial ability level and rate of cognitive change in late midlife or old age is mixed. As noted by Gow et al. (2012), most of the evidence still pertains to analyses of changes in manifest test scores using regression analyses (and the like) which may be less suited to address this issue compared to latent level analyses.

The study by Gow et al. (2012), which made efforts to overcome the drawback in prior studies by employing latent growth curve modelling of the adult data (initial ability was still in form of a manifest IQ score), interestingly reported both of the aforementioned patterns (i.e. high initial ability is unrelated to rate of change vs. reduces decline). One source of data was the Lothian Birth Cohort 1921 (LBC1921), for which IQ scores had been collected at age 11. These data were analyzed in relation to measures of general ability, reasoning, and memory, at

* Corresponding author at: Department of Psychology, Umeå University, S-90187 Umeå, Sweden.
E-mail address: michael.ronnlund@umu.se (M. Rönnlund).

http://dx.doi.org/10.1016/j.intell.2017.01.007
0160-2896/

ages 79 and 87. No tendency of a relationship between cognitive ability at age 11 and rate of cognitive decline from age 79 to 87 was observed. By contrast, their analyses of data from another longitudinal study, the National Survey of Health and Development (NSHD), suggested that higher ability at age 15 was associated with reduced decline between ages 43 and 53 in a latent *g* factor reflecting two indicators (verbal memory and search speed). The authors discussed potential reasons for the discrepancy between the two data sets, including a difference in age of initial cognitive assessment and survival effects, but the results could also be taken to suggest that early ability level is more prone to be protective of, or at least, be more likely to be evident for, "early" as opposed to late-life cognitive decline.

In common with a higher initial ability level, a higher educational attainment has been hypothesized to buffer against cognitive decline. Education might be expected to be protective of decline, indirectly, to the extent that it constitutes a (rough) proxy for *g* (cf. Strenze, 2007), which, as noted, has been associated with attenuated cognitive decline, at least in some prior studies. Alternatively, higher educational attainment might increase a so-called "cognitive reserve", reflected by more efficient neural processing and increased resistance to brain damage (Stern, 2002). To the extent that a higher educational attainment is linked to occupations and lifestyles assumed to be more cognitively stimulating, the effects of education on such a reserve might be enforced (e.g. Le Carret, Lafont, Mayo, & Fabrigoule, 2003). Based on the latter view, formal schooling might be expected to be positively associated with midlife cognitive level, even after the adjustment of initial ability level, and to attenuate cognitive decline in advanced age. In line with the first prediction, studies that examined general ability in adulthood in relation both to education and early ability level, confirmed the existence of a positive relationship between schooling and adult cognitive ability, beyond initial (childhood) IQ (e.g. Gow et al., 2012; Husén & Tuijnman, 1991). With regard to the second prediction, some studies suggested that educational attainment reduces cognitive decline, but as noted in a review by Anstey and Christensen (2000), the results are inconsistent and, possibly, subject of a publication bias. Also, more recent large-scale studies failed to detect an association between education and cognitive decline (e.g. van Dijk, van Gerven, van Boxten, van der Elst, & Jolles, 2008; Zahodne et al., 2011), including decline in reasoning ability (Tucker-Drob, Briley, Starr, & Deary, 2009). Thus, whereas educational attainment is clearly related to cognitive level across adulthood, the results of a number of longitudinal studies were inconsistent with the view that it is protective of age-related decline.

The objective of the present study was to examine potential determinants of midlife level and long-term changes, in a *g* factor, including an early adult (latent) ability factor and education. The analyses involved data for a sample of men who were cognitively assessed at age 18 (conscript tests), in midlife (around age 50), and re-assessed at five-year intervals up to 15 years later. A first study of this sample (Rönnlund, Sundström, & Nilsson, 2015), revealed high levels of stability (>0.90) of individual differences from age 18 to age 50 on a *g* factor, and a strong correlation between latent *g* and working memory factors around age 65. High levels of interindividual stability was also observed from the midlife assessment to the longitudinal follow-up measurements, but there was evidence of significant between-person differences in rate of change over the 15-year interval. The fact that few prior studies addressed long-term changes in *g* is a noteworthy omission provided that age-related influences on tests drawn from different ability domains are shared to a large extent (e.g. Lindenberger & Ghisletta, 2009; Salthouse & Ferrer-Caja, 2003), which implies the operation of one or a limited set of common factors, in addition to domain specific factors.

Apart from examining the role of early ability level and education, we considered relations to two physiological variables that were identified as predictors of cognitive decline in prior studies. The first was pulse pressure. A higher pulse pressure, i.e. a widening of the difference between systolic and diastolic blood pressure, is assumed to reflect arterial stiffness and tends to be observed middle-age (e.g. Skurnick, Aladjem, & Aviv, 2010), mainly due to increased systolic pressure. Several studies reported a significant link between arterial stiffness (as reflected by higher pulse pressure or pulse wave velocity) and worse cognitive performance or a higher rate of cognitive decline (Tsao et al., 2013; Waldstein et al., 2008). The cognitive measures in these studies either targeted more specific abilities (e.g. memory) or were single crude measures of global cognitive functioning (e.g. MMSE scores, Folstein, Folstein, & McHugh, 1975). To our knowledge, no prior study examined pulse pressure in relation to longitudinal changes in a *g* factor.

The second variable attended, to was Body Mass Index. High BMI has been associated with lower cognitive performance in cross-sectional studies (e.g. Nilsson & Nilsson, 2009) and accelerated decline in longitudinal studies (Cournot et al., 2006; Dahl et al., 2009). As for pulse pressure, the studies mainly targeted measures of specific cognitive abilities, for example memory functions. With regard to relations to *g*, the available results is limited and not unequivocal. In particular, a study by Corley, Gow, Starr, and Deary (2010), observed a negative association between BMI (levels) and a *g*-factor, extracted by principal component analysis, at age 70 (no association was observed for speed or episodic memory). However, the association vanished once social class and childhood IQ were accounted for. Hence, this study demonstrated that inclusion of a measure of early ability serves an important control purpose in the study of age-related cognitive change that could alter the conclusions regarding the influence of other factors on cognitive changes.

2. Method

2.1. Participants

The midlife cognitive data emanated from the Betula prospective cohort study (Nilsson et al., 1997, 2004) in Umeå, Sweden. The Betula study involved random sampling of participants from the population registry in Umeå, and a comprehensive measurement of cognitive functions and health-related variables (for details pertaining to recruitment, samples and measures, see Nilsson et al., 1997). The present study involved a group of participants in two subsamples: Sample 1 (S1) and Sample 3 (S3) as these subsamples were invited to longitudinal follow-ups five (1998–2000), ten (2003–2005), and fifteen years (2008–2010) after the test occasion considered as baseline in the present study, that took place in 1993–1995.

Following approval from a regional ethic committee, cognitive test scores collected at draught boards (age 18) were retrieved. Conscript data were stored by the Swedish military archives. The cognitive test data were retrieved for a subset of the men in S1–S3 (who took the conscript tests during the period from 1954 to 1967, when standardized scores had been registered). The present study sample involved 262 participants in S1 and S3, who were 45, 50, or 55 years (approximately 1/3 at each of the age levels) at baseline (See Table 1).

Table 1
Summary of sample characteristics as a function of retest status (returnees vs. dropouts) at the final, 15-year, follow-up. Standard deviations are presented in parenthesis.

	Returnees	Dropouts
n	176	86
Age	50.1 (4.0)	49.5 (4.1)
Education (years)	12.3 (3.8)	12.1 (4.0)
GAS (age 18)	5.7 (1.7)	5.7 (1.7)
BDT (age 50)	12.3 (2.8)	12.1 (2.9)
BP systolic	132.0 (17.0)	133.9 (17.4)
BP diastolic	85.3 (9.9)	87.8 (9.9)
BMI	26.0 (3.3)	26.5 (3.8)

GAS = General Ability Score (Stanine), BDT = Block Design Test (scaled score), BP = Blood pressure, BMI = Body Mass Index.