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Up to speed: Birth cohort effects observed for speed of processing in older adults: Data from the Good Ageing in Skåne population study

Marieclaire Overton*, Mats Pihlsgård, Sölve Elmståhl

Division of Geriatric Medicine, Lunds University, Skånes University Hospital, Malmö, Sweden

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A B S T R A C T

Neuropsychological test-based norms are vital for accurate assessment of older adults' level of cognition. Hence, it is important that these scores are not conflated with birth cohort effects. With data drawn from the Swedish Good Ageing in Skåne (GÅS) population study, this study examined birth cohort effects on test scores measuring several cognitive domains. A time-lag design with three distinct birth years, separated by 5–7 years, and with two age-matched samples of older participants, was used. Participants aged 60 were born 1942–1955 and those aged 81 were born 1920–1933. Results reveal significant ($p < 0.05$) birth cohort effects on speed of processing, episodic memory, attention, executive functioning and vocabulary test scores. Effect sizes for specific cohort comparisons (e.g. 1942–43 vs. 1947–48) were modest (Cohen's $d = 0.19$–0.43). When adjusting for participants' level of education classified in years or in categories, birth cohort effects on test scores remained stable. Findings support the presence of birth cohort effects in samples of older adults, showing that participants' level of education cannot fully account for these effects. Thus, neuropsychological test scores should routinely be examined for birth cohort effects in cross-sectional data for a correct assessment of cognition.

1. Introduction

There has been a substantial rise in mean scores on various intelligence tests across generations and ages during the 20th century (Trahan, Stuebing, Fletcher, & Hiscock, 2014). This phenomenon is commonly referred to as the Flynn effect, birth cohort/cohort effects, or generational effects (Verhaeghen, 2013). Flynn (1984) reported gains of up to 3 IQ points per decade on the Stanford-Binet and Wechsler tests, which has been confirmed in more recent meta-analyses (Trahan et al., 2014) using various types of IQ tests (Pietschnig & Voracek, 2015). Existing research on cohort effects have mainly used samples of younger individuals (Skirbekk, Stonawski, Bonsang, & Staudinger, 2013), while focusing on test scores from measures of collective forms of IQ, or measures highly related to Spearman's *g* (Rönnlund & Nilsson, 2008). Neuropsychological tests are predominantly used when evaluating the level of cognition in ageing samples, and these types of tests bear many similarities to measures of IQ (Dickinson & Hiscock, 2011). The limited cohort research using older adults (Pietschnig & Voracek, 2015), and the resemblance between measurements of cognition and IQ, lead us to investigate if birth cohort effects exist when testing different cognitive abilities in an older population sample.

1.1. What are birth cohort effects and what is rising?

Gains on various types of mental abilities, have been detected for multiple birth cohorts, as well as age categories, ranging from preschoolers (e.g. Hanson, Smith, & Hume, 1985) to older adults (e.g. Karlsson, Thorvaldsson, Skoog, Gudmundsson, & Johansson, 2015). The magnitude of gains varies between countries, and over different time intervals (Pietschnig & Voracek, 2015), complicating attempts to clarify the puzzle of birth cohort related gains.

A main question of interest is: what do birth cohort effects actually represent (Trahan et al., 2014)? Explanations are many, but most theoretical models propose that test score gains reflect a specific cognitive or mental entity, for example: abstract reasoning, non-verbal abilities, fluid and crystalized intelligence, or Spearman's *g*. Larger gains on non-verbal performance, such as on the Raven's Progressive Matrices (Neisser, 1997) or non-verbal parts of the Wechsler subtests (Dickinson & Hiscock, 2011) have been observed in contrast to verbal measures, suggesting that gains are primarily due to improvements in non-verbal abilities. In reference to crystalized intelligence (Gc) and fluid intelligence (Gf) (Horn & Cattell, 1966), a well-recognised principle is that measures of Gf are more vulnerable to cohort effects than measures of Gc (e.g. Lynn, 2009; Pietschnig & Voracek, 2015). In contrast, Rönnlund and Nilsson (2008) discovered advances on test performance

* Corresponding author at: Jan Waldenströms gata 35, CRC, Building 28, fl.13, Skåne University Hospital, SE-205 02 Malmö, Sweden.
E-mail address: Marie_Claire.Overton@med.lu.se (M. Overton).

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measuring both Gc and Gf. Similarly, Pietschnig, Voracek, and Formann (2010), found equal sized gains for crystalized intelligence in German speaking countries equivalent to gains of fluid intelligence in English speaking countries. That mental ability measures strongly related to Spearman's *g* demonstrate larger gains, than those with a smaller *g*-loading is known as the Jensen effect (Rushton, 1998). Colom and Juan-Espinosa (2001), among others, provide evidence for this account using a Spanish standardisation of the Differential Aptitude Test (DAT) battery, discovering that test score gains highly correlated to the *g*-factor for tests measuring Gf, but not for measures of Gc.

Adding to the puzzling nature of birth cohort effects is the extent to which effects are applicable on cognitive or neuropsychological test scores, other than pure IQ tests. The close relationship between IQ and cognition (Hiscock, 2007) should entail that cognitive test scores are also susceptible to birth cohort effects, and Dickinson and Hiscock (2011) postulate three reasons for this association. Firstly, many neuropsychological tests are similar to cohort-influential IQ-tests. Secondly, test scores on neuropsychological tests often correlate with scores on IQ tests, and thirdly, as IQ tests, many neuropsychological tests have outdated normative scores. At current, cohort effects have been found for multiple cognitive domains, e.g. semantic (Rönnlund & Nilsson, 2008), episodic memory, verbal fluency (Rönnlund & Nilsson, 2008, 2009; Skirbekk et al., 2013) speed of processing tasks (reported in Salthouse, 2014; Verhaeghen, 2013), trail making (test part A and B) (Dickinson & Hiscock, 2011), and spatial abilities (Karlsson et al., 2015). However, to date no cohort effect research has focused on metacognition, an ability that uses reasoning and is susceptible to ageing (Dahl, Allwood, Rennemark, & Hagberg, 2010). Studies differ in which cognitive domains are cohort sensitive, thus more research is desirable. This investigation aims to examine cognitive domains that have not yet been studied, e.g. metacognition, as well as previously studied domains that measure both components of Gc and Gf.

Substantial decreases in gains for both measures of Gc and Gf have been observed in recent decades, suggesting that cohort related gains are generally shrinking (Pietschnig & Voracek, 2015). Reports from Scandinavia show effects stagnating, and even reversing (Sundet, Barlaug, & Torjussen, 2004; Teasdale & Owen, 2008). Of note, these studies examined men, in their late teens, enrolling for military service, and found stagnation beginning in the later part of the 20th century.

1.2. Proposed causes of birth cohort effects

Causes of birth cohort effects include both genetic and environmental influences on mental ability (Trahan et al., 2014), and explanations can depend on what type of cognitive entity is proposed to be rising with generations. For example, if the researchers appoint the rises in terms of non-verbal ability, then they may also favour an explanation involving greater exposure to visual and interactive media over explanations involving child rearing practices (Hiscock, 2007). Factors such as nutrition (Lynn, 1990), sibling sizes (Rönnlund & Nilsson, 2008), education, increased exposure to testing (Brand, 1996), more complex visual environment (Greenfield, 1998), and child rearing practices (Lynn, 2009) have been suggested causes for observed gains.

The most favoured and proposed theory for cohort effects is the concurrent improvement of education (e.g. Lynn, 2009). This is not surprising with education being the most constant individual difference predictor of level of cognition in meta-analyses as well as longitudinal studies (Schaie, 2011). Since the beginning of the 20th century, substantial positive developments in education have been persistent throughout western society (Gustafsson, 2008). Pietschnig and Voracek (2015) remark in their meta-analysis that education plays a major role in explaining cohort related gains, but that education is not fully accountable, especially for gains in Gf, as Gf usually reflects biological influences, whereas Gc reflect cultural and educational influences (Cattell & Horn, 1978). In addition, cohort effects have been observed in pre-schoolers (Williams, 2013). In Rönnlund and Nilsson's (2008) study, education predicted up to 50% of gains on measures of both Gf and Gc, which indicates that measures of Gf abilities can also be endorsed by education. There are numerous ways of measuring level of education (e.g. high vs. low education or length of education measured in years). This may partially explain dissimilarities in magnitudes of education as an explanatory factor of cohort effects. Since education is considered a major predictor of effects, education, and the way it is defined, should always be considered as a contributing factor when examining cohort effects.

1.3. Ageing and birth cohort effects

The existing evidence for cohort effects rests on samples from younger individuals (e.g. military service entrance exams) and verification of effects in samples over 50 years of age at current is rare. Cohort investigators are constantly pronouncing the significance of studying older participants, especially as the average age of populations is increasing (Pietschnig & Voracek, 2015). Yet, there is a handful of studies with emphasis on older adults. Finkel, Reynolds, McArdle, and Pedersen (2007a) observed, in a sample of Swedish twins aged 50 +, lower average scores on tests measuring verbal ability, memory, and spatial ability for cohorts born between 1900 and 1925 in comparison to birth years 1926–1948. Using a time-lag design, with a sample aged 35–80, born between 1909 and 1969, Rönnlund and Nilsson (2008) observed advances for semantic, and episodic memory for the later born cohorts. Noticeably, stagnation was noticed for individuals born 1954 and later. In an additional Swedish population study (Karlsson et al., 2015), there were considerable cohort related improvements on measures of spatial ability and reasoning. Skirbekk et al. (2013) found advances for measures of immediate recall, delayed recall, and verbal fluency for samples born 1936–1955 in comparison to those born 1930–1949 in a UK population sample aged 50–74. A question of interest is whether later born cohorts, in comparison to earlier born cohorts, experience cognitive decline at the same rate as earlier born cohorts. Evidence at current is conflicting on the matter, with some studies showing steeper cognitive decline in earlier born cohorts compared to later born cohorts. (Gerstorf, Ram, Hoppmann, Willis, & Schaie, 2011; Skirbekk et al., 2013) and others finding the reverse effect (Finkel et al., 2007a; Karlsson et al., 2015).

1.3.1. Why are birth cohort effects important for ageing?

Already in the 60s, Schaie (1965) remarked that environments change over time, hence age differences based on cross-sectional data are confounded with cohort differences, and should be considered with great caution. In relation to ageing research, there are two reasons why birth cohort effects are particularly vital to consider. These are misleading age trajectories and misleading age norms.

For one, cohort effects may interfere with interpretation of age-related cognitive decline; when decline begins (onset), the magnitude of the decline, and the magnitude in relation to age (steepness/how fast it goes). For example, cross-sectional data can demonstrate a much earlier onset of age-related cognitive decline when cohort effects are ignored (Nyberg, Lövdén, Riklund, Lindenberger, & Bäckman, 2012). Regarding the magnitude of decline, Connor, Spiro, Obler, and Albert (2004) demonstrated that up to 50% of the age-related cognitive decline observed in the cross-sectional data was likely a cohort effect, when compared to longitudinal data.

Next, norms for different age categories are usually obtained using cross-sectional designs, therefore norms are potentially confounded by cohort effects, leading to out-dated norms. A consequential concern of applying an out-of-date norm is that an individual could be misclassified as being cognitively intact when in fact the person has a cognitive deficiency. Dickinson and Hiscock (2011) confirmed this concern when comparing norms from 1968 to norms from 2004 on the trail making test (TMT: part A or B). The authors present three potential situations with risk for cognitive misclassification. Firstly, when the