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Better Cognition in New Birth Cohorts of 70 Year Olds, But Greater Decline Thereafter

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Abstract

Objectives: To evaluate birth cohort differences in level of cognition and rate of change in old age.

Methods: Data were drawn from three population-based Swedish samples including age-homogenous cohorts born 1901/02, 1906/07, and 1930, and measured on the same cognitive tests at ages 70, 75, and 79 as part of the Gerontological and Geriatric Populations Studies in Gothenburg (H70). We fitted growth curve models to the data using a Bayesian framework and derived estimates and inferences from the marginal posterior distributions.

Results: We found moderate to large birth cohort effects in level of performance on all cognitive outcomes. Later born cohorts, however, showed steeper linear rate of decline on reasoning, spatial ability, and perceptual- and motor-speed, but not on picture recognition memory and verbal ability.

Discussion: These findings provide strong evidence for substantial birth cohort effects in cognition in older ages and emphasize the importance of life long environmental factors in shaping cognitive aging trajectories. Inferences from cognitive testing, and standardization of test scores, in elderly populations must take into account the substantial birth cohort differences.

Keywords: Aging—Cohort differences—Cohort effects—Cognition—Cognitive change

Birth cohort difference in level of cognitive functioning is a well-documented and replicated finding (Rönnlund, Carlstedt, Blomstedt, Nilsson, & Weinehall, 2013; Schaie & Strother, 1968; Wheeler, 1942). Later born cohorts tend, on average, to outperform earlier born cohorts on most cognitive outcomes (for review see Schaie, Willins, & Pennak, 2005). The largest birth cohort differences are generally found on measures of fluid-like abilities that emphasize usage of abstraction, mental speed, and reasoning, whereas smaller birth cohort differences are often found on measure of crystallized-like abilities that require general knowledge and vocabulary. Substantial gains in level of cognitive performance between birth cohorts have been demonstrated across a variety of cultural contexts (Flynn, 1987), at different ages (Rönnlund & Nilsson, 2008; Schaie, Labouvie, & Buech, 1973), including very old age (Christensen et al., 2013).

Less is known about birth cohort differences in rate of cognitive change in old age. The existing evidence is inconclusive. Some studies report less steep average decline among the later born cohorts (Dodge, Zhu, Lee, Chang, & Ganguli, 2014; Schaie, 2005), others report a steeper average decline among the later born cohorts (Gerstorf, Ram, Hoppmann, Willis, & Schaie, 2011; Hülür, Infurma, Ram, & Gestrof, 2013), and yet others report no, or very little evidence for, differences in rate of change across birth cohorts (Finkel, Reynolds, McArdle, & Petersen, 2007; Zeliniski & Kennison, 2007).

In this study, we further evaluate the evidence for birth cohort differences not only in level of performance but also for rate of change in five measures of cognition, tapping the domains of visuospatial ability, reasoning, perceptual- and motor-speed, picture recognition memory, and verbal ability. Data were drawn from repeated measurement occasions where the same cognitive test battery was administered at ages 70, 75, and 79 in three representative population-based birth cohorts living in Gothenburg, Sweden. This data provide a unique and valuable opportunity to quantify birth cohort differences in both cognitive functioning and subsequent change.

In a previous study (i.e., Karlsson, Thorvaldsson, Skoog, Gudmundsson, & Johansson, 2015), we evaluated birth cohort differences in level of performances and rates of change on the measures of spatial ability and reasoning in the H70 data. In this study, we extend previous analyses to a larger number of cognitive measurements. In addition, we present the evidence in the format of conditioned probability distributions of the respective parameters, given the H70 data, using a Bayesian analytical framework.

Method

Participants

All three birth cohorts were identified in a similar manner and systematically selected from the Swedish Revenue Office Register as part of the Gerontological and Geriatric Population Studies in Gothenburg, Sweden (H70). The first birth cohort (*n* = 1,148) was born between July 1, 1901 and June 30, 1902, on days ending with 2, 5, and 8. Baseline participation rate for this cohort was 85%. Of the baseline sample, 40% (*n* = 460) were randomly selected for participation in the cognitive assessments. Participation rate for this subsample was 80%, 59% were women and 15% had more than compulsory education of 6 years. Further information about demographics for this cohort can be found in Rinder, Roupe, Steen, and Svanborg (1975) and Svanborg (1977). The second birth cohort (*n* = 1,281) was born between July 1, 1906 and June 30, 1907 on days ending with 2, 5, and 8. The baseline participation rate for this cohort was 81%. Among these, 40% (*n* = 512) were selected for cognitive assessments. Participation rate for this subsample was 75%, 56% were women and 18% had more than compulsory education. Further information about this cohort can be found in Nilsson (1983). The third birth cohort (*n* = 783) was born in 1930 on days ending with 3, 6, 12, 18, 21, 24, and 30. The baseline participation rates for this cohort was 66%, 59% were women and 46% had more than compulsory education (7 years). This cohort sample was then further extended at the second wave of data collection, at age 75, with the inclusion of all individuals in the population born on days 2, 3, 5, 6, 11, 12, 16, 18, 20, 21, 24, 27, or 30 of each month (*n* = 1,250). The baseline response rate for this sample was 63%. Half of the participants in this cohort were then randomly selected for the cognitive testing at age 70, but all participants were selected at age 75 and 79. Additional information about this cohort can be found in Wiberg, Waern, Billstedt, Östling, and Skoog (2013).

In order to minimize biasing influences of floor effects on estimates of change, due to factors such as severe dementia, we omitted all participants with a cognitive score of zero at baseline from our analyses. For the same reason, we also omitted measurements at age 79 for participants with scores of zero on both the 75- and 79-year measures. In total, we omitted data from 53 of the participants, (i.e., 21 from cohort 1901/02, 11 from cohort 1906/07, and 21 from cohort 1930).

Cognitive Measurements

The cognitive tests used in the H70 study are based on Thurstone's (1938) theory of primary mental abilities and included in the Dureman and Sälde (1959) test battery that was widely used in Sweden at the time when the H70 study was initiated.

Block Design measures spatial ability. Participants are given colored blocks and asked to construct replicas of prototype model designs presented to the participants in two colors. Seven prototypes are presented with an increasing difficulty. The performance is scored based on how fast the participants correctly replicate the prototypes. Maximum score is 42 and the total time limit is 20 min.

Figure Logic is a nonverbal measure of inductive reasoning. Participants are presented with geometrical figures, organized in rows of five figures per row, and asked to identify the figure that differs in some respect from the other four figures. Individual total raw scores is calculated as total correct items – (total wrong items/4) to adjust for wrong answers and guessing. The items are not presented in an order of difficulty and the participants are encouraged not to dwell too long on each item if they encounter difficulties. The time limit is 8 min and the maximum score is 30.

Figure Identification is a measure of perceptual- and motor-speed. Participants are asked to match, as quickly as possible, a target figure with one identical figure placed in line among four others. The total raw score is calculated as total correct items – (total wrong items/4) as to penalize for wrong answers and guessing. Maximum score is 60 and the time limit is 4 min.

Thurstone's Picture Memory is a recognition test. The A version of this test was used in the H70 study, including 28 pictures presented at the approximate rate of one picture each 5 s. After all the pictures are presented participants are asked to identify the correct picture they had previously seen in a line of three other pictures that include similar objects. Maximum score on this test is 28.

Synonyms measure verbal ability, or the ability to comprehend the meaning of certain word. Participants are asked to match a target word with one synonym among five choices. The maximum score is 30 and the time limit is 7 min. The words are presented in a magnified form to avoid visual problems.

The Block Design test and the Figure Identification test were administered on all occasions, that is, at ages 70, 75, and 79, in all three birth cohorts. The Figure Logic test was omitted at age 75 and 79 for birth cohort 1906/07, the Thurstone's Picture Memory test was omitted at age 70 for cohorts 1901/02 and 1930, and at age 75 for cohort 1906/07. The Synonyms test was omitted at age 75 for cohort 1930. At age 70, half of the sample in cohort 1901/02 was randomly selected to take only the Figure Logic and the Synonym test. At age 75, cohort 1930 received a shorter version of the Figure Identification test with a maximum score of 30 instead of 60. Further information about these tests and their psychometric properties can be found in Dureman, Kebbon, and Österberg (1971) and their usage in the H70 study in Berg (1980). The various reliability coefficients reported by Dureman and colleagues, and Berg for these measures range from the lowest value of 0.82 split-half reliability in the Thurstone's Picture Memory test to the highest value of 0.96 split-half reliability in the Figure Identification test. The reported reliability measures for the other tests are in the range between these values.

Statistical Analyses

We fitted linear growth curve models to the data from each of the outcome variables separately within a Bayesian framework (e.g., Gelman et al., 2014; for an introduction to Bayesian data analyses in developmental reserach see e.g., van de Schoot et al., 2014; Walker, Gustafson, & Frimer, 2007) using non- or low-informative prior distributions. Growth curve models are essentially multilevel models (e.g., Snijders & Bosker, 2012), sometimes referred to as hierarchal linear models (e.g., Raudenbush & Bryk, 2002), with the repeated measurements at level 1, or time, nested within the individuals at level 2. In all models, we specified the time variable as chronological age (counting by year) centered at the baseline value of age 70, the cohort variable was dummy coded using the 1901/02 birth cohort as reference group, and we included both gender and education as mean centered time constant covariates into the models. We then modeled the time and individual specific data points using a normal prior distribution with the mean derived from the linear combinations of the level 1 variables by coefficients, and the precision, or the reciprocal of the residuals, using a uniform prior in the range of 0–10 raised to the power of −2. We estimated all level 2 mean values (i.e., fixed effects) using a normal prior distribution with a mean of 0 and a low precision of 0.01. The variance and covariance matrix (i.e., random effects) of the intercept and the age slope were estimated using a scaled inverse Wishart prior distribution with 3 degrees of freedom. The parameter estimates were derived through a numerical approximation using a Markov Chain Monte Carlo (MCMC) Gibbs sampling in JAGS (Plummer, 2003). For each model we used three chains, each with 150,000 iterations, a burn-in of 75,000, and a thinning factor of 5, resulting in 15,000 sampling steps per chain, and a total of 45,000. To evaluate convergence of each chain on the target distribution we plotted the trace, autocorrelations, and the marginal posterior density plots for each of the reported parameters. To assist in our inferences we used the 95% highest density intervals (HDI) for each parameter, defined as the interval enclosing 95% of the highest probability density of the marginal posterior distributions. Occasional missing data on the outcome variables were defined, modeled, and thereby handled in the integration of the posterior distribution across the parameter space under the assumption that missing data is missing at random as conventionally defined (Little & Rubin, 1987). There were no missing data for the age, gender, and education variables.

Results

Descriptive for each of the cognitive outcome variables stratified by birth cohort and age at measurement are shown in Table 1 along with the standardized and unconditioned effect sizes (i.e., Cohen's *d*). The standardized and jittered data points for all cognitive tests are shown in the Supplementary Figure S1. The boxes in the figures refer to ±1 standard deviation from the mean value. By simply eyeballing the data in Supplementary Figure S1, it is obvious that there are large birth cohort differences in level of performance for most of the cognitive outcomes. This is particularly evident at age 70 on the spatial ability, reasoning, and the perceptual- and motor-speed measures (see Table 1 for exact effect sizes). The most informative comparisons, in terms of birth cohort effects, are those between the 1901/02 and 1930 birth cohorts. At age 70, these comparisons have effect sizes in the range between 0.63 and 1.19, at age 75 between 0.42 and 0.87, and at age 79 between 0.50 and 0.80. On all measures, except for picture recognition memory, there was a reduction in the cohort effect sizes across ages. The patterns of cohort effect are smaller and more stable across time for the picture recognition memory and the verbal ability measures.

The raw score change trajectories for all the cognitive tests are plotted in Figure 1. The overlaid bold/red lines refer to the estimated average change trajectory for the specific birth cohort as obtained from the growth curve models. Fixed effect estimates from the growth curve models are shown in Table 2. In all the models, except the picture recognition memory, we used cohort 1901/02 as comparison group. Other group estimates, within the same model, are therefore interpreted as deviation from the 1901/02 estimate. For example, the estimated central tendency (i.e., the mean) for birth cohort 1901/02 at age 70 for the spatial ability measure was 12.90, 95% HDI [12.06, 13.74], points. This estimate was 2.20, 95% HDI [1.18, 3.21], and 4.72, 95% HDI [3.65, 5.79], points higher for cohorts 1906/07 and 1930, respectively. Similar interpretation applies for the slope (i.e., the age interaction) estimates. The estimated central tendency of a linear rate of change between age 70 and 79 for birth cohort 1901/02 was −0.31, 95% HDI [−0.41, −0.21], points a year. This estimate was −0.19, 95% HDI [−0.31, −0.06], and −0.28, 95% HDI [−0.41, −0.15], points lower for cohort 1906/07 and 1930, respectively, indicating a reliably steeper average decline in the later born cohorts. Parameter estimates from the other models are interpreted in a similar manner, however, as we only had one measure of picture recognition memory for cohort 1901/02 we used cohort 1906/06 as reference group for that model. In order to facilitate comparisons of the effect sizes

Table 1. Standardized (Cohen's d Effect Sizes) Mean Differences in Cognitive Performance Across Cohorts Born in 1901/02, 1906/07, and 1930, and Measured at Ages 70, 75, and 79 As Part of the H70 Study

	Age 70					Age 75					Age 79				
	d Effect size		Descriptive			*d* Effect size		Descriptive			*d* Effect size		Descriptive		
Cohorts	1906/07	1930	*M*	*SD*	*n*	1906/07	1930	*M*	*SD*	*n*	1906/07	1930	*M*	*SD*	*n*
Spatial ability															
1901/02	0.36	0.92	13.38	6.64	174	0.25	0.58	12.83	6.45	274	−0.02	0.55	11.73	7.28	191
1906/07	—	0.56	15.94	6.90	383	—	0.33	14.61	6.83	259	—	0.57	11.57	7.43	209
1930		—	19.95	6.68	222		—	17.01	7.04	332		—	15.67	6.88	266
Reasoning															
1901/02	0.25	0.81	12.95	4.56	297		0.42	12.78	5.02	270		0.50	12.15	5.22	178
1906/07	—	0.57	14.13	4.64	378	—					—				
1930		—	16.86	4.54	220		—	14.82	5.23	348		—	14.57	5.18	272
Perceptual- and motor-speed															
1901/02	0.40	1.19	16.17	8.73	175	0.21	0.87	16.27	6.95	268	−0.01	0.80	14.71	6.94	178
1906/07	—	0.80	19.51	6.79	375	—	0.66	18.05	6.74	256	—	0.81	14.63	7.60	211
1930		—	26.14	7.58	221		—	23.54	4.62	363		—	21.43	7.04	302
Picture recognition memory															
1901/02							0.58	18.17	5.05	271					
1906/07	—	0.45	18.96	4.52	375	—					—	0.62	17.40	5.88	211
1930		—	21.07	4.53	222		—	20.84	4.66	356		—	20.27	4.64	284
Verbal ability															
1901/02	0.21	0.63	17.51	6.36	295	0.05		17.76	6.87	270	−0.15	0.58	17.53	7.30	186
1906/07	—	0.43	18.80	6.42	373	—		18.01	6.55	255	—	0.73	16.58	7.85	211
1930		—	21.50	5.23	204		—					—	21.18	5.18	277

Note: The *d* effect sizes are standardized based on the baseline (i.e., age 70) distribution of the respective test.

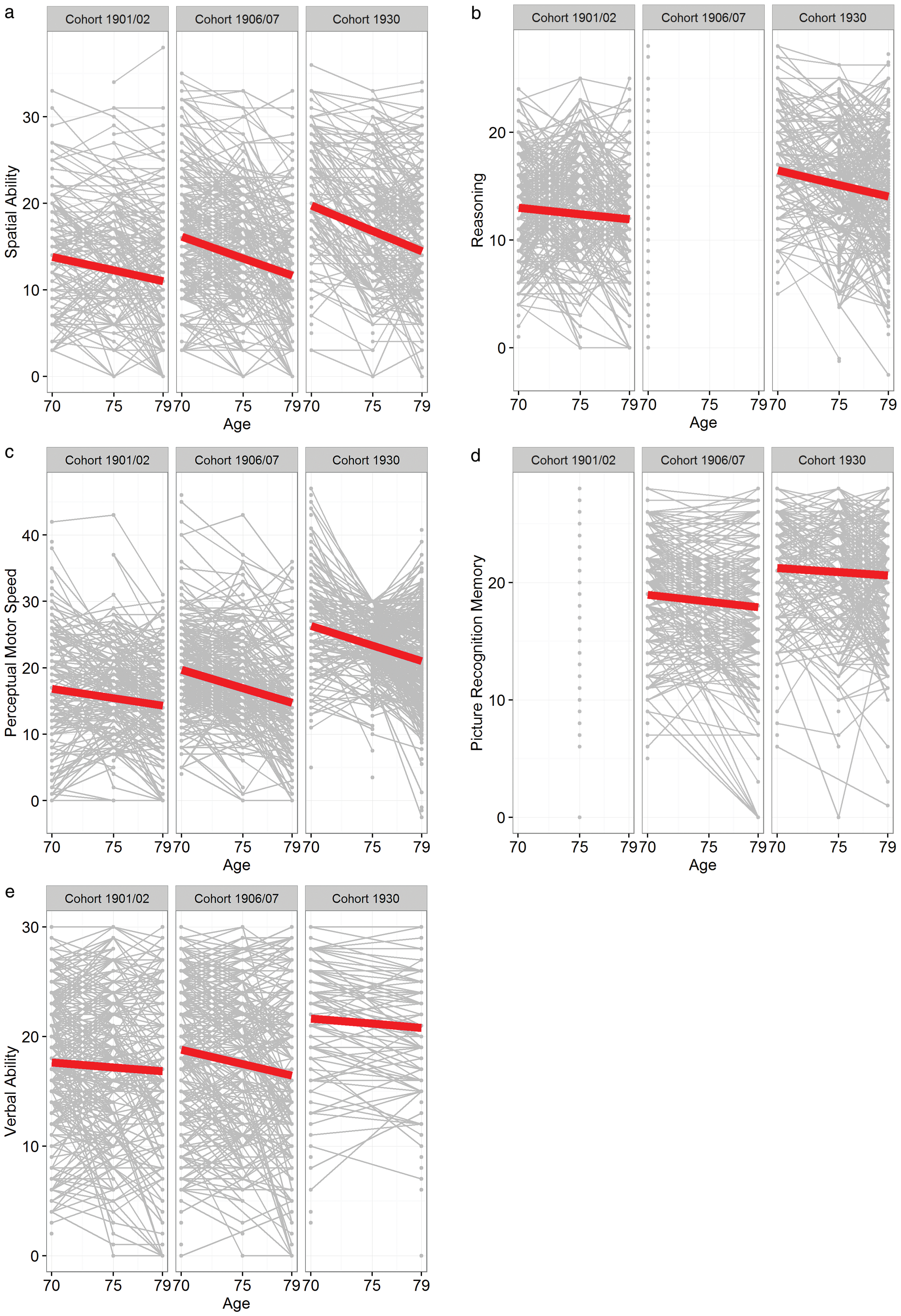

Figure 1. Raw score trajectories from all cognitive tests for cohorts born 1901/02, 1906/07, and 1930 and measured at ages 70, 75, and 79 as part of the H70 study. The bold/red lines refer to the estimated average change trajectories.

across the different cognitive domains we report in the fifth column in Table 2 the effect sizes as standardized based on the baseline distribution for cohort born 1901/02 (information provided in Table 1 can be used to standardize these estimates based on alternative distributions).

The conditioned marginal posterior probability density distributions of the differences between cohort 1901/02 and 1930 on level of performance in all the tests at age 70 are plotted in Supplementary Figure S2. These figures demonstrate the probability density for the specific values of the parameters (i.e., birth cohort effects in level of performance) given the H70 data and the model specification, including the priors which are specified as non- or low-informative in these models and have therefore only minor influences of the estimation and the inferences. The posterior distributions are presented in Supplementary Figure S2 separately for each of the three chains used in the numerical approximation allowing evaluation of the convergence of the chains for the specific parameter. Confirming the descriptive, these plots demonstrate strong evidence for birth cohort differences in level of cognitive performance at Age 70 on all cognitive measures. Note in particular that an integral over the posterior distribution close to the parameter value of zero is extremely small and almost non-existing on all the cognitive outcomes, indicating a very small probability that a null-hypothesis is true given the observed data.

The marginal posterior probability density distributions of the differences between cohort 1901/02 and 1930 on rate of linear change in all the cognitive tests, from age 70 to 79, are plotted in Supplementary Figure S3. As shown in these figures, the data provides strong evidence for birth cohort difference in rate of change for the spatial ability, reasoning, and perceptual- and motor-speed measures, where cohort 1930 shows a steeper average decline. This difference is however close to zero for the picture recognition memory and verbal ability measures, indicating no cohort difference in rate of change and a support for the null-hypothesis.

Discussion

Evidence of a secular change in intellectual status and decline in the general aging population is important from a life-span theoretical standpoint. Theories in developmental psychology need to account for observations of substantial cohort trends. Obviously, the large cohort differences reported in this study emphasize the substantial role of environmental factors in shaping life-span cognitive trajectories. There is no single known genetic marker, or combination of genetic markers, with comparable effect sizes (cf. Payton, 2009). Our findings of large cohort effects in this study should boost the awareness and certainty among aging researchers that changes in environmental contingencies, such as increased cognitive stimulation through longer and better education, more complex work environment, better public health care system, and improved nutrition, have substantial long-term effects on cognitive functioning as here seen in the elderly population.

Observations of large birth cohort effects are also important for researchers and practitioners using cognitive measures to assist in their evaluation of functional disability, dementia status, and working capability among older people. Standardization of cognitive batteries, interpretation of test scores, establishment of cut-off values, and decision making based on cognitive evaluations need to be conducted in the context of secular changes, that is, cohort and generation effects (e.g., Flynn, 2009). The findings of substantial birth cohort effects also provide an input to the ongoing discussion about overall functioning and capability of older adults in relation to current norms of exit from the labor market, that is, retirement age. Although our analyses provide clear evidence for a better overall cognitive performance in later born cohorts, the evidence of steeper decline suggest that we cannot expect that later born cohorts are immunized for subsequent cognitive decline.

We propose three viable alternatives that may explain our findings of a steeper average rate of decline among the members of the later born cohorts on the tests of spatial ability, reasoning, and perceptual- and motor-speed. The first explanation relates to the cognitive reserve hypothesis (e.g., Stern, 2012), which suggests that individuals with higher intellectual capacity can cope with accumulation of age-related brain pathologies (e.g., accumulation of amyloids or white matter hyperintensities) for a longer period of time in comparison with the less intellectually able individuals. However, when the more able individuals start to decline, they decline, on average, at a steeper rate due to a greater severity of the brain pathologies that have surpassed critical thresholds. Given that the later born cohorts, on average, score higher on the cognitive tests, we also expect that they have generally a better cognitive reserve and therefore show a steeper rate of decline when they initiate the decline phase. With only three measurements occasions currently available for each birth cohort we are unfortunately not able to reliably estimate the time of onset of cognitive decline in the respective birth cohorts, which would be needed to further clarify this issue.

A second explanation may relate to birth cohort differences in selective survival (e.g., Nesselroade, 1988) and left centering in our data. Presumably a larger proportion of the frailest individuals, those that we expect to show the steepest age-related cognitive decline, in the earlier born cohorts have already at age 70 dropped out of the population due to mortality. In that respect are the earlier born cohorts more likely to represent a more selected group of individuals who are less likely to show a steep decline in comparisons with the later born cohorts.

A third explanation may relate to the psychometrical properties of the tests that we used, where the reliability to detect change may be related to level of functioning, such that change is measured with a higher precision among those who score higher. As the individuals belonging to the later born cohorts generally perform at a higher level, it may be also easier to detect change among them.

We note however that these are only speculations and that the finding of a steeper rate of decline among the later born cohorts did not generalize to tests of picture

Table 2. Estimates of Birth Cohort Differences in Level of Performance and Rate of Change From Growth Curve Models Fitted to Data From the Three Birth Cohort in the H70 Study

Cognitive ability	Parameters[a]	Marginal posterior median	95% HDI[b]	Standardized effect size[c]
Spatial ability (Block Design)	Level at age 70			
	Cohort 1901/02	12.90	[12.06, 13.74]	
	Cohort 1906/07 vs 1901/02	2.20	[1.18, 3.21]	0.33
	Cohort 1930 vs 1901/02	4.72	[3.65, 5.79]	0.71
	Slope age 70–79			
	Cohort 1901/02	−0.31	[−0.41, −0.21]	−0.05
	Cohort 1906/07 vs 1901/02	−0.19	[−0.31, −0.06]	−0.03
	Cohort 1930 vs 1901/02	−0.28	[−0.41, −0.15]	−0.04
Reasoning (Figure Logic)	Level at age 70			
	Cohort 1901/02	12.47	[11.94, 12.99]	
	Cohort 1906/07 vs 1901/02	1.03	[0.37, 1.68]	0.23
	Cohort 1930 vs 1901/02	2.81	[2.11, 3.52]	0.62
	Slope age 70–79			
	Cohort 1901/02	−0.13	[−0.21, −0.06]	−0.03
	Cohort 1906/07 vs 1901/02	—	—	
	Cohort 1930 vs 1901/02	−0.16	[−0.26, −0.05]	−0.04
Perceptual- and motor-speed (Figure Identification)	Level at age 70			
	Cohort 1901/02	16.87	[15.91, 17.81]	0.08
	Cohort 1906/07 vs 1901/02	2.75	[1.62, 3.89]	0.32
	Cohort 1930 vs 1901/02	8.89	[7.28, 9.69]	1.02
	Slope age 70–79			
	Cohort 1901/02	−0.29	[−0.41, −0.16]	−0.03
	Cohort 1906/07 vs 1901/02	−0.25	[−0.41, −0.10]	−0.03
	Cohort 1930 vs 1901/02	−0.31	[−0.47, −0.15]	−0.04
Picture recognition memory (Thurstone’s)	Level at age 70			
	Cohort 1901/02 vs 1906/07	−0.15	[−0.87, 0.58]	−0.03
	Cohort 1906/07	19.47	[18.78, 20.15]	0.11
	Cohort 1930 vs 1906/07	1.60	[0.79, 2.41]	0.35
	Slope age 70–79			
	Cohort 1901/02 vs 1906/07	—	—	
	Cohort 1906/07	−0.20	[−0.27, −0.13]	−0.04
	Cohort 1930 vs 1906/07	0.06	[−0.04, 0.13]	0.01
Verbal ability (Synonyms)	Level at age 70			
	Cohort 1901/02	16.92	[16.21, 17.63]	−0.09
	Cohort 1906/07 vs 1901/02	1.06	[0.21, 1.92]	0.17
	Cohort 1930 vs 1901/02	2.44	[1.47, 3.42]	0.38
	Slope age 70–79			
	Cohort 1901/02	−0.09	[−0.16, −0.02]	−0.01
	Cohort 1906/07 vs 1901/02	−0.17	[−0.25, −0.07]	−0.03
	Cohort 1930 vs 1901/02	−0.01	[−0.11, 0.09]	−0.00

Notes: [a]Birth cohort 1901/02 is the reference group in all models except in the picture recognition memory model where cohort 1906/07 is the reference group. Education and gender are included as covariates in all models.

[b]Highest density interval.

[c]Computed as the proportion of the observed baseline standard deviation for the 1901/02 cohort on the respective test (cohort 1906/07 is used for the picture recognition test).

recognition memory and verbal ability. The reason for this is unknown, but we suspect that this could be related to the fact that the aging effects in these types of cognitive domains are relatively less pronounced. It is well known that measurements of recognition (e.g., Danckert & Craik, 2013) and crystallized abilities, such as verbal meaning (e.g., McArdle, Ferrer-Caja, Hamagami, & Woodcock, 2002; Rönnlund, Nyberg, Bäckman, & Nilsson, 2005), show relatively small aging effects in comparison with delayed recall and fluid-like measures and consequently may also show small cohort difference in rate of decline. Our findings provide strong support for the notion that there are birth cohort differences in rate of decline in old age, where the later born cohort decline faster in comparison to the earlier born, but only on those measure that that are known to be age sensitive.

Methodological Implications of Cohort Effects

It is well known that birth cohort effects in level of cognitive performance and rate of change have serious ramification for the interpretation of age trends from cross-sectional data (Hofer, Flaherty, & Hoffman, 2006; Schaie, 1965). The same applies to inferences based on data from age-heterogeneous longitudinal studies. However, in such study designs the birth cohort differences in both level of performance and rate of change can be quantified and thereby modeled and accounted for (e.g., Sliwinski, Hoffman, & Hofer, 2010). Also, some of the proposed modeling procedures for adjustment of retest (or practice) effects in longitudinal studies (e.g., Rabbitt, Diggle, Smith, & Holland, 2001) rely on the assumption of no, or little, cohort differences. Similar cohort effects as reported in this study can lead to serious bias in both the age and retest effects estimates from such growth curve models (Hoffman, Hofer, & Sliwinski, 2010).

Strength and Limitations

A major strength of our cognitive aging study on birth cohort effects is that we were able to compare three age homogenous representative population-based samples born up to 30 years apart, living in the same city, measured at the same chronological ages (i.e., 70, 75, and 79), and on the same cognitive test battery. The birth cohort effects observed are in fact so large that they are obvious by simple eyeballing of the data (Supplementary Figure S1). Quantification and inferences of the adjusted effect sizes are based on the marginal posterior distributions, obtained from a Bayesian framework, reflecting the probability distributions of the birth cohort differences, in either level of performance or rate of change, given the H70 data and the modeling specification (for comparable estimates based on maximum likelihood functions from model fitted to the spatial ability and the reasoning tests in the H70 study, see Karlsson et al., 2015). Despite study strengths, there are of course some limitations, such as a shorter version of the perceptual- and motor-speed measure being used at age 75 for cohort 1930. This will lead to underestimation of the cohort effects at age 75 and potentially a somewhat steeper decline estimate. The participation rate was also lower in the 1930 cohort (i.e., 66%) leading to a relatively less reliable estimate for that cohort. Despite these shortcomings, and some differences across the cognitive tests, our general patterns of finding were unequivocal.

Conclusions

The presented evidence from the H70 study is conclusive of moderate to large birth cohort effects in level of cognitive performance at ages 70–79 in the general population. The evidence for birth cohort differences in rate of cognitive change was significant on three out of five measures, that is, on spatial ability, reasoning, perceptual- and motor-speed, but not on picture recognition memory and verbal ability. Our findings underline the importance of environmental influences contributing to cognitive aging and that standardizations and usage of cognitive tests in an elderly population must take into account potential birth cohort differences.

Supplementary Material

Please visit the article online at http://psychsocgerontology.oxfordjournals.org/ to view supplementary material.

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