A Global Perspective on Cognitive Abilities and Educational Attainment

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Background: Age-related cognitive decline combined with demographic changes represents a social, economic, and health-related challenge. Extending schooling and improving the quality of education can be one important policy response for reducing the incidence of poor cognitive function among seniors. This study gives a global comparison of the impact of education on cognition, using standardized cognitive measures from representative surveys of individuals aged 50 and above. We present results on how cognitive performance is related to individual and national education across countries of Asia, America, Africa, and Europe.

Methods: Data are from aging surveys conducted in 2006-2010 covering more than 20 countries. Mental health is assessed using immediate recall and verbal fluency tests. We use a multilevel approach to identify the influence of individual education as well as the influence of national-level education, controlling for sex, age, and health.

Results: Studying those who were born between 1926 and 1956 we find a positive education-cognition relation for all countries, in spite of their very different characteristics with respect to demography, educational distribution, selection into schooling, and level of economic and social development. We also find that an increase in the national education level not only increases an individual's level of education but also has an additional positive effect on his/her cognition.

Conclusion: Education is significantly positively associated with cognitive function across all countries. Raising the level and quality of education could represent a potential mechanism for improving cognition at older ages.

Keywords: Aging, education, mental health, cognition

Introduction

The positive association between education and cognition has been known for a long time having been the focus of several country-level or regional studies (1-4). Education is related to higher cognitive functioning at younger, prime, and older ages (5-7). Poor cognitive health among many seniors can be a major problem in poorer countries (8), which have the largest absolute number of individuals suffering from poor cognitive health and Alzheimer's disease (9), and in richer countries, where the elderly shares are greater (10). To our knowledge, there has been no study to date on the relation between education and cognitive health that includes the majority of the world's elderly population, although there has been a focus on particular mental health diseases. The current study analyzes standardized cognitive tests for representative samples of people aged 50 and above across the world. We focus in particular on the individual-level and country-level effects of education on cognition.

The causal effect of education is difficult to identify because of the positive selection of individuals with better cognitive ability into higher schooling and other factors related to the outcome variables. Recently, Marcus Richards and Amanda Sacker argued that education does in fact improve cognition (11). This was supported by evidence on variations in schooling that are not related to preschool ability (12). Analyses of monozygotic twins with different education levels also suggest that schooling significantly improves cognitive functioning (13).

The slope of the aging curve, regardless of initial ability or education (14), is found to be relatively similar in several studies; including the Berlin aging survey (15), the Victoria Longitudinal Study (16), and in data from Scotland (17) and England (18). Other studies, however, find that age variation differs across individuals with different education and ability levels (19). In a study of Italians aged 40-85, Capitani et al. found that for some abilities

(verbal fluency, spatial memory, and Raven's Progressive Matrices), education was associated with a parallel increase across age groups, while for other tests (visual attention and verbal memory), the age slope became less steep with more education (20).

Education may have different effects in different countries. Being highly educated in a poor country, characterized by considerable inequalities in standards of living and health and often low-quality mass schooling, can have different outcomes than being educated in a wealthier nation. A greater selectivity into education could imply a stronger preselection of people enrolling in higher education.

Furthermore, education may differ in terms of its effects on specific mental outcomes. The fluid–crystallized cognitive ability dichotomy, whereby fluid represents the ability to solve novel problems and crystallized represents the amount of acquired knowledge (21) could suggest the following, namely, that verbal fluency, which relates to crystallized cognitive functions, is affected more by schooling, as it represents one's accumulated vocabulary, whereas immediate recall, which relates to both fluid and crystallized cognitive functions, should decline more with age. This is because the ability to encode and store new information declines over the life cycle, while experience improves memory retrieval strategies (6).

There could also be a country-level education effect on cognition in addition to an individual's education. That is, an individual's cognitive functioning may be influenced by the education levels of the rest of the population, regardless of his/her own education. This has been found in terms of cognitive health self-ratings (22) or of school performance, where being socialized with studious, disciplined peers can be beneficial (23-25).

Method:

Study population: As datasets we use the surveys HRS, JSTAR, SAGE, and SHARE, which are designed to be comparable and nationally representative of the non-institutionalized population aged 50+. The range of countries we are able to consider in this study offers an overview of various world regions.

The Health and Retirement Study (HRS) is a large-scale longitudinal project launched by the University of Michigan in 1992 in the USA. The study, where we use wave 8 data collected in 2006/07, provides information about income, work, assets, pension plans, health insurance, disability, physical health and functioning, cognitive functioning, and health care expenditures (26). In 2007 the Japanese Study of Aging and Retirement (JSTAR) was conducted by the Research Institute of Economy, Trade, and Industry (RIETI) and Hitotsubashi University (27).

The Survey of Health, Ageing and Retirement in Europe (SHARE) is a multidisciplinary and cross-national panel database of micro data on health, socioeconomic status, and social and family networks of more than 45,000 individuals in 15 European countries (28). The second wave, which we use for our analysis, was collected in 13 countries (Austria, Belgium, Czech Republic, Denmark, France, Germany, Greece, Italy, Netherlands, Poland, Spain, Sweden, and Switzerland) in 2006/07. Developed by the WHO Multi-Country Studies unit as part of a Longitudinal Survey Programme, the Study on global AGEing and adult health (SAGE) compiles comprehensive longitudinal information on the health and well-being of adult populations and the aging process in six countries (including China, India, Ghana, Mexico, Russian Federation, and South Africa). The survey instruments and methods were adapted from those used by other surveys, like HRS and SHARE.

Measures: We investigate two cognitive ability measures; first, a memory test (immediate recall), where ten words are read out and the respondents have one minute to recall as many words as possible, and second, a vocabulary size test (verbal fluency), where the task is to name as many different animals as the interviewee can think of within one minute.

We use educational attainment based on the International Standard Classification of Education (ISCED) to compare education across countries. The following categories are distinguished: (i) no formal education or less than one year primary; (ii) uncompleted primary up to uncompleted lower secondary (ISCED 1); (iii) secondary which includes completed lower secondary, (un)completed higher secondary, and uncompleted tertiary education (ISCED 2-4); (iv) tertiary including completed tertiary (ISCED 5-6).

To represent the national education level, it is important to consider the educational distribution within the countries and within two age groups. Therefore we use the shares of tertiary educated as the national education level variable in our models.

As we mentioned in the introduction, being more highly educated in a poorer country can have different implications than being more highly educated in a wealthier one; therefore we include GDP in our models. We control additionally for the following health conditions, which have been shown to influence cognition (29, 30): currently taking medication for anxiety or depression, ever being told that one has had a heart attack, coronary heart disease, angina, or any other heart problem, or ever being told one has had a stroke or cerebral vascular disease, and self-reported general health status.

Data analyses: We analyze the effect of education on standardized cognitive performance measures, as described above. We compare age variation in cognition by education across

countries and also consider position in educational distribution as a measure of educational selection.

To identify the variation in education as a determinant of cognitive abilities we use a multilevel model approach. As education could have a different influence on the more fluid abilities (immediate recall) relative to more crystallized abilities (verbal fluency), we do not sum up to a general mental health measure, but analyze the influence on immediate recall and verbal fluency separately.

We divide the sample into two broad age groups: from 50-64 years and from 65-79 years. This is done for several reasons. The younger group is more likely to be economically active, which could affect cognitive health. Further, these groups have gone through the school system during very different time periods. The younger group had all their schooling after World War II. Moreover, the older group is likely to have been exposed to more health problems, poor nutrition, and higher mortality (partly due to current old age but also due to growing up in periods with a lower life expectancy, see (10)).

There are strong gender differences in educational attainment in many countries, particularly among seniors - hence we run our models for males and females separately to account for different gender-specific effects.

Results:

With respect to country differences in education we first of all identify large variation between countries in terms of average cognitive performance for those aged 50 and above. International differences in cognitive outcomes and dementia can be affected by factors such

as working life experiences, retirement ages, diet, disease exposure, pollutants, physical exercise, and social activity patterns (31-33).

The standardized average immediate recall scores of everyone aged between 50-64 and 65-79 years according to level of education (no education, primary, secondary, and tertiary) are shown in Figure 1. Ranking the countries by performance of the primary-educated, we find that Denmark and Sweden are among the top performers for both age groups, while the Spanish and the Italians perform poorly for both age groups. While the pattern of verbal fluency scores again shows northern European countries, Sweden and Denmark, as leaders, the pattern is different for the bottom of the ranking with the poorest performance in terms of fluency being found in India, South Africa, and Russian Federation (see Figure 2).

(FIGURE 1 and FIGURE 2 ABOUT HERE)

We use multilevel regression models to take into account the effects of both individual level effects and country level effects. We run the models separately for men and women between 50 and 64 and between 65 and 79 years. We use the same model setup for both dependent variables; verbal fluency and then immediate recall.

The model includes age, self-reported health, individual education, health conditions influencing cognition, as well as national education level and GDP as explanatory variables. Furthermore, we assume that there are differences among countries and different effects of individual education across countries; consequently, we include a random intercept as well as a random slope (after a positive likelihood-ratio test for all ages and both sexes). After further likelihood-ratio tests, interactions were not included, as they were found not to be significant.

Immediate recall

Individual education is found to be important for cognitive functioning; therefore our results confirm what has already been indicated in literature for single countries. While no education is related to reduced ability level, secondary and tertiary education relate to a greater cognitive performance compared with primary education. Additionally, the effect of tertiary education on cognitive performance is almost twice as high as that of secondary education across all ages and for both sexes. For instance, tertiary educated women aged 50 experience an increase of 0.594 SD in their immediate recall scores relative to their primary educated counterparts.

Our analysis further identifies the influence of national education on individual cognitive performance. We find that within countries where the average education is higher, the immediate recall score of a person is also higher. The highest increase due to national education is evident for females. Particularly among older females we find that increasing the share of tertiary educated results in a gain of 1.925 SD per basis point.

Moreover the country gap for no education is not as big as the gap for higher educated, showing that the gap increases as education levels get higher. For instance, the between-country variance in the slopes for no-education females is 0.002, whereas for tertiary-educated it increases to 0.054.

(TABLE 1 ABOUT HERE)

Fluency

The results for education with respect to verbal fluency are similar, although stronger, than for immediate recall (see Table 2). At the individual education level, no education lowers the cognitive scores, while secondary and tertiary education raise performance in comparison to

being primary educated. For instance, women of a country aged 50 gain an increase of 0.707 SD in their verbal fluency scores from having tertiary education compared with their primary educated counterparts. The between-country variance in these slopes is quite small for no education, but increases with higher education levels; for tertiary educated women between 50 and 64, for instance, it is 0.063 SD. Analogous to the results of modelling immediate recall, the highest boost due to national education can be seen for older females (the gain would be 2.214 SD). The between-country variance reaches a maximum for women between 50 and 64 years, where the variance partition coefficient is 0.197, which indicates that 19.7% of the variance in verbal fluency ability can be attributed to differences between countries.

(TABLE 2 ABOUT HERE)

Conclusion

How education affects mental health is important for the "emerging field of cognitive epidemiology" as noted by Deary and Johnson (34). Education has been found to significantly raise levels of cognitive functioning, such as memory (5, 35, 36). Epidemiological research has identified low educational attainment as an important risk factor for low cognitive functioning and the risk of Alzheimer's disease (37, 38). Countries with better cognitive functioning levels tend to be those with longer average schooling. Northern Europeans and Americans have globally the highest educational attainment among their 50+ population and also the best cognition (39, 40).

To give a further example: Chinese women with primary education aged 60 have an immediate recall score of -0.300 (and a -0.403 verbal fluency score), whereas tertiary educated women have an immediate recall score of 0.317 (and 0.295 verbal fluency score).

Increasing the share of tertiary educated from the current level of 3.5% by 10% to 13.5% could imply that primary educated women would gain in terms of immediate recall 0.114 (0.147 verbal fluency) and tertiary educated could even reach an immediate recall score of 0.431 (0.442 verbal fluency).

By comparison, in Sweden with a share of 26.7% tertiary-educated 50-64 year-olds, primary-educated women aged 60 reach an immediate recall score of 0.312 (1.263 verbal fluency) and tertiary-educated 0.629 (1.594 verbal fluency).

Hence, the gap between primary- and tertiary-educated is greater for countries with a smaller share of higher-educated people. Therefore, countries may gain more at lower levels than higher levels, as the potential is greater. Strengthening mental healthis particularly important in some low- and mid-income countries (like China), where poor cognitive functioning among seniors is a significant problem (39).

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In references: JSTAR datasets, produced by the Research Institute of Economy, Trade and Industry (RIETI) and Hitotsubashi University, distributed by RIETI in Tokyo, Japan.

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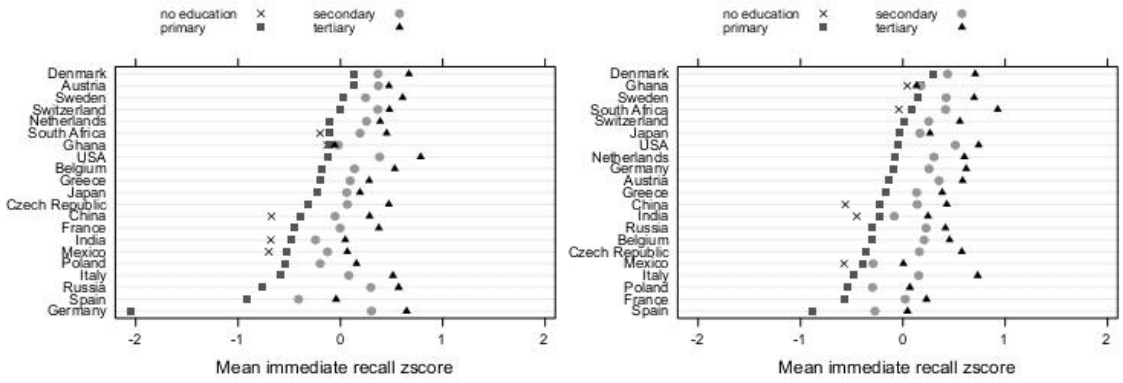
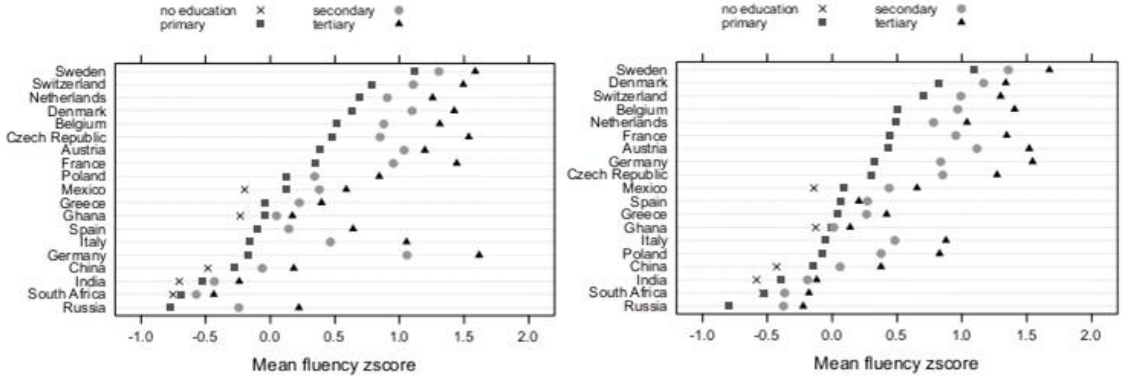
Figure 1: Average standardized immediate recall score for no education, primary, secondary and tertiary educated 50-64 year-olds (left-hand side) and 65-79 year-olds (right-hand side).



Source: HRS, JSTAR, SAGE, and SHARE; own calculations; note: there are <30

observations for primary educated Germans.

Figure 2: Average standardized verbal fluency score for no education, primary, secondary and tertiary educated 50-64 year-olds (left-hand side) and 65-79 year-olds (right-hand side).



Source: HRS, JSTAR, SAGE, and SHARE; own calculations; NOTE: there are <30

observations for primary educated Germans.

Table 1: Estimates gained by linear multilevel model for immediate recall abilities for both sexes and both age groups

	females 50-64		**females 65-79**		**males 50-64**		**males 65-79**	
	Estimate	s.e.	Estimate	s.e.	Estimate	s.e.	Estimate	s.e.
Country level								
Share with tertiary educ.	1.140	0.50	1.925	0.69	1.065	0.45	1.105	0.53
GDP	0.058	0.05	0.003	0.04	-0.011	0.04	-0.010	0.03
Individual level								
Education (primary)								
no education	-0.180	0.03	-0.195	0.06	-0.315	0.10	-0.118	0.05
secondary	0.337	0.04	0.324	0.05	0.337	0.04	0.307	0.04
tertiary	0.594	0.06	0570.	0.06	0.630	0.06	0.603	0.05
good self-rep. health	0.243	0.02	0.273	0.02	0.287	0.02	0.286	0.02
Intercept	-0.460	0.40	1.708	0.41	0.228	0.36	1.565	0.32
Random Effects-Variance								
Intercept	0.067		0.063		0.057		0.055	
Education (primary)								
no education	0.002		0.017		0.090		0.007	
secondary	0.023		0.031		0.019		0.015	
tertiary	0.054		0.037		0.052		0.039	
BIC	56799		42659		45934		35347	
Sample size:	21791		16605		17591		13849	

Source: HRS, JSTAR, SAGE, and SHARE;

We control for age as well as for taking medication for anxiety or depression, heart attack or similar, or stroke/cerebral vascular disease

Table 2: Estimates gained by linear multilevel model for verbal fluency abilities for both sexes and both age groups.

	females 50-64		**females 65-79**		**males 50-64**		**males 65-79**	
	Estimate	s.e.	Estimate	s.e.	Estimate	s.e.	Estimate	s.e.
Country level								
Share with tertiary educ.	1.474	0.97	2.214	1.08	0.955	0.88	1.716	1.07
GDP	0.246	0.09	0.231	0.07	0.210	0.07	0.202	0.07
Individual level								
Education (primary)								
no education	-0.150	0.02	-0.230	0.05	-0.200	0.04	-0.133	0.03
secondary	0.320	0.05	0.296	0.05	0.270	0.03	0.275	0.04
tertiary	0.707	0.06	0.642	0.08	0.592	0.07	0.558	0.06
good self-rep. health	0.089	0.02	0.148	0.02	0.108	0.02	0.169	0.02
Intercept	-2.121	0.74	-0.934	0.59	-1.728	0.62	-0.605	0.60
Random Effects-Variance								
Intercept	0.150		0.107		0.084		0.080	
Education (primary)								
no education	0.001		0.019		0.007		0.000	
secondary	0.033		0.036		0.013		0.021	
tertiary	0.063		0.104		0.071		0.049	
BIC	36623		25637		32461		22148	
Sample size:	17024		11284		14290		9695	

Source: HRS, JSTAR, SAGE, and SHARE;

We control for age as well as for taking medication for anxiety or depression, heart attack or similar, or stroke/cerebral vascular disease