Inequality in old age cognition across the world

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Abstract

What is commonly found in studies that look at later-life cognitive abilities is a strong effect of educational attainment on retarding the deterioration of such abilities. In this sense, education is a protective measure for cognition reserve. In a more aggregate perspective, we propose a measure of later-life cognition inequality per cohort in 27 countries with diverse degree of economic development and comparable cognition tests. We relate cognitive inequality with corresponding past inequalities in education in each country. The survival rate of the cohort is also included in linear regressions in order to disentangle the effects of age and education composition on cognition inequality. Our results show a sizeable positive effect of past educational inequalities on present inequality of old age cognition. Furthermore, the survival rate is positively associated with todays' cognitive inequality. Surviving females bring such a relative cognitive profile into old age that this results in an increase of cognitive inequality. Therefore, countries that experienced a large gender gap in education are more prone to suffer more later-life cognitive inequality

Keywords: Old age, cognitive abilities, education, inequality

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1. Introduction

An adequate cognitive functioning in old age means better levels of autonomy and wellbeing. A country may be performing better than others if this shows a higher level of later-life cognition (e.g. using an average score). But, what about the dispersion of these cognitive abilities among the elderly? Do we need to look at this inequality? What this inequality is really showing and what mechanisms can explain its levels?

Perhaps, we are observing the long-term effects of initial educational inequalities in the country. It is also needed inquiring about the role of cohort and gender differential survival rates because socio-economic status is related with mortality and education. Our hypothesis is that past educational inequalities and differential in survival rates are important drivers for present inequality of later-life cognition.

Literature on old age wellbeing and health determinants is increasing. There is a booming research agenda on studying and measuring early life conditions and past exposure to shocks on present conditions such as health status and wellbeing. What is commonly found in studies that look at cognitive functioning in old age is a strong effect of educational attainment on preventing a faster deterioration of cognitive abilities. In this context, education has been interpreted as a protective measure (the same applies for protecting against mental health problems). The beneficial effect of education has passed on robust techniques such as Regression Discontinuity methods and using educational policy reforms as natural experiments (Banks and Mazzona, 2012; Glymour et al. 2008). However, inequality in cognitive functioning has not been studied. We believe this is important because an increasing old population need skills to properly function at later ages. Longer years of life will add to wellbeing only if they are spent in good health and functioning. Thus, measuring inequality in cognitive abilities can be interpreted as measuring distribution of wellbeing in old age. Measuring cognitive abilities in old age is equivalent to measure human capital in the later stages of production. Cognitive abilities are an indicator of accumulated human capital that depreciates, although the individual can take measures for cognitive maintenance or repairing (McFadden, 2008). Given the positive association between human capital and economic progress, cognitive inequality is somewhat picking up the distributional structure of income. Furthermore, elderly individuals with more cognitive impairments are less autonomous and can represent a major public health problem in the context of ageing societies. As reported by Bonsang *et al.* (2012), cognitive impairment or dementia is associated with lower quality of life, increased disability and higher health expenditures. In this case, cognitive inequality is associate with inequality in subjective wellbeing and health.

The paper is organized as follows. The next section presents the data. Section 3 presents the methods and variables. Section 4 presents and discusses the results. Finally, section 5 provides a conclusion.

2. Data

The data to compute inequality of old age cognition are drawn from 5 surveys measuring the living conditions of the elderly. The Survey of Health, Ageing and Retirement in Europe (SHARE) is used to extract information for Israel and 19 European countries: Austria, Germany, Sweden, Netherlands, Spain, Italy, France, Denmark, Greece, Switzerland, Belgium, Israel, Czech Republic, Poland, Ireland, Luxembourg, Hungary, Portugal, Slovenia and Estonia. The data for United Kingdom (only England) are extracted from the English Longitudinal Study of Ageing (ELSA). The Study on Global Ageing and Adult Health (SAGE) is used to extract data for China, Ghana, Russia and South Africa. The data for India are drawn from the Longitudinal Aging Study in India (LASI), and the data for Mexico are extracted from the Mexican Health and Aging Study (MHAS). There is a total of 27 countries surveyed between 2007 and 2013 with comparable information on old age cognitive abilities (see Table 1).

Table 1. List of employed surveys

Survey	Country and year of interview
SHARE	Austria (2013), Germany (2013), Sweden (2013), Netherlands (2013), Spain (2013), Italy (2013), France (2013), Denmark (2013), Greece (2007), Switzerland (2013), Belgium (2013), Israel (2013), Czech Republic (2013), Poland (2012), Ireland (2007), Luxembourg (2013), Hungary (2011), Portugal (2011), Slovenia (2013), Estonia (2013)
ELSA	UK (2010)
SAGE	China (2008), Ghana (2008), Russia (2008), South Africa (2008)
LASI	India (2010)
MHAS	Mexico (2012)

The data to measure inequality in education per in the analysed countries are drawn from the Barro-Lee dataset of educational attainment 1950-2010 (Barro and Lee 2013). This dataset contains the distribution of population by educational level in 5-year age groups for every 5 year between 1950 and 2010. The age groups are 15-19, …, 70-74 and open groups 15+, 25+ and 75+. The life table's survivors of World Population Prospects 1950-2100 (2015 Revision, United Nations) are used to compute the survival probabilities of cohorts.

3. Methods and variables

The effects of past educational inequalities on old age cognitive inequality are measured with OLS regressions where the unit of analysis is the synthetic cohort. For this aim, the population interviewed in the above mentioned surveys is divided in 6 age groups (50-54, 55-59, 60-64, 65-69, 70-74 and 75-79) within each country, which result in a sample of 159 synthetic cohorts (country-cohort points). Inequalities are measured for each synthetic cohort. Old age cognitive inequality is measured in the year of the survey, i.e. between 2007 and 2013, while educational inequality is measured in the past with the Barro-Lee data when the cohort was aged 25-29. Similarly, the survival rate of the cohort is measured when the cohort was aged 25-29. This particular base cohort is chosen because the decisions on educational investment have already been taken for most of individuals at age 25-29. The regressions use the following model specification:

$$A_{c,i} = \alpha_c + \beta_1 E_{c,i,t} + \beta_2 S_{c,i,t} + \varepsilon_{c,i} \quad , t\text{=year when c was 25-29} \qquad (1)$$

The subscripts *c* and *i* indicate the country and cohort, respectively. The dependent variable $A_{c,i}$ is the inequality index of cognitive abilities measured within the synthetic cohort *c,i* around year 2010. The term $E_{c,i,t}$ is the inequality index of educational attainment for the synthetic cohort *c,i* measured in the year the cohort was aged 25-29. For example, in the case of the India's cohort 65-69, cognition inequality is computed in 2010 with the LASI survey, while educational inequality is measured for the cohort 25-29 of 1970 with the Barro-Lee data. The term $S_{c,i,t}$ indicates the survival probability of the synthetic cohort *c,i* measured in the year the cohort was aged 25-29 up to the current age of the cohort.

3.1 Inequality of old age cognition

The surveys use comparable tests to measure cognitive functioning in old age. *Immediate memory* is measured with the number of correctly recalled answers to a 10-words list that was just previously read by the interviewer. *Delayed recall memory* is measured with the number of correctly recalled answers to the same 10-words list after some minutes they were read in the interview. *Average memory* is simply the average of both memory tests. *Verbal fluency* is the number of all possible animals the respondent can name in one minute. The memory tests are divided by 10 and the verbal fluency is divided by 100, and therefore, all test scores range from 0 to 1.

3.2 Inequality in educational attainment

The distribution of educational attainment in the Barro-Lee data (BL data) includes seven categories: no education, incomplete primary, complete primary, incomplete secondary, complete secondary, incomplete tertiary and complete tertiary. In addition, the database reports the average years of education spent in primary, secondary and tertiary levels. This data has been mostly used in economic growth research and human capital dynamics, although some studies have also analysed inequality. The study by Thomas *et al.* (2001) was the first one that computed and analysed educational Gini indexes with this data. The present paper uses the formula employed by Thomas *et al.* (2001) to compute Ginis of educational attainment[1]:

$$Gini = \left(\frac{1}{\bar{y}}\right) \sum_{i=2}^{n} \sum_{j=i}^{i-1} p_i p_j \, |y_i - y_j| \qquad (2)$$

y_i, y_j : Cumulative average of education years of each educational level.

n: : Number of educational levels.

p_i, p_j : Shares of population in certain educational level.

Thomas *et al.* (2001) used 7 categories of educational level (n=7) no education, complete and incomplete primary, secondary and tertiary. Given that BL data does not have average years of schooling for incomplete levels of education, the authors used another source for duration of education levels and assumed that incomplete education levels were half of the years of the subsequent level. Benaabdelaali *et al.* (2012) use the same formula for the Gini index and the seven educational levels in the BL data, but they do not rely on external data for

[1] The duration of each educational level employed by Barro and Lee (2013) has been kindly shared by Jong Wha Lee.

educational level durations. Instead, they assume that males and females show the same average years of schooling in each level. Castello and Doménech (2002, 2014) use BL data and compute Ginis of educational attainment with a formula employing four educational levels, i.e. no education, primary, secondary and tertiary. They don't need to rely in any other data source to compute Gini indexes. In general, all these papers show that educational inequality is negatively related to average years of education and educational inequality is declining.

Other alternative datasets of historical educational attainment are the one constructed by Daniel Cohen (Cohen and Soto 2007 and Cohen and Leker 2014) which reports educational attainments for 95 countries, every ten years from 1960 to 2020. The database displays the average years of education of the population aged 15+, 25+, 25-64 and by 5-year age groups. Likewise, the data by Crespo-Cuaresma *et al.* (2013) reports educational attainment for 175 countries in 1960-2050 and by sex. The Wittgenstein Centre Data Explorer includes projections of educational attainment for 1970-2100 in 195 countries by sex and 5-year age groups.

3.3 Cohort survival rates

The computation of survival rates uses the series of life table survivors of the United Nations World Population Prospects 1950-2100. The survival rate (by sex and total) is measured back in the year the cohort was aged 25-29. This measures the probability that the individuals aged 25-29 in the past will survive until the current age of the cohort. The following formula is employed:

$$S_{c,i,t} = {(l_{25+x,t} + l_{3o+x,t})}\Big/{(l_{25,t} + l_{3o,t})} \quad , t\text{=year when } c \text{ was 25-29} \qquad (3)$$

The term $l_{25,t}$ from a period life table indicates the number of surviving individuals at age 25 in year *t*, and $l_{25+x,t}$ is the number of individuals in who will survive up to age 25+*x*. Both $l_{25,t}$ and $l_{30,t}$ are employed in order to take into account the number of survivors in the 5-year age group.

4. Results

The main econometric results are reported in Table 2. Past educational inequalities are statistically significant and positively explain present inequalities in old age cognition. For example, one point increase in educational Gini lead to 0.57 points increase in today's delayed memory. However, once the total survival rate of the cohort is introduced, the gini of education loss its predictive power. Total survival rate is negatively associated with old age cognitive inequalities. This means that selective mortality plays an important role in the level of cognitive inequality. In particular, the results indicate that the survival rate has equalizing effects on the distribution of cognition. Perhaps, the individuals that survive across periods are the ones with higher education and health and hence with higher cognition. This group of individuals may be more homogenous in terms of education and cognition with respect to individuals that die across periods.

Given that males and females considerably differ in their mortality profiles (males present larger mortality rates than females) it is perhaps more accurate to include in the regressions a variable measuring this differential. The results indicate that the survival rate differences (females minus males) increase the gini of old age cognition. So, an increase in the surviving probability of females, which in general have less education, will increase the lvel of cognitive inequality, while an increase of the surviving probability of males will reduce the level of cognitive inequality.

Table 2. OLS estimates of old age cognitive inequality

Variables	gini of immediate memory			gini of delayed memory			gini of average memory			gini of verbal fluency		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
gini of education	0.287***	-0.016	0.212***	0.571***	-0.062	0.388***	0.357***	-0.029	0.254***	0.117***	-0.018	0.085**
	(0.063)	(0.055)	(0.057)	(0.122)	(0.089)	(0.097)	(0.073)	(0.062)	(0.063)	(0.033)	(0.039)	(0.031)
survival rate		-0.127***			-0.265***			-0.162***			-0.056***	
		(0.015)			(0.029)			(0.020)			(0.015)	
survival rate (female - male)			0.230***			0.563***			0.315***			0.100***
			(0.049)			(0.082)			(0.058)			(0.028)
constant	0.087***	0.268***	0.085***	0.108***	0.486***	0.102***	0.092***	0.323***	0.089***	0.159***	0.239***	0.158***
	(0.019)	(0.025)	(0.014)	(0.037)	(0.041)	(0.024)	(0.022)	(0.030)	(0.015)	(0.010)	(0.020)	(0.009)
observations	159	159	159	159	159	159	159	159	159	159	159	159
R-squared	0.615	0.827	0.680	0.604	0.844	0.706	0.591	0.831	0.676	0.824	0.856	0.833

Robust standard errors are clustered by country and are in parentheses. Regressions include country dummies. * p<0.10, ** p<0.05, *** p<0.01.

5. Conclusions

We find evidence of long term effects of past educational inequality on present cognitive inequality among the elderly. Inequality of educational attainment experienced by the cohort in the past has a positive and significant effect on present cognitive inequality within the cohort.

Cohort's survival rate has an equalizing effect on the distribution of present cognition. It seems that the dead have contributed to counterbalance the increase of cognitive inequality. As we can see from the gender differential survival rates, the relative better fit of females contributes to increase cognitive inequality.

Surviving females bring such a relative cognitive profile into old age that this results in an increase of cognitive inequality. Given the lower educational attainment of old females, and the positive relationship between education and cognitive abilities, we can highlight that countries that experienced a large gender gap in education are more prone to suffer more later-life cognitive inequality.

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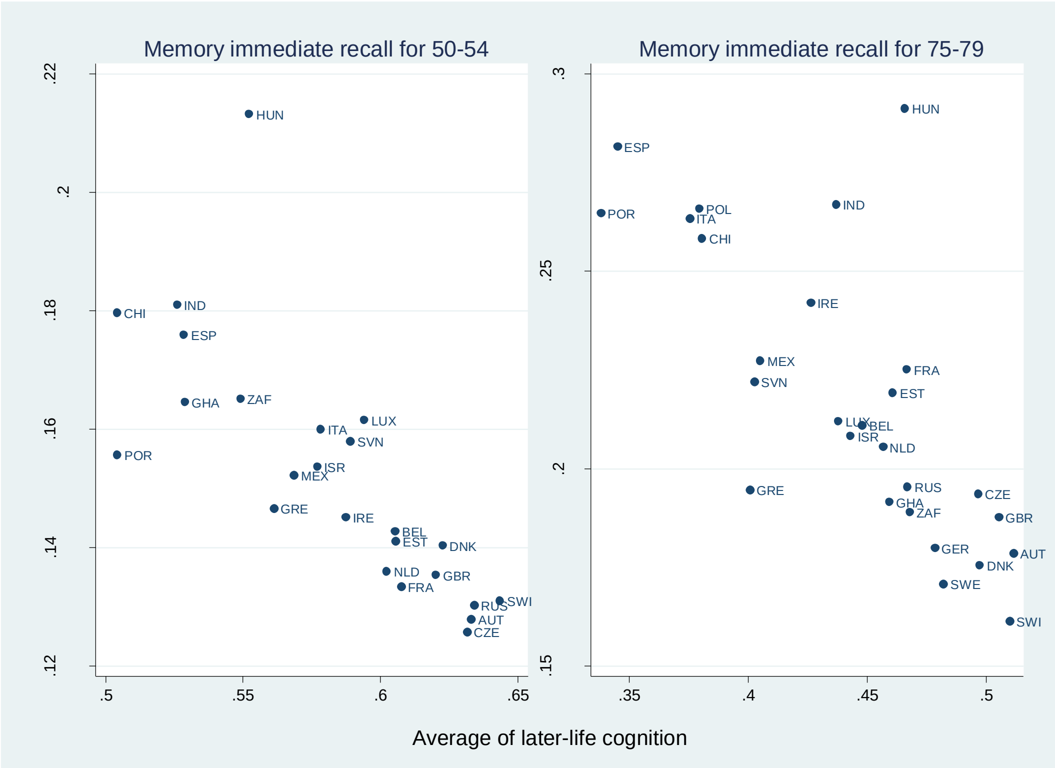
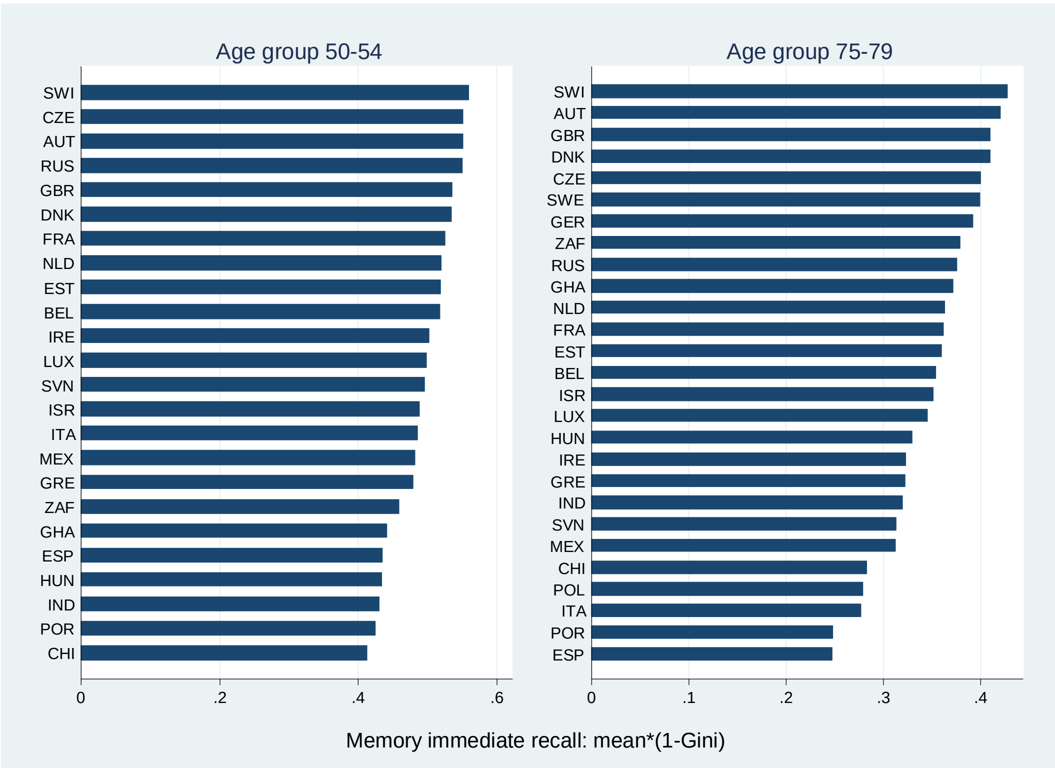
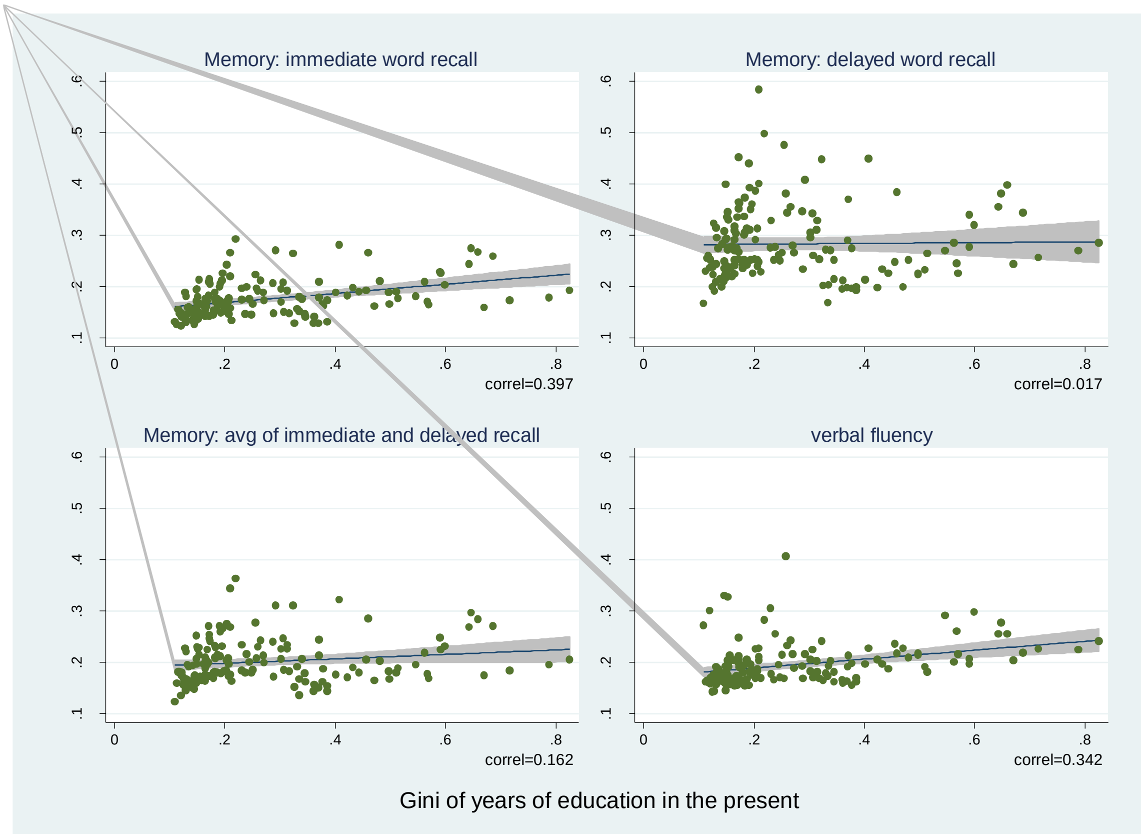
Appendix

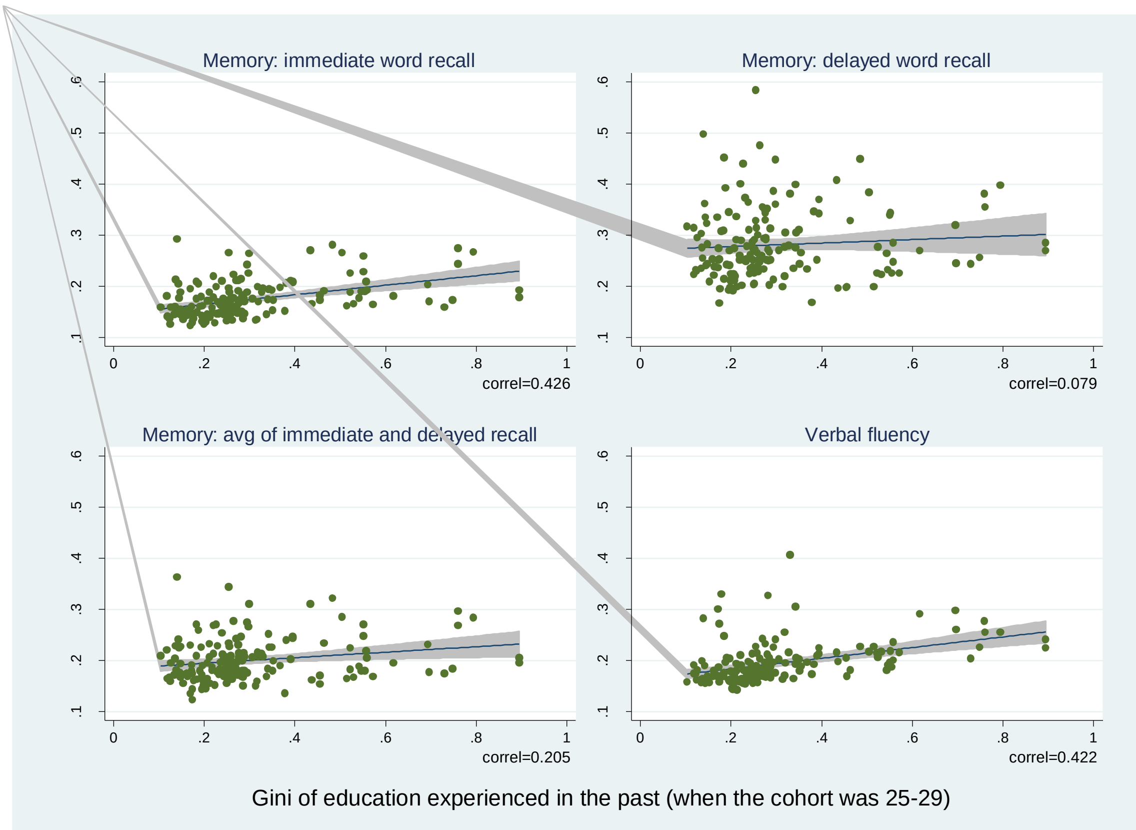
Gini and means of cognition





Cognition and education levels





Cognition and survival rate