

Paper for the Annual Meeting of the Population Association of America, March 31 - April 2, 2016,
Washington, DC

Version 4 March 2016

Is Income Equality also Better for Your Cognitive Health? A Multilevel Analysis on Trajectories of Cognitive Function at Older Ages

Anja K Leist & Louis Chauvel, Institute for Research on Socio-Economic Inequality (IRSEI), University of Luxembourg

anja.leist@uni.lu; louis.chauvel@uni.lu

Abstract

This paper contributes to research on contextual associations with older-age cognitive function by investigating to which extent country-level income inequality is associated with older-age cognitive function and decline. Data came from the Survey of Health, Ageing and Retirement in Europe (SHARE), providing information on cognitive function (fluency, immediate and delayed recall) of respondents aged 50-80 years coming from a total of 16 European countries that participated in at least two waves of SHARE. A total of 44,303 observations were available at first and second measurement, 13,509 observations at third measurement, and 9,736 observations at fourth measurement. Three-level hierarchical models (measurements nested within individuals nested within countries) were run, showing that income inequality was negatively associated with cognitive level but not with decline. The findings suggest that income inequality is not associated with cognitive trajectories. Mechanisms of maintaining cognitive function at older ages may not be susceptible to country-level income inequalities.

Background

Cognitive function is one of the main drivers of living autonomously as long as possible in older age. There is evidence that cognitive function at older ages is at least in part a reflection of cognitively stimulating activities throughout the life course, such as education (Lee, Kawachi, Berkman et al. 2003), occupational complexity (Andel, Vigen, Mack et al. 2006; Finkel, Andel, Gatz et al. 2009; Kröger, Andel, Lindsay et al. 2008) and social and other stimulating activities (Glei, Landau, Goldman et al. 2005; Wilson, Barnes, Krueger et al. 2005). Recent evidence also suggests that macroeconomic conditions, in particular recessions during working ages, are associated with unfavorable changes in working conditions, such as lay-off or plant closure (Riumallo-Herl, Basu, Stuckler et al. 2014), which in turn may be linked

to lower cognitive function at older ages (Leist, Hessel, Avendano 2014). Aside from few papers targeting the links between economic recessions and later cognitive function at other life stages (Doblhammer, van den Berg, Fritze 2013), there is to the best of our knowledge no research on the links between income inequality and later cognitive function. However, there are plausible pathways on income inequality and cognitive trajectories. Income inequality could induce stress, which may in turn lead to cognitive impairments. There is much evidence that population health benefits from low levels of income inequality (Wilkinson and Pickett 2010), although this approach has been critically reflected (e.g. Avendano & Hessel 2015), and income-health gradients are not associated with level of income inequality (Chauvel and Leist 2015).

In this paper, we test the assumption that in more unequal countries, individuals may feel chronically stressed or deprived and in turn show steeper aging-related cognitive decline compared with less unequal countries. In order to design effective policy measures, it is necessary to investigate if country characteristics such as higher income inequality are related to less favorable trajectories of cognitive function.

We use hierarchical mixed modeling to assess trajectories of cognitive decline with four measurements of cognitive function nested within individuals (Level 2) nested within countries (Level 3). We assume level of income inequality to be related with *level* of cognitive function, do however not interpret this association as associations may also stem from past educational systems, policies, healthcare systems etc., and most importantly also from differences in languages in which cognitive tests were administered. We argue though that associations of income inequality with cognitive *decline* reflect valid differences in trajectories of cognitive function over time.

Data

Using the *Survey of Health, Ageing and Retirement in Europe* (SHARE), we consider four measurement occasions of cognitive function at four waves (2004/5, 2006/7, 2010/11, 2012/13), which have been described elsewhere in more detail (Börsch-Supan, Brugiavini, Jürges et al. 2005; Börsch-Supan and Jürges 2005; Malter & Börsch-Supan 2015).

Cognitive function was assessed with immediate and delayed word recall and verbal fluency (see Dewey and Prince 2005). A summary cognitive score of averaged z-scores was built if at least two tests were available. Summary scores of test occasions 2, 4, and 5 were built using first-test mean and standard deviation.

Income inequality was assessed by Gini, provided by the World Income Inequality Database (UNU-WIDER 2015). Economic development was indicated by gross domestic product (GDP, UNU-WIDER

2015). Most recent available values of income inequality and GDP per country, most of them of year 2006, were used, which corresponds roughly to wave of entry of most respondents.

Strategy of data analysis

Concerning number of higher level units required for multilevel modeling, Gelman (2007) argues that data analysis with few higher-level units is valid and benefits from hierarchical modeling (see also Hill and Gelman 2007). With release of wave five of SHARE, ten countries were available with four measurements of cognitive function and additional six countries with at least two measurements, sufficient to include countries as third level.

Descriptive statistics

After selecting respondents aged 50-80 years at first test and excluding respondents with missing values and less than two testing occasions, a total of 44,303 observations was available at first and second measurement, 13,509 observations at third measurement, and 9,736 observations at fourth measurement.

Mixed models

We run hierarchical mixed (random effects) models, and test if Gini and other variables influence aging-related cognitive decline by entering interaction terms with age (see Glymour, Tzourio, Dufouil 2012; Leist, Glymour, Mackenbach et al. 2013, for similar procedures). To summarize, we follow a successive model building strategy where we tested for each step improvement of model fit. Final models include individual-level controls, varying slopes on individual and country level, age in decades, and centered Gini, centered GDP, and interaction of Gini with age. Gini and GDP were not collinear. Living with partner and reporting good or better health was associated with lower aging-related decline (Results not shown). Main effect of Gini was significant. The non-significant interaction term of Gini and age showed that income inequality did not influence cognitive trajectories (Table 1). Post-estimating empirical Bayes predictors of education-cognition gradients (with the Stata command predict, reffects after xtmixed), we do not find a strong correlation of Gini with education-cognition gradients, meaning that the effects of Gini play out similarly on cognition across the distribution of education.

Table 1. Multilevel Models with Individual Controls, Fixed Effects of Gini, GDP, and Interaction Terms of Gini with Age

	Coeff.	CI	
Age in decades	-0.226***	-0.210	-0.242
Education (ref. \leq lower sec)			
Upper secondary	0.363***	0.349	0.376
Tertiary	0.644***	0.629	0.660
Female	0.167***	0.156	0.178
Living together	0.080***	0.067	0.093
Less than good health	-0.217***	-0.230	-0.217
GDP	0.000	0.000	0.000
Income inequality (Gini)	-0.040	-0.061	-0.020
Income inequality*age	0.03	-0.007	0.019
Constant	-0.191***	-0.279	-0.104
Country:			
var(age in decades)	0.001		
var(_cons)	0.029		
Individual:			
var(age in decades)	0.037		
var(_cons)	0.253		
cov(age in decades, _cons)	-0.041		
Residual	0.253		

Discussion

Explanation of findings

This is the first study to test if income inequality has detrimental effects on cognitive function and decline at older ages. Our findings suggest that in a sample of 16 countries over a period of almost 10 years, income inequality is not related with cognitive trajectories. Thus, mechanisms of maintaining cognitive function at older ages are not susceptible to country-level income inequalities. We discuss strengths and limitations.

The reason why income inequality was not associated with rates of cognitive change could be the same as in a multitude of other studies testing effects on cognitive aging with advanced methodological approaches. Many of those studies find that variables of interest, for example education, are not related

with cognitive change. This could be because cognitive peaks, which could be subject to external influences, are occurring at earlier ages (Glymour et al. 2012). Also, income inequality may only affect certain subpopulations, for example working-age poor, and not affect the general older population of SHARE. However, our analysis of the association of Gini with the education-cognition gradient (empirical Bayes predictors) showed an only marginal association. Further, there may be a lag between income inequality and its effects on population health or cognitive function. Zhen (2012) looked at the lag between income inequality and mortality, and concluded that only with a lag of five years, the effects of income inequality start to show. These effects peak at seven years, and diminish again after 12 years. So it may well be that with a longer time interval available we would find effects of income inequality on premature cognitive aging. Following this point, it would be desirable to exploit in a larger sample with more countries not only the covariations of income inequality and cognitive aging patterns, but to experiment with possible lags as well, and, lastly, to control for more country characteristics simultaneously.

Strengths and limitations

One strength is the use of a multi-country data set with four available waves, which made it possible to follow cognitive trajectories of a large sample of older individuals over almost 10 years.

At the moment we did not include information on childhood and working age conditions from the SHARELIFE wave of SHARE in 2008/9, where life histories were extensively documented. A possibility is that childhood conditions regarding health and socioeconomic background, as well as working-age conditions such as occupational class, years in labor market, etc. could also illuminate the research question under investigation. Unfortunately, life histories of the respondents do not include objective measures on childhood cognitive abilities as one would wish for this research question, rather only self-rated school performance in native language and mathematics. However, these measures can partly adjust for the stability of cognitive skills across the life span and determine the amount to which external influences such as economic conditions can contribute to later-life cognitive function.

One criticism regarding the study of income inequality is that there is a need to translate macroeconomic conditions to individual realities. Indeed, studies on the individual level show that poverty and economic deprivation are linked to direct impairments in cognitive functioning (Mani et al. 2013; Lynch et al. 1997), although to our knowledge, the effect of economic deprivation in terms of duration or intensity on rates of cognitive decline has not been systematically investigated yet. Income inequality on a macro-level can nonetheless be translated into individual life conditions, when societal inequality is reflected in media, visible as drastic differences in affluence, and direct comparisons with individuals of the same cohort or educational level. The countries in this sample though reflect a set with rather homogeneous

levels of – mostly – moderate inequality and rather similar levels of economic development. A more diverse set of countries with greater diversity in levels of income inequality and economic development would help to illuminate the impact of income inequality on cognitive function.

We tested the association of current income inequality on cognitive level and aging. Another interesting hypothesis would be that income inequality at earlier life stages influences later cognitive function, maybe via the potential to build up cognitive reserve at school ages or in the process of graduating. Further research should develop frameworks at which ages individuals may be particularly sensitive to economic conditions and target the question if earlier exposure to income inequality (assessed via historical levels of income inequality) can be used to explain cognitive function at later ages.

Investigating the reverse pathway, cognitive abilities (intelligence) seem to be closely related to economic development of countries (Rindermann 2008), indeed Rindermann provides a list of society attributes moderately to strongly, and probably reciprocally, related with adolescents' intelligence scores such as democracy, interpersonal trust, economic freedom, and gross domestic product (2008; p. 136). The link between cognitive skills and economic development of countries has also been closely investigated by Hanushek and Woessmann (2008; 2012), but little evidence has been found that cognitive scores explain higher U.S. wage inequality (Blau & Kahn 2005).

Lately, another critical appraisal of the income inequality hypothesis has been put forward by Avendano and Hessel (2015) who deconstruct approaches to investigate the links between municipal or country-level income inequality and mortality. The authors argue that it may not be so much income inequality at work, but rather the contextual level factors that are associated with (low) income inequality, for example the generous social policies in Scandinavian countries that are in turn associated with better health, i.e. higher life expectancy. Also, average educational attainment is different across countries, which is associated with cognitive abilities in younger adults, but most likely also with cognitive abilities of the general population (Rindermann 2008). Only the identification of the drivers of cognitive level and changes at later ages will allow the designing of policy measures to increase cognitive abilities of the population.

Conclusions

This is to our knowledge the first study to test income inequality on cognitive trajectories of older Europeans. While income inequality was not associated with rates of cognitive change, it was associated with cognitive level, in that in more equal countries, cognitive levels were higher on average. This association could however be due to other country characteristics as well. Further research should aim at disentangling the effects of income inequality and other macro-level conditions that could be linked with better cognitive function and rates of cognitive change over time.

Acknowledgments

This paper uses data from SHARE Wave 5 release 1.0.0, as of March 31st 2015 (DOI: 10.6103/SHARE.w5.100) or SHARE Wave 4 release 1.1.1, as of March 28th 2013 (DOI: 10.6103/SHARE.w4.111) or SHARE Waves 1 and 2 release 2.6.0, as of November 29th 2013 (DOI: 10.6103/SHARE.w1.260 and 10.6103/SHARE.w2.260) or SHARELIFE release 1.0.0, as of November 24th 2010 (DOI: 10.6103/SHARE.w3.100). The SHARE data collection has been primarily funded by the European Commission through the 5th Framework Programme (project QLK6-CT-2001-00360 in the thematic programme Quality of Life), through the 6th Framework Programme (projects SHARE-I3, RII-CT-2006-062193, COMPARE, CIT5- CT-2005-028857, and SHARELIFE, CIT4-CT-2006-028812) and through the 7th Framework Programme (SHARE-PREP, N° 211909, SHARE-LEAP, N° 227822 and SHARE M4, N° 261982). Additional funding from the U.S. National Institute on Aging (U01 AG09740-13S2, P01 AG005842, P01 AG08291, P30 AG12815, R21 AG025169, Y1-AG-4553-01, IAG BSR06-11 and OGHA 04-064) and the German Ministry of Education and Research as well as from various national sources is gratefully acknowledged (see www.share-project.org for a full list of funding institutions).

References

Andel R, Vigen C, Mack WJ, Clark LJ, Gatz M (2006) The effect of education and occupational complexity on rate of cognitive decline in Alzheimer's patients. *Journal of the International Neuropsychological Society* 12 (01):147-152 doi:10.1017/S1355617706060206

Avendano M, Hessel P (2015) The income inequality hypothesis rejected? *European Journal of Epidemiology* 30(8), 595-598

Blau Francine D, Kahn LM (2005) Do cognitive test scores explain higher US wage inequality? *Review of Economics and Statistics* 87.1: 184-193

Börsch-Supan A, Brugiavini A, Jürges H, et al. (2005) Health, ageing and retirement in Europe. Mannheim Research Institute for the Economics of Aging (MEA), Mannheim

Börsch-Supan A, Jürges H (2005) The Survey of Health, Aging, and Retirement in Europe – Methodology. Mannheim Research Institute for the Economics of Aging (MEA), Mannheim

Chauvel L, Leist AK (2015) Socioeconomic hierarchy and health gradient in Europe: the role of income inequality and of social origins. *International Journal for Equity in Health* 14 (1):132. doi:10.1186/s12939-015-0263-y

Dewey ME, Prince MJ (2005) Cognitive function. In: Börsch-Supan A, et al. (eds) *Health, Ageing and Retirement in Europe - First Results from the Survey of Health, Ageing and Retirement in Europe*. MEA, Mannheim, pp 108-117

Doblhammer G, van den Berg GJ, Fritze T (2013) Economic conditions at the time of birth and cognitive abilities late in life: Evidence from ten European countries. *PLoS ONE* 8 (9):e74915. doi:10.1371/journal.pone.0074915

Finkel D, Andel R, Gatz M, Pedersen NL (2009) The role of occupational complexity in trajectories of cognitive aging before and after retirement. *Psychology and Aging* 24 (3):563-573. doi:10.1037/a0015511

Gelman, A (2007) Statistical modeling, causal inference, and social science. Blog. Webpage accessed June 10 from http://andrewgelman.com/2007/08/16/no_you_dont_nee/

Gelman A, Hill J (2007) Data analysis using regression and multilevel/hierarchical models. Cambridge University Press

Glei DA, Landau DA, Goldman N, Chuang Y-L, Rodríguez G, Weinstein M (2005) Participating in social activities helps preserve cognitive function: an analysis of a longitudinal, population-based study of the elderly. *International Journal of Epidemiology* 34 (4):864-871. doi:10.1093/ije/dyi049

Glymour MM, Tzourio C, Dufouil C (2012) Is cognitive aging predicted by one's own or one's parents' educational level? Results from the Three-City Study. *American Journal of Epidemiology* 175 (8):750-759

Hanushek, EA, Woessmann, L (2008) The role of cognitive skills in economic development. *Journal of Economic Literature*: 607-668

Hanushek, EA, Woessmann, L (2012) Do better schools lead to more growth? Cognitive skills, economic outcomes, and causation. *Journal of Economic Growth* 17(4):267-321

Hill J, Gelman A (2007) Data analysis using regression and multilevel/hierarchical models. Cambridge University Press

Kröger E, Andel R, Lindsay J, Benounissa Z, Verreault R, Laurin D (2008) Is complexity of work associated with risk of dementia? *American Journal of Epidemiology* 167 (7):820-830. doi:10.1093/aje/kwm382

Lee S, Kawachi I, Berkman LF, Grodstein F (2003) Education, other socioeconomic indicators, and cognitive function. *American Journal of Epidemiology* 157 (8):712-720. doi:10.1093/aje/kwg042

Leist AK, Glymour MM, Mackenbach J, van Lenthe F, Avendano M (2013) Time away from work predicts later cognitive function: Differences by activity during leave. *Annals of Epidemiology* 23:455-462. doi:10.1016/j.annepidem.2013.05.014

Leist AK, Hessel P, Avendano M (2014) Do economic recessions during early and mid-adulthood influence cognitive function in older age? *Journal of Epidemiology and Community Health* 68:151-158. doi:10.1136/jech-2013-202843

Lynch, JW, Kaplan, GA, Shema, SJ (1997) Cumulative impact of sustained economic hardship on physical, cognitive, psychological, and social functioning. *New England Journal of Medicine*, 337(26): 1889-1895

Mani A, Mullainathan S, Shafir, E, Zhao J (2013) Poverty impedes cognitive function *Science* 341(6149): 976-980

Malter F, Börsch-Supan A (Eds.) (2015) SHARE Wave 5: Innovations & Methodology Munich: MEA, Max Planck Institute for Social Law and Social Policy

Riumallo-Herl C, Basu S, Stuckler D, Courtin E, Avendano M (2014) Job loss, wealth and depression during the Great Recession in the USA and Europe. *International Journal of Epidemiology*:dyu048

UN World Income Inequality Database (WIID3c) (2015) <https://www.wider.unu.edu/project/wiid-world-income-inequality-database>.

Wilkinson R, Pickett K (2010) The spirit level. Why equality is better for everyone. Penguin Books, London

Wilson RS, Barnes LL, Krueger KR, Hoganson G, Bienias JL, Bennett DA (2005) Early and late life cognitive activity and cognitive systems in old age. *Journal of the International Neuropsychological Society* 11 (4):400-407

Zheng H (2012) Do people die from income inequality of a decade ago? *Social Science & Medicine*, 75(1): 36-45