As You Sow, So Shall You Reap: Gender-role Attitudes and Late-life Cognition

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Abstract

This study analyzed the relationship between gender-role attitudes and gender differences in cognitive functioning in later life across countries. Previous studies found that traditional gender-role attitudes are associated with substantial reductions in educational outcomes and labor force participation of women. This lack of opportunity for women to engage in (potentially) cognitively stimulating activities over the life course is likely to translate in poorer cognitive performance of women in later life. This hypothesis was tested using representative samples from 27 countries covering more than 60 percent of the world population aged 50 and above. As expected, late-life gender differences in cognitive functioning systematically varied across countries. We found significant associations between gender differences in cognition and gender-role attitudes across countries. Indeed, older women were found to perform relatively better in countries characterized by more equal gender-role attitudes. By exploiting cross-country variations in changes in gender-role attitudes across cohorts, we confirmed that this association was robust against the inclusion of country and cohort-fixed effects. Further analyses suggested that this association is unlikely to be driven by reverse causality.

Keywords: Cognition, Aging, Gender-roles Attitudes.

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Introduction

Age-related cognitive decline is one of the major challenges for aging societies. Understanding causes of women's and men's cognitive functioning in later ages, thus, is pivotal (1). Cognitive impairment is associated with reductions in the quality of life, higher health-related expenditures, lower productivity, and reductions in societies' capacity to deal with technological and societal change (2). Older women are particularly challenged as they have higher age-specific dementia rates and higher longevity than men (3). In most countries in the world, the proportion of women is about two to one for those above 80 years (4).

Only few studies have approached the question of potential societal determinants of gender differences in cognition in later life, and those that do tend to focus on socioeconomic factors and economic development (5-8), while less attention has been paid to cultural determinants. Little is known, for instance, about the impact of gender-role attitudes on women's cognitive performance in later life. Gender roles prescribe which types of behaviors, activities, and attributes a given society considers appropriate for men and women, respectively (9). We propose that gender-role attitudes cumulatively impact women's cognitive functioning by influencing their exposure to cognitively stimulating tasks during the life course including education and economic activities.

This study is the first to investigate the effect of gender-role attitudes in shaping gender differences in cognitive functioning in later life across countries and cohorts. Earlier studies that examined the effect of gender-role attitudes on differences between women and men in cognitive performance focused on younger ages (10-12).

Old-age cognition

Age-related decline in one important component of cognitive functioning, that is, fluid abilities, has been well documented: a large amount of evidence suggests that aging is associated with a

decline in the speed of new information processing, executive control of thought processes and episodic memory[2] (13-16).

At the same time, there are great interindividual differences in the degree of decline and the decline has been demonstrated to show plasticity, that is, modifiability of age-related changes depending on the available resources (13, 17). Several types of resources have been identified to support brain plasticity (18). Education is one such resource. Higher levels of cognitive functioning and lower degrees of neuropathology have been found to result from longer education (19). Various attempts have been made to overcome selection problems that most likely confound this findings. For instance, extension of compulsory schooling has been used as a natural experiment to test its effect on cognitive performance both in early and later adulthood (20, 21). Further, longitudinal analyses found that human capital investments improved cognitive development (22, 23), and MZ twins discordant in their educational attainment differed in their later cognitive trajectory accordingly (24). Cognition has also been shown to be positively related to labor-market participation and the age at retirement (25, 26), occupation and job-task content (27-29), leisure activities (30, 31), and lifestyle – (for a review, see: (18, 32, 33)).

Gender-role attitudes

Gender-role attitudes are likely to affect the way men and women engage in those activities over the life course that have been demonstrated to buffer against cognitive decline. Several studies have indeed found that traditional gender-role attitudes are associated with substantial reductions in female human-capital investment and in female labor supply (34, 35). Conceptually, gender-role attitudes influence women's behavior through several mechanisms.

[2] Episodic memory refers to memory of information about specific past events that involved the self (i.e., events personally experienced) and occurred at a particular time and place (e.g., a previous holiday).

First, gender-role attitudes influence gender identity, a person's gender-related sense of self. Gender identity has been recognized as one driver of many individual decisions and outcomes through its influences on beliefs (i.e. priors) and values (i.e., preferences), which can include behaviors affecting cognitive performance over the life course (36). In an environment where the expectation is that a men should work in the labor force and a woman should be a housewife, female gender identity implies that women should not outperform men. This, in turn, will likely affect female relative to male behavior and performance in school and at work (37).

Second, and not unrelatedly gender-role attitudes influence the design of formal institutions such as the legal system or regulations in the labor market, which constrain or incentivize the choice set of individuals (38), which in turn most likely affect cognition in later life. Societies characterized by traditional gender-role attitudes tend not to promote and even hamper gender equality (e.g., legislation about maternity leave, anti-discrimination laws, and gender differences in mandatory retirement age). Thus, women may face barriers to access education or the labor market, independently of their own beliefs or preferences. Recently, Alesina and Guiliano (38) emphasized the reciprocal relationship between social norms and institutions. Social norms and culture can affect individual outcomes, which likely interacts with institutional settings such as educational opportunities (10), see also (39). For instance, women's relative disadvantage in spatial reasoning disappears in a matrilineal society (Khasi, Northeast India) compared to the case of the Kharbi (patrilineal society; 39).

Based on such evidence and considerations, we expected that women living in an environment characterized by traditional gender-role attitudes would have lower incentives to invest in human capital and to participate to the labor market across the life course, which will yield lower cognitive performance later in life.

Results

As expected, we found that across countries more egalitarian gender-role attitudes were associated with better female cognitive performance in later life (i.e., immediate and delayed word recall, and word fluency). We used data from surveys that included comparable cognitive test scores for nationally representative samples of individuals aged 50 and above. The sample of countries is characterized by large differences in gender-role attitudes. The included surveys are: the Health and Retirement Study (HRS), the Survey of Health, Ageing and Retirement in Europe (SHARE), the English Longitudinal Study on Ageing (ELSA), and the World Health Organization Study on Global AGEing and Adult Health (SAGE). More detailed description of the data can be found in the Supplementary Materials. The analytic sample included 226,661 observations of individuals born between 1920 and 1959 from 27 countries.

As expected and depicted in Figure 1, the relative female advantage in immediate word recall test score varied significantly across countries. Results for delayed word recall and word fluency are presented in the Supplementary Materials. These results are consistent with those presented for the immediate word recall test. Gender differences in cognitive performance vary widely across countries. In 19 out of the 27 nations, women on average demonstrated higher immediate word recall scores. The relative female advantage varied from -7.1% for Ghana to +10.5% in Sweden.

To investigate the role of gender-role attitudes in explaining those large variations among countries, we classified countries according to responses to a question on gender-role attitudes from the World Values Surveys (WVS) based on the percentage of the population born between 1920 and 1959 who agreed with the following statement: "*When jobs are scarce, men should have more right to a job than women.*" We hypothesized that in countries that had a majority of respondents agreeing with this statement, older women (as compared to older men) would also demonstrate

lower levels of cognitive functioning. Figure 2 supports this hypothesis. Cross-country variation in gender differences in cognitive functioning at older age was significantly associated with cross-country differences in gender-role attitudes. Older women were observed to perform relatively better in countries where fewer individuals thought that men have more rights for a job than women when jobs were scarce. Figure 2 also shows that the association is not driven by just some countries. Controlling for differences between world regions (Africa, America, Asia, and Europe) by including fixed effects for them does not eliminate the gender differences in cognition (see Table S3). Furthermore, including the log of the Gross Domestic Product per capita in 2010 as a proxy for the economic development of the 27 countries in the model (see Table S4) left the association between level of cognition and gender-role attitudes virtually unchanged, while economic development was left unrelated to gender differences in cognitive performance when gender-role attitudes were controlled. This suggests that gender differences in cognitive functioning are not associated with the level of economic development per se but rather more specifically with the changes in gender-role attitudes that may be associated with economic development.

Checking for robustness of results

A challenge to the causal interpretation of our results is that there may be unobserved heterogeneity among the countries under study that may be correlated with both gender-role attitudes and gender difference in cognitive performance leading to a spurious correlation. Thus, we ran a cross-country cross-cohort analysis investigating the direct association between differences in gender-related attitudes and differences in female cognitive performance. To do so, we defined three cohorts: those born between 1920 and 1939, between 1940 and 1949 and between 1950 and 1959 (see Table S1 and Table S2 for sample sizes by country and cohort). By including both country-fixed and cohort-fixed effects, we were able to capture cross-country unobserved heterogeneity and the general trend across cohorts.

Results provided further support for our hypothesis that gender-role attitudes affect gender differences in cognition at older age (see Table S5): Countries where younger cohorts showed less traditional gender-role attitudes were found to be associated with higher levels of cognitive functioning among older women than in countries where no such cohort differences in gender-role attitudes existed.

Checking for reverse causality: Protestanism

More traditional gender-role attitudes, however, may also arise in countries where women perform less well to start with. In order to check for this possibility of reverse causality, we applied an instrumental variable approach. We used country differences with regard to whether Protestants were the dominant religious group as an instrument for gender-role attitudes across countries. In particular, we measured the proportion of individuals being Protestant in a given country.

The choice of this instrument was motivated as follows: First, religion is ranked as a top determinant of self-identity (40). Moreover, the Catholic Church and Protestant churches have long shared the same norms for a traditional model of the family and a clear gender division at home and in society at large. However, during the twentieth century, Protestant churches appeared to have changed their position concerning the role of women to a greater extent than the Catholic Church. For instance, an increasing number of Protestant churches have been accepting women into the Clergy (41). Among major religious groups, Protestantism has in several studies been found to be the one that is least likely to emphasize traditional gender roles (42, 43). Furthermore, reverse causality (where Protestantism should result from gender differences in cognition) is less likely to be an issue than in the case of gender-role attitudes (which in theory could follow gender differences in cognition rather than to be their cause). It seemed reasonable to assume that differences in the prevalence of Protestantism among countries are unrelated to gender differences in cognition, except through its effect on gender-role attitudes. It is indeed unlikely that

Protestantism spread to some countries rather than others centuries ago because gender differences in cognition where more favorable to women back then (in particular as women did not have much of a say in this spreading).

Results confirmed the hypothesis that Protestant countries were more likely to have more egalitarian gender-role attitudes (see the first column of Table S7 and Figure S5). The association between non-egalitarian gender-role attitudes and Protestantism is negative and highly significant (the F-test of the excluded instrument confirmed that our instrument is highly relevant, see Table S7). Further, results confirmed that the relative female advantage in cognitive functioning was lower in countries with unequal gender-role attitudes (see Table S7; endogeneity tests did not reject the hypothesis that gender-role attitudes are exogenous).

As a check we estimated the same model by using European countries only. Results are consistent with those using all the countries considered in this study (See Table S7bis).

Cohort-varying instrument: Importance of religion

In order to further assess the robustness of our findings, we used yet another identification strategy that has been available in our cross-country cross-cohort design. We implemented an alternative instrument, that is, the importance of religion (or religious devoutness) that varies both across countries and across cohorts (cohort differences in the prevalence of Protestantism within country are too small to be used as a source of exogenous variation for gender-role attitudes). The importance of religion has also been found to be associated with traditional gender-role attitudes, fertility and labor-force behavior (35, 44).

We used the cohort-related changes in the importance of religion for individuals across countries as an instrument to further investigate the causal strength of gender-role attitudes predicting female cognitive performance in later life. The importance of religion was measured by the following question available in the WVS: "*How important is religion in your life*? Very

important/quite important/not important/not at all important." From this variable we derived the percentage of individuals reporting that religion was very important in their life by cohort and country.

First, we found that the importance of religion was a predictor of gender-role attitudes and the F-statistics testing the hypothesis that the coefficient of the importance of religion is equal to zero was high (well above 10), confirming that the relationship was strong enough to avoid the issue of weak instrument (see Table S9). Second, using the instrumental variable approach, the hypothesis that cohort-related changes in gender-role attitudes affected cohort-related changes in gender differences in cognition in later life was supported (see Table S9). These analyses provided further evidence that it was unlikely that the negative association between gender difference in cognition and non-egalitarian gender-role attitudes was driven by reverse causality.

Potential mediators: Education and work

Finally, we investigated to which degree education and labor-market participation during the life course were associated with the effect of gender-role attitudes on gender differences in cognition. To test for those mediators, we had to conduct the analyses at the individual level (Tables S3 and S5; more details about the method and the variables used in the analysis can be found in the Supplementary Materials). For both, the cross-country (see Table S10) and for the inter-cohort analysis across countries (see Table S11), we found that about 30% of the association between gender-role attitudes and gender differences in immediate word recall were explained by level of education and labor-market participation across the life course. Those results support our hypothesis that gender-related attitudes impact cognitive functioning by influencing women's likelihood of participating in cognitively stimulating activities during their life course.

Discussion and implications

The present study is the first to demonstrate how pervasive the productivity and health effects of gender inequality can be. Further, the study adds to the literature on the importance of cultural characteristics for determining life-course outcomes such as cognitive performance later in life. In the context of global population aging and increased relative longevity for women, this study demonstrated that promoting gender equality not only has beneficial effects on women's educational and labor-market outcomes but also on their brain health in later life.

In other words, the present results provided a new reason for why policies promoting gender equality are crucial in particular in times of population aging. Given the current trend toward more equal gender-role attitudes among younger cohorts in many countries, we may expect further improvements in the relative position of women in terms of cognitive functioning at older age in these nations and consequently lower levels of disability among older women in these countries.

Materials and methods

Data

For the empirical analysis, we used data from surveys that included comparable cognitive test scores for nationally representative sample of older individuals. We used data from SHARE. SHARE is a multidisciplinary and cross-national panel database of micro data on health, socio-economic status and social and family networks of more than 110,000 individuals aged 50 or over from 19 European countries (Sweden, Denmark, Estonia, Germany, Poland, Netherlands, Belgium, Luxembourg, France, Austria, Czech Republic, Switzerland, Italy, Greece, Spain, Portugal, Slovenia, Hungary, Ireland) and Israel. All data were collected by face-to-face, computer-aided personal interviews, supplemented by a self-completion paper and pencil questionnaire. Moreover, SHARE is harmonized with the U.S. Health and Retirement Study (HRS) and the English Longitudinal Study on Ageing (ELSA). Thus, it allowed us to include the United States and England in our analysis given they are comparable with SHARE. We were also able to employ the World Health Organization Study on global AGEing and adult health (SAGE) which includes measures of cognition coming from comparable cognitive tests available in SHARE, ELSA and HRS. SAGE is a survey based on a national representative sample of individuals aged 50+ in China, Ghana, India, Mexico, Russia, and South Africa.

The analytical sample was based on respondents aged between 50 and 93 and born between 1920 and 1959 with available cognitive test scores. There are observations with missing information for the cognitive test scores (around 5% of the full sample). In order to check whether it might induce a selection bias, we tested the association between gender-role attitudes and the gender differences in the proportion of missing and found no significant association suggesting that our analysis is unlikely to suffer from sample selection bias due to missing test scores.

For SHARE, we combined data from the first two waves (conducted in 2004/2005 and 2006/2007) and the fourth and fifth wave (conducted in 2010/2011 and 2013). Given the panel structure of the SHARE data, some individuals have been tested several times. We also carried out the analysis by restricting it to respondents who performed the cognitive test for the first time only. The results were largely consistent with those presented in this study (Table S13 and S14 present the main results with this sample selection, full results are available upon request). Regarding SAGE, we used the wave 1, which has been collected between 2007 and 2010. For HRS, we used the tenth wave which has been carried out in 2010. For ELSA, we used the fourth wave which was carried out in 2009. In total, the sample included 226,661 observations from 27 countries. Table S1 in the supplementary materials presents the total number of observations by country and cohorts. Israel was not included in the analysis because the measure of gender-role attitudes we used (described below) is not available for this country.

Measures

Cognitive performance

All surveys measured cognitive performance by employing short and simple tests of episodic memory (learning and recall) and executive functioning (verbal fluency) using the respective national language. In the *episodic memory task*, participants were asked to memorize ten words, and to list as many of these words as they could remember in one minute. The interviewer read a list of 10 words (e.g., book, child, hotel, etc.) to the respondent, and asked the respondent to recall as many words as possible from the list in any order (immediate recall). After a short interval, the delayed recall measurement followed. The procedure for SAGE was slightly different as respondents are given three trials for the immediate word recall. For our analysis, we used the score of the first trial to ensure comparability across surveys.

For the *fluency task*, respondents had to name as many different animals as possible in one minute. This test was not implemented in the HRS. This is the reasons why we decided to focus on immediate word recall for our main analysis as it was available and comparable across all surveys included in this study. Cognitive capacities, including the capacity to remember, have been shown to be predictive of functional levels among older adults, and are important for both social and professional outcomes (45-47). The average relative female advantage in immediate word recall by country is presented in Figure 1. The averages for delayed word recall and word fluency are presented in Figures S3a and S3b.

Gender-role attitudes

The measure of gender-role attitudes was obtained from the *World Values Surveys*, a data set specifically designed for cross-national comparison of values and norms. The questionnaires contain information on different types of attitudes and preferences, as well as information on standard demographic characteristics. In particular there are several questions that quantify individuals' attitudes about gender roles. While there exist many measures of gender inequality by country most of them are calculated taking into account the full population at a given historical point in time and do not allow differentiating between cohorts. Given that there may exist large differences in gender-role attitudes across cohorts within countries, we thus preferred to use data from an individual-level survey, such as the World Value Survey, that allowed us to compute gender-related attitudes separately for each cohort under study.

Several items of the World Value Survey are indexing values regarding the role of women in society. However, many of them were either not available for all the countries we included or were based on small subsamples that would cast doubts about the reliability of the measurement. Amongst the items available for all countries, there were some indicative of related concepts but not exactly indexing gender-role attitudes. For example, individuals were asked whether they

agreed with the following statements: “A pre-school child suffers with a working mother” and “Being a housewife is just as fulfilling as working outside the home”. Those statements include other normative values such as the way children should be raised or the trade-off between taking care of the home or working for pay and they do not explicitly describe a hierarchical dimension between men and women. Therefore, we decided to focus on the one item that was asked of the largest number of individuals in all the countries under study, and that explicitly evokes a hierarchical relationship between men and women: “*When jobs are scarce, men should have more right to a job than women*”. Respondents were then asked to choose between: ‘agree’, ‘neither’, and ‘disagree’. We computed a dummy variable that is equal to one when the individual agrees with the statement and zero otherwise. Based on 87,711 observations, we then calculated the proportion of individuals born between 1920 and 1959 agreeing with this statement by country and merged it with our analytical sample. Sampling weights are used so that our measure is representative of our target population. Table S2 in the supplemental materials presents the total number of observations by country and cohorts. For the cross-country cross-cohort analysis, we calculated this proportion specifically for country and cohort. Figure S1 presents the measure of gender-role attitudes by country. It is worth noting that men’s and women’s answers to this item were highly correlated within countries. Figure S2 shows the association between gender-role attitudes of men and women across countries. The correlation coefficient is equal to 0.94.

Statistical approaches

Description. We first conducted descriptive analyses at the country-level where we linked gender differences in cognitive test scores with the measure of gender-role attitudes. This empirical analysis follows the methodology that Guiso et al. used to study gender difference in mathematic achievements for younger age groups (48). The unconditional relationship between gender-role attitudes and gender differences in immediate word recall is presented in Figure 2, and Figure S4

displays this association for all three cognitive test scores. The associations were estimated by Ordinary Least Squares, and are presented in Table S3 and S4.

Inference statistics. In a second step, we identified the relationship between gender-role attitudes and gender differences in cognition across cohorts within countries. The advantage of this method is that we can control for unobserved cross-country (and cohort-invariant) heterogeneity and for unobserved cohort (and cross-country invariant) heterogeneity that may be associated with gender difference in cognition and gender-role attitudes. More specifically, the equation being estimated was the following:

$$\Delta C_{it} = \alpha_i + \lambda_t + \beta GR_{it} + \varepsilon_{it}, \quad (1)$$

where ΔC_{it} is the relative female advantage in cognitive test score of cohort *t* from country *i*, α_i is the country fixed effect, λ_t is the cohort fixed effect, GR_{it} is the measure of gender-role attitudes for the cohort *t* in country *i*, ε_{it} is an idiosyncratic error term, and β is our parameter of interest to be estimated. This parameter was identified thanks to the fact that countries have experienced different cohort-related variations in gender-role attitudes. We defined three cohorts: those born between 1950 and 1959, between 1940 and 1949 and between 1920 and 1939. We chose a longer range for the oldest cohort to have a sufficient number of observations to ensure the accuracy of our estimates. Also it seems a reasonable assumption that changes in gender-role attitudes happened more slowly for those cohorts. The number of observations by cohort is approximately equal (See Tables S1 and S2). Results are presented in Table S5.

Robustness. Given the cross-sectional nature of our empirical analysis, we cannot rule out the possibility that the observed differences in cognition are due to differences in age-related cognitive decline. However, note that several studies have found similar differences in age-related cognitive changes for older men and women in other contexts (49-51).

To rule out reverse causality, we employed the instrumental variable approach using both percentage of Protestantism and the degree of religiosity as an instrument which was based on the instrumental variables estimator. Degree of religiosity was introduced as a second instrumental variable because unlike Protestantism it displays a rather strong historical dynamic that allows testing for cohort differences. Results are presented in Table S7 for the instrumental variables estimator at the country level using Protestantism as an instrument and in Table S9 for the instrumental variables estimator at the country-cohort level using religious devoutness as an instrument. The data on religious affiliation was derived from the world religion database (52) and the data on the degree of religiosity were taken from the World Value Surveys.

The association between Protestantism and gender-role attitudes is depicted in Figure S5 and the relationship between Protestantism and gender differences in cognitive test scores is presented in Figure S6 (Table S6 presents the estimates). Results from the analysis estimating the association between cohort-related changes in religious devoutness and gender difference in cognition within countries is presented in Table S8.

Does education and labor-market participation during the life course mediate the association between gender-role attitudes and gender difference in cognitive functioning?

In order to shed lights on the mechanisms possibly underlying the association between gender-role attitudes and gender difference in cognitive functioning in later life, we performed similar analyses at the micro-level and were thus able to control for respondents' educational attainment and for labor-market participation during the life course. Educational attainment was measured with a categorical variable: No education, primary education, secondary education, and more than secondary education (See Table S12). We also added a dummy variable equal to one if education level was missing (1.7% of the full sample). Labor-market participation during the life course was

approximated by a dummy variable that was equal to one when the individual reported having never worked. We chose to use this proxy for labor-market participation during the life course because it is available for all the surveys used for the analysis. More detailed information about labor-market history is unfortunately not available for all surveys. We also added a dummy variable equal to one if this information was missing (0.53% of the full sample)

The first micro-level analysis was based on the cross-country variation in gender-role attitudes. For the analysis, we weighted the data so that each country has the same weight in the analysis. The results were thus not driven by the sample size differences across countries. In order to replicate the results from the cross-country analysis presented in Table 2, we estimated the following equation:

$$\begin{aligned} C_{ic} &= \delta_0 + \sum_{c=1}^{C-1} \delta_{1\_c} country_c + \delta_1\ woman_{ic} \\ &+ \delta_2\ asia_c \times woman_{ic} + \delta_3 africa_c \times woman_{ic} + \delta_4\ america_c \times woman_{ic} \\ &+ \delta_5\ woman_{ic} \times GRA_c + \eta_{ic} \end{aligned} \quad (2)$$

Where C_{ic} is the normalized cognitive test score (with mean zero and standard error of one at the country-level) of individual i living in country c, $country_c$ are the country dummies, $asia_c$, $africa_c$, and $america_c$ are the continent dummies (Europe being the reference category), $woman_{ic}$ is a dummy that is equal to one if the individual is a woman, GRA_c is the measure of gender-role attitudes for country c and η_{ic} is the idiosyncratic error term. We used clustered standard errors at the country-level to account for intra-correlation of the error terms within countries.

Results are presented in Table S10. The first line shows that we replicated the results from the cross-country analysis where we replaced the relative female advantage in cognitive test scores by the absolute female advantage in the normalized test scores by country. On the second line, results from the micro-analysis using equation (2) show that results from the cross-country analysis

were replicated. The third line presents the estimated effect of gender-role attitudes on gender difference in cognitive test score when controlling for a quadratic function of age; results were not sensitive to the inclusion of age in the model. The fourth line presents the results when controlling for education (which is found to be a strong predictor of cognitive functioning, as expected): 20 percent of the association between gender-role attitudes and gender difference in immediate and delayed word recall and 35 percent for word fluency were explained by gender differences in education. The fifth line displays results when controlling for a dummy variable equal to one when the individual reports that he/she has never worked, which turned out to be a predictor of cognitive functioning. It shows that education and having never worked account for about 30 percent of the association between gender-role attitudes and gender difference in immediate and delayed word recall and about 40 percent for word fluency. While the association becomes only significant at the 10 percent level for word fluency, it remained highly significant for immediate and delayed word recall.

We also performed the micro-level analysis when using the cross-country cross-cohort approach. The micro-level equation was specified as follows:

$$C_{ict} = \gamma_0 + \sum_{c=1}^{C-1} \gamma_{1\_c} country_c + \sum_{t=1}^{T-1} \gamma_{2\_t} cohort_t + \sum_{c=1}^{C-1}\sum_{t=1}^{T-1} \gamma_{3\_ct} country_c \times cohort_t$$
$$+ \sum_{c=1}^{C-1} \gamma_{4\_c} country_c \times woman_{ict} + \sum_{t=1}^{T-1} \gamma_{5\_t} cohort_t \times woman_{ict} \qquad (3)$$
$$+ \gamma_6 \ woman_{ict} + \gamma_7 \ woman_{ict} \times GRA_{ct} + \nu_{ict}$$

where $cohort_t$ are the cohort dummies and ν_{ict} is the idiosyncratic error term. The sample was weighted so that each country-cohort group has the same weight for the estimation. Table S11 presents the results. The first two lines show the results from the country-cohort analysis while the third line presents those of the micro-level analysis and confirm that the results are similar. Controlling for a quadratic age trend tempers the association between gender-role attitudes but it

remains highly significant. The effects of including education and the dummy for having never worked have similar impact on the association between gender-role attitudes and gender differences in the different cognitive test scores.

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References

1. Miralbell Blanch J (2012) Biomarkers of cognitive decline and dementia. in *TDX (Tesis Doctorals en Xarxa).*
2. Vecchio N, Fitzgerald JA, Radford K, & Fisher R (2015) The association between cognitive impairment and community service use patterns in older people living in Australia. *Health & social care in the community*.
3. Wimo A, *et al.* (2013) The worldwide economic impact of dementia 2010. *Alzheimer's & Dementia* 9(1):1-11. e13.
4. UNPD (2015) World Population Prospects 2014. *United Nations Population DIvision. New York.* .
5. Yount KM (2008) Gender, Resources Across the Life Course, and Cognitive Functioning in Egypt. *Demography* 45(4):907-926.
6. Lei X, Hu Y, McArdle JJ, Smith JP, & Zhao Y (2012) Gender differences in cognition among older adults in China. *Journal of Human Resources* 47(4):951-971.
7. Weber D, Skirbekk V, Freund I, & Herlitz A (2014) The changing face of cognitive gender differences in Europe. *Proceedings of the National Academy of Sciences* 111(32):11673-11678.
8. Maurer J (2011) Education and Male-Female Differences in Later-Life Cognition: International Evidence from Latin America and the Caribbean. *Demography* 48(3):915-930.
9. WHO (2015) What do we mean by "sex" and "gender"? in *Gender, women and health*.
10. Guiso L, Monte F, Sapienza P, & Zingales L (2008) Culture, gender, and math. *SCIENCE-NEW YORK THEN WASHINGTON*- 320(5880):1164.
11. Reilly D (2012) Gender, Culture, and Sex-Typed Cognitive Abilities. *PLoS ONE* 7(7).

12. Hyde JS & Mertz JE (2009) Gender, culture, and mathematics performance. *Proceedings of the National Academy of Sciences* 106(22):8801-8807.
13. Baltes PB, Lindenberger U, & Staudinger UM (2006) Lifespan theory in developmental psychology. *Handbook of Child Psychology*, eds Damon W & Lerner RM (Wiley, New York), Vol 1. Theoretical models of human development, pp 569-664.
14. Dixon RA, Bäckman L, & Nilsson L-G (2004) *New frontiers in cognitive aging* (Oxford: Oxford University Press).
15. Salthouse TA (2014) Aging cognition unconfounded by prior test experience. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*:gbu063.
16. Small SA (2001) Age-related memory decline: current concepts and future directions. *Archives of Neurology* 58(3):360-364.
17. Staudinger UM (2015) Images of Aging: Outside and Inside Perspectives. *Annual Review of Gerontology and Geriatrics* 35(1):187-209.
18. Hertzog C, Kramer AF, Wilson RS, & Lindenberger U (2008) Enrichment effects on adult cognitive development can the functional capacity of older adults be preserved and enhanced? *Psychological science in the public interest* 9(1):1-65.
19. Williams JW, Plassman BL, Burke J, Holsinger T, & Benjamin S (2010) Preventing Alzheimer's disease and cognitive decline. (Agency for Healthcare Research and Quality, Rockville, MD), pp 1-727.
20. Schneeweis N, Skirbekk V, & Winter-Ebmer R (2014) Does Education Improve Cognitive Performance Four Decades After School Completion? *Demography* 51(2):619-643.
21. Falch T & Sandgren Massih S (2011) The Effect of Education on Cognitive Ability. *Economic Inquiry* 49(3):838-856.

22. Deary IJ, Whiteman MC, Starr JM, Whalley LJ, & Fox HC (2004) The Impact of Childhood Intelligence on Later Life: Following Up the Scottish Mental Surveys of 1932 and 1947. *Journal of Personality and Social Psychology* 86(1):130-147.

23. Scazufca M, Almeida OP, & Menezes PR (2010) The role of literacy, occupation and income in dementia prevention: the São Paulo Ageing & Health Study (SPAH). *International Psychogeriatrics* 22(08):1209-1215.

24. Haworth C, Daleb P, & Plomin R (2008) A Twin Study into the Genetic and Environmental Influences on Academic Performance in Science in nine year old boys and girls. *International Journal of Science Education* 30(8):1003-1025.

25. Bonsang E, Adam S, & Perelman S (2012) Does retirement affect cognitive functioning? *Journal of Health Economics* 31(3):490-501.

26. Grotz C, *et al.* (2015) Retirement age and the age of onset of Alzheimer's disease: Results from the ICTUS study. *PloS one* 10(2):e0115056.

27. Schooler C, Mulatu MS, & Oates G (1999) The continuing effects of substantively complex work in the intellectual functioning of older workers. *Psychology and Aging* 14(3):483-506.

28. Altonji JG, Kahn LB, & Speer JD (2014) Trends in earnings differentials across college majors and the changing task composition of jobs. *The American Economic Review* 104(5):387-393.

29. Autor DH, Levy F, & Murnane RJ (2003) The Skill Content of Recent Technological Change: An Empirical Exploration. *The Quarterly Journal of Economics* 118(4):1279-1333.

30. Scarmeas N, Levy G, Tang M-X, Manly J, & Stern Y (2001) Influence of leisure activity on the incidence of Alzheimer's disease. *Neurology* 57(12):2236-2242.

31. Newson RS & Kemps EB (2005) General lifestyle activities as a predictor of current cognition and cognitive change in older adults: a cross-sectional and longitudinal examination. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences* 60(3):P113-P120.

32. Fillit HM, *et al.* (2002) Achieving and maintaining cognitive vitality with aging. *Mayo Clinic Proceedings*, (Elsevier), pp 681-696.

33. Fratiglioni L, Paillard-Borg S, & Winblad B (2004) An active and socially integrated lifestyle in late life might protect against dementia. *The Lancet Neurology* 3(6):343-353.

34. Vella F (1994) Gender roles and human capital investment: The relationship between traditional attitudes and female labour market performance. *Economica*:191-211.

35. Fortin NM (2005) Gender role attitudes and the labour-market outcomes of women across OECD countries. *oxford review of Economic Policy* 21(3):416-438.

36. Akerlof GA & Kranton RE (2000) Economics and identity. *Quarterly journal of Economics*:715-753.

37. Bertrand M (2011) New perspectives on gender. *Handbook of labor economics* 4:1543-1590.

38. Alesina AF & Giuliano P (2015) Culture and Institutions. *Journal of economic literature* 53(4):898-944.

39. Granato J, Inglehart R, & Leblang D (1996) The effect of cultural values on economic development: theory, hypotheses, and some empirical tests. *American journal of political science*:607-631.

40. Castells M (2003) The power of identity: The information Age: Economy, society and culture, Volume II (The information age).

41. Korpi W (2000) Faces of inequality: Gender, class, and patterns of inequalities in different types of welfare states. *Social Politics: international studies in gender, state & society* 7(2):127-191.

42. Hoffmann JP & Miller AS (1997) Social and political attitudes among religious groups: Convergence and divergence over time. *Journal for the Scientific Study of Religion*:52-70.

43. Kenworthy L & Malami M (1999) Gender inequality in political representation: A worldwide comparative analysis. *Social Forces* 78(1):235-268.

44. Guetto R, Luijkx R, & Scherer S (2015) Religiosity, gender attitudes and women's labour market participation and fertility decisions in Europe. *Acta Sociologica* 58(2):155-172.

45. Skirbekk V, Loichinger E, & Weber D (2012) Variation in cognitive functioning as a refined approach to comparing aging across countries. *Proceedings of the National Academy of Sciences* 109(3):770-774.

46. Schmidt FL & Hunter J (2004) General mental ability in the world of work: occupational attainment and job performance. *Journal of Personality and Social Psychology* 86:162-173.

47. Cavallini E, Bottiroli S, Fastame MC, & Hertzog C (2013) Age and subcultural differences on personal and general beliefs about memory. *Journal of Aging Studies* 27(1):71-81.

48. Guiso L, Sapienza P, & Zingales L (2003) People's opium? Religion and economic attitudes. *Journal of monetary economics* 50(1):225-282.

49. de Frias CM, Nilsson L-G, & Herlitz A (2006) Sex Differences in Cognition are Stable Over a 10-Year Period in Adulthood and Old Age. *Aging, Neuropsychology, and Cognition* 13(3-4):574-587.

50. Gerstorf D, Ram N, Hoppmann C, Willis SL, & Schaie KW (2011) Cohort Differences in Cognitive Aging and Terminal Decline in the Seattle Longitudinal Study. *Developmental Psychology* 47(4):1026-1041.

51. Ferreira L, Ferreira Santos-Galduróz R, Ferri CP, & Fernandes Galduróz JC (2014) Rate of cognitive decline in relation to sex after 60 years-of-age: A systematic review. *Geriatrics & gerontology international* 14(1):23-31.

52. Johnson TM & Grim BJ (2010) World Religion Database.

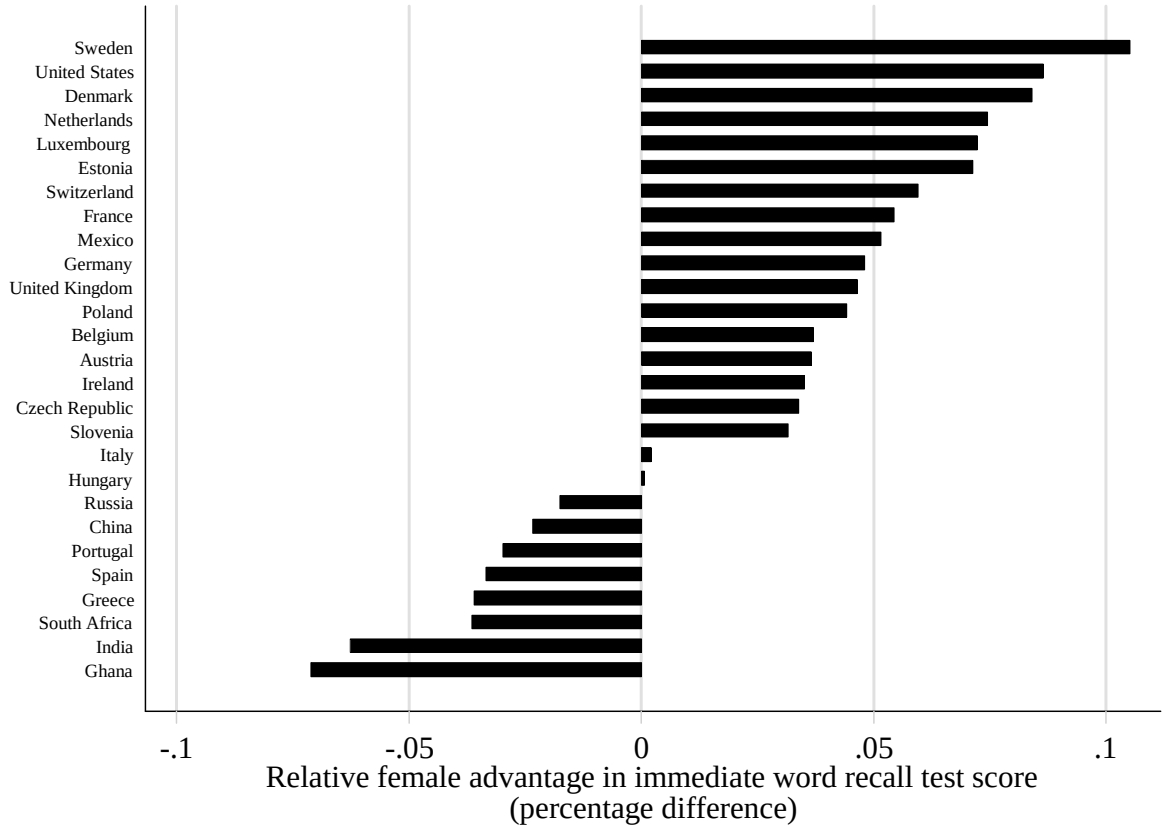

Figure 1. Relative female advantage in immediate word recall test score of individuals born between 1920 and 1959 by country. Data source: SHARE, HRS, ELSA, SAGE. The relative female advantage in cognitive test score (ΔC) is equal to $(C_f - C_m)/ C_m$, with C_f and C_m are the average cognitive test score of women and men, respectively.

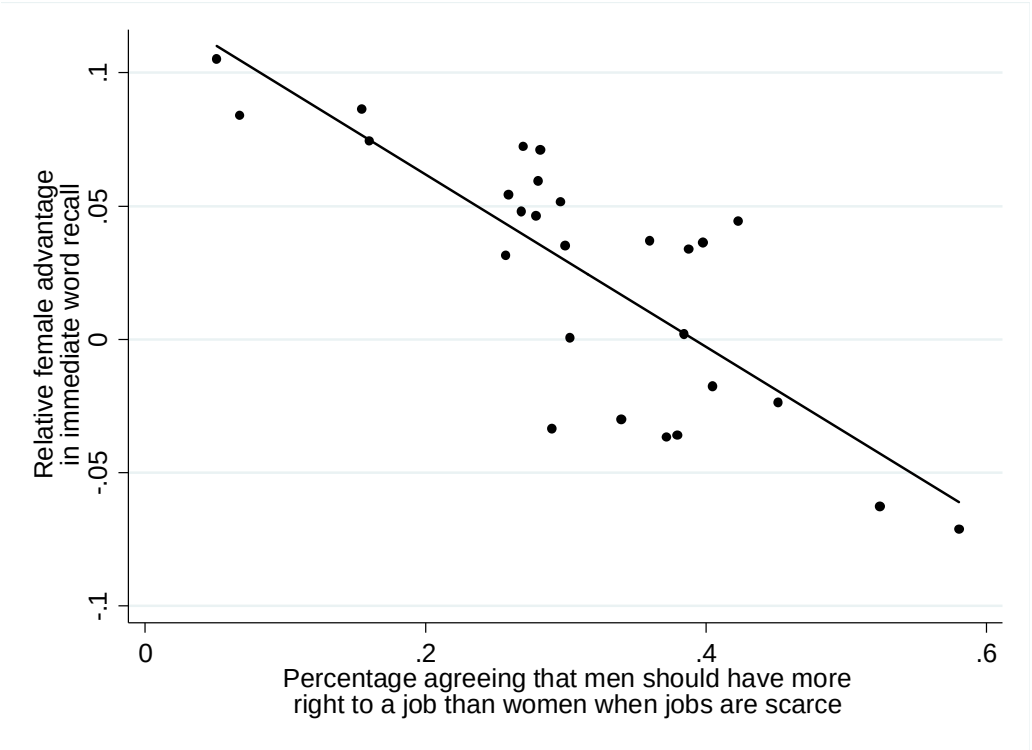

Figure 2. Negative cross-country association between relative female advantage in immediate word recall and the percentage of individuals born between 1920 and 1959 agreeing with a statement that men should have more right to a job when jobs are scarce. Data source: SHARE, HRS, ELSA, SAGE for immediate word recall and WVS for the percentage of individuals born between 1920 and 1959 agreeing with a statement that men should have more right to a job when jobs are scarce. The relative female advantage in cognitive test score (ΔC) is equal to $(C_f - C_m)/ C_m$, with C_f and C_m are the average cognitive test score of women and men, respectively.

Supplementary materials

Table S1. Sample size by country and cohort (SHARE, HRS, ELSA, SAGE).

	1920-1939	1940-1949	1950-1959	Total
Austria	3,552	4,146	3,231	10,929
Belgium	5,480	5,146	5,448	16,074
China	3,507	3,786	5,108	12,401
Czech Republic	3,581	5,220	4,498	13,299
Denmark	2,785	3,367	3,283	9,435
Estonia	3,878	3,687	3,605	11,170
France	5,183	4,611	4,775	14,569
Germany	3,949	4,035	3,403	11,387
Ghana	1,458	1,250	1,473	4,181
Greece	2,146	1,824	1,435	5,405
Hungary	703	965	1,164	2,832
India	1,625	2,326	2,495	6,446
Ireland	366	390	303	1,059
Italy	4,453	4,886	3,209	12,548
Luxembourg	286	424	671	1,381
Mexico	860	877	411	2,148
Netherlands	3,505	4,473	3,472	11,450
Poland	1,299	1,375	1,324	3,998
Portugal	477	708	687	1,872
Russia	1,335	974	1,221	3,530
Slovenia	1,502	1,628	2,036	5,166
South Africa	1,015	1,280	1,300	3,595
Spain	4,968	4,060	3,716	12,744
Sweden	4,225	4,668	2,495	11,388
Switzerland	2,626	2,911	2,843	8,380
United Kingdom	3,586	3,660	2,870	10,116
United States	6,759	5,078	7,321	19,158
Total	75,109	77,755	73,797	226,661

Table S2. Sample size for value-based questions from the World Values Survey.

	1920-1939	1940-1949	1950-1959	Total
Austria	977	777	751	2,505
Belgium	1,466	990	1,072	3,528
China	514	1,042	1,546	3,102
Czech Republic	1,961	1,430	1,540	4,931
Denmark	615	636	690	1,941
Estonia	1,187	955	1,114	3,256
France	1,078	709	950	2,737
Germany	2,822	2,072	2,489	7,383
Ghana	52	136	212	400
Greece	362	321	449	1,132
Hungary	913	749	978	2,640
India	768	962	1,950	3,680
Ireland	584	464	540	1,588
Italy	1,388	985	1,111	3,484
Luxembourg	306	305	423	1,034
Mexico	702	921	1,347	2,970
Netherlands	1,120	1,235	1,254	3,609
Poland	1,246	915	1,399	3560
Portugal	990	560	558	2,108
Russia	2,047	1,281	2,134	5,462
Slovenia	1,240	965	1,300	3,505
South Africa	1,053	1,055	1,885	3,993
Spain	2,512	1,622	1,840	5,974
Sweden	1,143	1,212	1,170	3,525
Switzerland	671	655	678	2,004
United Kingdom	1,309	903	952	3,164
United States	1,490	1,245	1,761	4,496
Total	30,516	25,102	32,093	87,711

Table S3. Regression results of female advantage in cognition and gender-role attitudes (negative views on women).

	Relative female advantage in:		
	Immediate recall	Delayed recall	Fluency
Gender-role attitudes	-0.242***	-0.373***	-0.160**
	(0.060)	(0.090)	(0.067)
America	0.017	0.029	-0.023
	(0.022)	(0.032)	(0.032)
Asia	-0.029	-0.043	-0.010
	(0.021)	(0.031)	(0.023)
Africa	-0.045*	-0.085**	-0.039
	(0.024)	(0.036)	(0.026)
Intercept	0.106***	0.184***	0.024
	(0.018)	(0.027)	(0.020)
R^2	0.706	0.731	0.455
Number of countries	27	27	26

Note. Inegalitarian gender-role attitudes are associated with lower relative female advantage in cognitive test scores. Standard errors are in parentheses. *, **, *** mean that the coefficient estimate is significantly different from zero at the 10%, 5%, 1% levels, respectively. The dependent variables are the relative female advantage in cognitive test score (ΔC) and is equal to $(C_f - C_m)/C_m$, with C_f and C_m are the average cognitive test score of women and men by country, respectively. Gender-role attitudes is measured as the percentage of individuals agreeing with the statement: "When jobs are scarce, men should have more right to a job than women". Word fluency test scores are not available for US.

Table S4. Regression results of female advantage in cognition and gender-role attitudes (negative views on women).

	Relative female advantage in:		
	Immediate recall	Delayed recall	Fluency
Gender-role attitudes	-0.215***	-0.303***	-0.133*
	(0.067)	(0.096)	(0.073)
Log(GDP per capita)	0.008	0.019	0.008
	(0.008)	(0.011)	(0.009)
America	0.022	0.042	-0.013
	(0.022)	(0.032)	(0.034)
Asia	-0.019	-0.016	0.003
	(0.023)	(0.034)	(0.026)
Africa	-0.033	-0.054	-0.025
	(0.027)	(0.039)	(0.030)
Intercept	0.021	-0.035	-0.070
	(0.093)	(0.133)	(0.103)
R^2	0.718	0.763	0.477
Number of countries	27	27	26

Note. Inegalitarian gender-role attitudes are associated with lower relative female advantage in cognitive test scores when controlling for the economic development of the countries. Standard errors are in parentheses. *, **, *** mean that the coefficient estimate is significantly different from zero at the 10%, 5%, 1% levels, respectively. The dependent variables are the relative female advantage in cognitive test score (ΔC) and is equal to $(C_f - C_m)/ C_m$, with C_f and C_m are the average cognitive test score of women and men by country, respectively. Gender-role attitudes is measured as the percentage of individuals agreeing with the statement: “When jobs are scarce, men should have more right to a job than women”. GDP per capita measured in 2010 was obtained from the World Bank: http://data.worldbank.org/indicator/NY.GDP.PCAP.CD . Word fluency test scores are not available for US.

Table S5. Regression results of female advantage in cognition and gender-role attitudes (negative views on women) using country/cohort fixed effects.

	Relative female advantage in:		
	Immediate recall	Delayed recall	Fluency
Gender-role attitudes	-0.181**	-0.429***	-0.177***
	(0.073)	(0.117)	(0.064)
Country fixed effects	Yes	Yes	Yes
Cohort fixed effects	Yes	Yes	Yes
Within-R^2	0.565	0.616	0.774
Number of observations	81	81	78

Note. Countries where gender-role attitudes became more egalitarian (resp. inegalitarian) across cohorts are also those where the relative female advantage increased (resp. decreased) across cohorts. Standard errors are in parentheses. *, **, *** mean that the coefficient estimate is significantly different from zero at the 10%, 5%, 1% levels, respectively. The dependent variables are the relative female advantage in cognitive test score (ΔC) and is equal to $(C_f - C_m)/ C_m$, with C_f and C_m are the average cognitive test score of women and men by country and cohort, respectively. Gender-role attitudes is measured as the percentage of individuals agreeing with the statement: "When jobs are scarce, men should have more right to a job than women". Word fluency test scores are not available for US.

Table S6. Reduced form estimates: Regression results of female advantage in cognition and Protestantism.

	Relative female advantage in:		
	Immediate recall	Delayed recall	Fluency
% Protestants	0.089***	0.132***	0.063**
	(0.023)	(0.035)	(0.025)
America	0.024	0.040	-0.015
	(0.022)	(0.033)	(0.032)
Asia	-0.052***	-0.079**	-0.024
	(0.019)	(0.028)	(0.020)
Africa	-0.126***	-0.207***	-0.094***
	(0.023)	(0.036)	(0.025)
Intercept	0.015*	0.044***	-0.038***
	(0.009)	(0.013)	(0.009)
R^2	0.700	0.712	0.467
Number of countries	27	27	26

Note. Women have a higher relative advantage in cognitive test scores in Protestant countries. Standard errors are in parentheses. *, **, *** mean that the coefficient estimate is significantly different from zero at the 10%, 5%, 1% levels, respectively. The dependent variables are the relative female advantage in cognitive test score (ΔC) and is equal to $(C_f - C_m)/ C_m$, with C_f and C_m are the average cognitive test score of women and men by country, respectively. Word fluency test scores are not available for US.

Table S7. Instrumental Variables estimator. Results of female advantage in cognition and gender-role attitudes (negative views on women) using Protestantism as an instrument.

		Relative female advantage in:		
	Gender-role attitudes	Immediate word recall	Delayed word recall	Fluency
	First stage	IV	IV	IV
Gender-role attitudes		-0.306***	-0.455***	-0.216**
		(0.079)	(0.117)	(0.088)
% Protestants	-0.291***			
	(0.050)			
America	-0.035	0.013	0.024	-0.022
	(0.048)	(0.022)	(0.033)	(0.033)
Asia	0.111**	-0.018	-0.029	0.000
	(0.041)	(0.023)	(0.034)	(0.025)
Africa	0.304***	-0.033	-0.069*	-0.028
	(0.051)	(0.026)	(0.039)	(0.029)
Intercept	0.359***	0.125***	0.208***	0.040
	(0.019)	(0.024)	(0.035)	(0.026)
F-tests of the excluded instrument	34.2			
Wu-Hausman Endogeneity test (p-value)		0.188	0.261	0.319
Number of countries	27	27	27	26

Note. By using Protestantism as an instrument for gender-role attitudes, the results from the IV estimator suggest that gender-role attitudes are not endogenous. Standard errors are in parentheses. Small-sample statistics adjusting for degrees-of-freedom are used. *, **, *** mean that the coefficient estimate is significantly different from zero at the 10%, 5%, 1% levels, respectively. The dependent variables are the relative female advantage in cognitive test score (ΔC) and is equal to $(C_f - C_m)/ C_m$, with C_f and C_m are the average cognitive test score of women and men by country, respectively. Gender-role attitudes is measured as the percentage of individuals agreeing with the statement: “When jobs are scarce, men should have more right to a job than women”. Word fluency test scores are not available for US. The F-test of the excluded instrument for the word fluency test score is equal to 30.31.

Table S7bis. Instrumental Variables estimator. Results of female advantage in cognition and gender-role attitudes (negative views on women) using Protestantism as an instrument. **Europe only.**

		Relative female advantage in:		
	Gender-role attitudes	Immediate word recall	Delayed word recall	Fluency
	First stage	IV	IV	IV
Gender-role attitudes		-0.319***	-0.488***	-0.224**
		(0.094)	(0.140)	(0.087)
% Protestants	-0.280***			
	(0.052)			
Intercept	0.357***	0.128***	0.217***	0.042
	(0.019)	(0.028)	(0.042)	(0.026)
F-tests of the excluded instrument	29.48			
Wu-Hausman Endogeneity test (p-value)		0.198	0.186	0.086
Number of countries	20	20	20	20

Note. By using Protestantism as an instrument for gender-role attitudes, the results from the IV estimator suggest that gender-role attitudes are not endogenous. Standard errors are in parentheses. Small-sample statistics adjusting for degrees-of-freedom are used. *, **, *** mean that the coefficient estimate is significantly different from zero at the 10%, 5%, 1% levels, respectively. The dependent variables are the relative female advantage in cognitive test score (ΔC) and is equal to $(C_f - C_m)/ C_m$, with C_f and C_m are the average cognitive test score of women and men by country, respectively. Gender-role attitudes is measured as the percentage of individuals agreeing with the statement: “When jobs are scarce, men should have more right to a job than women”.

Table S8. Reduced form estimates: Regression results of female advantage in cognition and religiosity using country/cohort fixed effects.

	Relative female advantage in:		
	Immediate recall	Delayed recall	Fluency
% religion very important	-0.191***	-0.376***	-0.132**
	(0.061)	(0.101)	(0.056)
Country fixed effects	Yes	Yes	Yes
Cohort fixed effects	Yes	Yes	Yes
Within-R^2	0.590	0.619	0.766
Number of observations	81	81	78

Note. Countries where individuals became less (resp. more) devoted to religion across cohorts are also those where the relative female advantage increased (resp. decreased) across cohorts. Standard errors are in parentheses. *, **, *** mean that the coefficient estimate is significantly different from zero at the 10%, 5%, 1% levels, respectively. The dependent variables are the relative female advantage in cognitive test score (ΔC) and is equal to $(C_f - C_m)/ C_m$, with C_f and C_m are the average cognitive test score of women and men by country and cohort, respectively. Word fluency test scores are not available for US.

Table S9. Instrumental Variables Estimator. Results of female advantage in cognition and gender-role attitudes (negative views on women) using country/cohort fixed effects and using differential secularization process across cohort as an instrument.

		Relative female advantage in:		
	Gender-role attitudes	Immediate recall	Delayed recall	Fluency
	First stage	IV	IV	IV
Gender-role attitudes		-0.388***	-0.712***	-0.277**
		(0.128)	(0.202)	(0.107)
% religion very important	0.517***			
	(0.094)			
Country fixed effects	Yes	Yes	Yes	Yes
Cohort fixed effects	Yes	Yes	Yes	Yes
F-test of excluded instrument	30.46			
Endogeneity test (p-value)		0.026	0.060	0.226
Number of observations	81	81	81	78

Note. By using religious devoutness as an instrument for gender-role attitudes across cohorts and countries, the results from the IV estimator suggest that gender-role attitudes are not endogenous. Standard errors are in parentheses. Small-sample statistics adjusting for degrees-of-freedom are used. *, **, *** mean that the coefficient estimate is significantly different from zero at the 10%, 5%, 1% levels, respectively. The dependent variables are the relative female advantage in cognitive test score (ΔC) and is equal to $(C_f - C_m)/ C_m$, with C_f and C_m are the average cognitive test score of women and men by country and cohort, respectively. Gender-role attitudes is measured as the percentage of individuals agreeing with the statement: “When jobs are scarce, men should have more right to a job than women”. Word fluency test scores are not available for US. The F-test of the excluded instrument for the word fluency is equal to 29.69.

Table S10. Individual-level estimation of the effect of gender-role attitudes (at the country-level) on gender difference in cognitive test scores.

	Immediate recall	Delayed recall	Fluency
Country-level data			
Gender-role attitudes	-0.783***	-0.792***	-0.483**
	(0.168)	(0.158)	(0.192)
Individual-level data			
Gender-role attitudes x woman	-0.785***	-0.793***	-0.481***
	(0.119)	(0.099)	(0.124)
Individual-level data (controlling for age and age squared)			
Gender-role attitudes x woman	-0.781***	-0.790***	-0.475***
	(0.118)	(0.099)	(0.139)
Individual-level data (controlling for age and age squared, and education)			
Gender-role attitudes x woman	-0.635***	-0.645***	-0.316**
	(0.127)	(0.114)	(0.145)
Individual-level data (controlling for age and age squared, education, and for having never worked)			
Gender-role attitudes x woman	-0.549***	-0.561***	-0.211*
	(0.107)	(0.102)	(0.123)

Note. The individual-level analysis replicates the cross-country association found at the country level (comparison of the first two lines). The inclusion of age barely affects the association between gender-role attitudes and the gender difference in cognitive test scores (third line). The inclusions of education and labor force participation during the life course partly explain the association between gender-role attitudes and the gender difference in cognitive test scores across countries. Clustered (at the country-level) standard errors are in parentheses. *, **, *** mean that the coefficient estimate is significantly different from zero at the 10%, 5%, 1% levels, respectively. The dependent variables are the normalized test score (at the country level), except for the first line where it is the difference in the average normalized test score between women and men by country. Gender-role attitudes is measured as the percentage of individuals agreeing with the statement:

“When jobs are scarce, men should have more right to a job than women”. Word fluency test scores are not available for US. Equation (2) is used to estimate the model.

Table S11. Individual-level estimation of the effect of gender-role attitudes (at the country-cohort level) on gender difference in cognitive test scores.

	Immediate recall	Delayed recall	Fluency
Country-cohort level data			
Gender-role attitudes	-0.484**	-0.669***	-0.437**
	(0.186)	(0.195)	(0.192)
Individual-level data			
Gender-role attitudes x woman	-0.485***	-0.665***	-0.438***
	(0.158)	(0.155)	(0.120)
Individual-level data (controlling for age and age squared)			
Gender-role attitudes x woman	-0.394**	-0.581***	-0.357***
	(0.151)	(0.146)	(0.115)
Individual-level data (controlling for age and age squared, and education)			
Gender-role attitudes x woman	-0.350***	-0.546***	-0.317***
	(0.117)	(0.131)	(0.117)
Individual-level data (controlling for age and age squared, education, and for having never worked)			
Gender-role attitudes x woman	-0.282***	-0.479***	-0.210*
	(0.106)	(0.129)	(0.113)

Note. The individual-level analysis replicates the cross-country/cohort association found at the country/cohort level (comparison of the first two lines). The inclusion of age slightly affects the association between gender-role attitudes and the gender difference in cognitive test scores (third line). The inclusions of education and labor force participation during the life course partly explain the association between gender-role attitudes and the gender difference in cognitive test scores across cohorts within countries. Clustered (at the country-cohort-level) standard errors are in parentheses. *, **, *** mean that the coefficient estimate is significantly different from zero at the 10%, 5%, 1% levels, respectively. The dependent variables are the normalized test score (at the country level), except for the first line where it is the difference in the average normalized test score between women and men by country and cohort. Gender-role attitudes is measured as the

percentage of individuals agreeing with the statement: “When jobs are scarce, men should have more right to a job than women”. Word fluency test scores are not available for US. Equation (3) is used to estimate the model.

Table S12. Classification of educational level by survey.

ELSA		**HRS**		**SAGE**		**SHARE**	
Category of education	Recoded measure of eduction	Category of education	Recoded measure of eduction	Category of education	Recoded measure of eduction	Category of education	Recoded measure of eduction
refusal	.	0. no degree	0	no formal education	0	Refusal	.
don't know	.	1. ged	1	less than primary school	1	Don't know	.
not asked	.	2. hs	2	primary school completed	1	None	0
nvq4/nvq5/degree or equiv	3	3. hs/ged	2	secondary school completed	2	ISCED-97 code 1	1
higher ed below degree	2	4. aa/ lt ba	2	school (or equivalent) completed	2	ISCED-97 code 2	1
nvq3/gce a level equiv	2	5. ba	3	college/university completed	3	ISCED-97 code 3	2
nvq2/gce o level equiv	2	6. ma/mba	3	post-graduate degree completed	3	ISCED-97 code 4	2
nvq1/cse other grade equiv	1	7. law/md/phd	3	don't know	.	ISCED-97 code 5	3
foreign/other	.	8.other	3			ISCED-97 code 6	3
no qualification	0					Other	.

Table S13. Regression results of female advantage in cognition and gender-role attitudes (negative views on women). Sample restricted to individuals who participated to the cognitive test score for the first time in SHARE.

	Relative female advantage in:		
	Immediate recall	Delayed recall	Fluency
Gender-role attitudes	-0.251***	-0.397***	-0.166**
	(0.061)	(0.088)	(0.066)
America	0.018	0.030	-0.020
	(0.022)	(0.032)	(0.032)
Asia	-0.026	-0.037	-0.006
	(0.021)	(0.030)	(0.022)
Africa	-0.042	-0.079**	-0.036
	(0.025)	(0.036)	(0.026)
Intercept	0.107***	0.189***	0.023
	(0.019)	(0.027)	(0.020)
R^2	0.697	0.741	0.454
Number of countries	27	27	26

Note. Inegalitarian gender-role attitudes are associated with lower relative female advantage in cognitive test scores. Standard errors are in parentheses. *, **, *** mean that the coefficient estimate is significantly different from zero at the 10%, 5%, 1% levels, respectively. The dependent variables are the relative female advantage in cognitive test score (ΔC) and is equal to $(C_f - C_m)/C_m$, with C_f and C_m are the average cognitive test score of women and men by country, respectively. Gender-role attitudes is measured as the percentage of individuals agreeing with the statement: "When jobs are scarce, men should have more right to a job than women". Word fluency test scores are not available for US.

Table S14. Regression results of female advantage in cognition and gender-role attitudes (negative views on women) using country/cohort fixed effects. Sample restricted to individuals who participated to the cognitive test score for the first time in SHARE.

	Relative female advantage in:		
	Immediate recall	Delayed recall	Fluency
Gender-role attitudes	-0.188**	-0.391***	-0.173**
	(0.075)	(0.120)	(0.073)
Country fixed effects	Yes	Yes	Yes
Cohort fixed effects	Yes	Yes	Yes
Within-R^2	0.543	0.575	0.714
Number of observations	81	81	78

Note. Countries where gender-role attitudes became more egalitarian (resp. inegalitarian) across cohorts are also those where the relative female advantage increased (resp. decreased) across cohorts. Standard errors are in parentheses. *, **, *** mean that the coefficient estimate is significantly different from zero at the 10%, 5%, 1% levels, respectively. The dependent variables are the relative female advantage in cognitive test score (ΔC) and is equal to $(C_f - C_m)/ C_m$, with C_f and C_m are the average cognitive test score of women and men by country and cohort, respectively. Gender-role attitudes is measured as the percentage of individuals agreeing with the statement: "When jobs are scarce, men should have more right to a job than women". Word fluency test scores are not available for US.

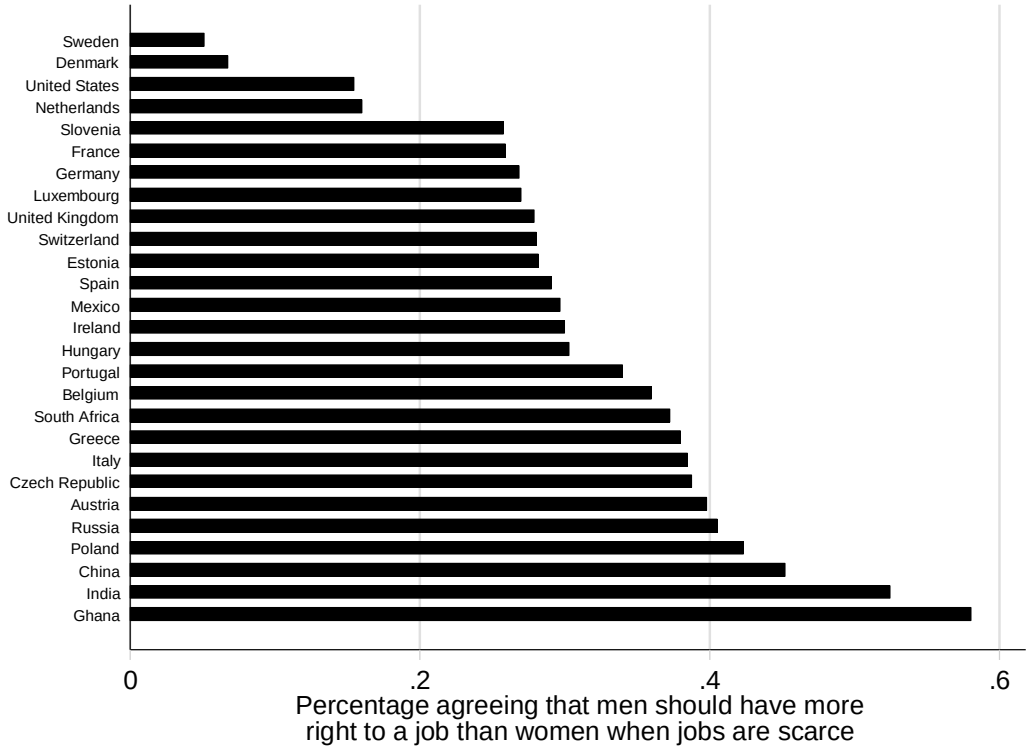

Figure S1. Percentage of individuals born between 1920 and 1959 who agree with the following statement: When jobs are scarce, men should have more right to a job than *women*. Data source: WVS.

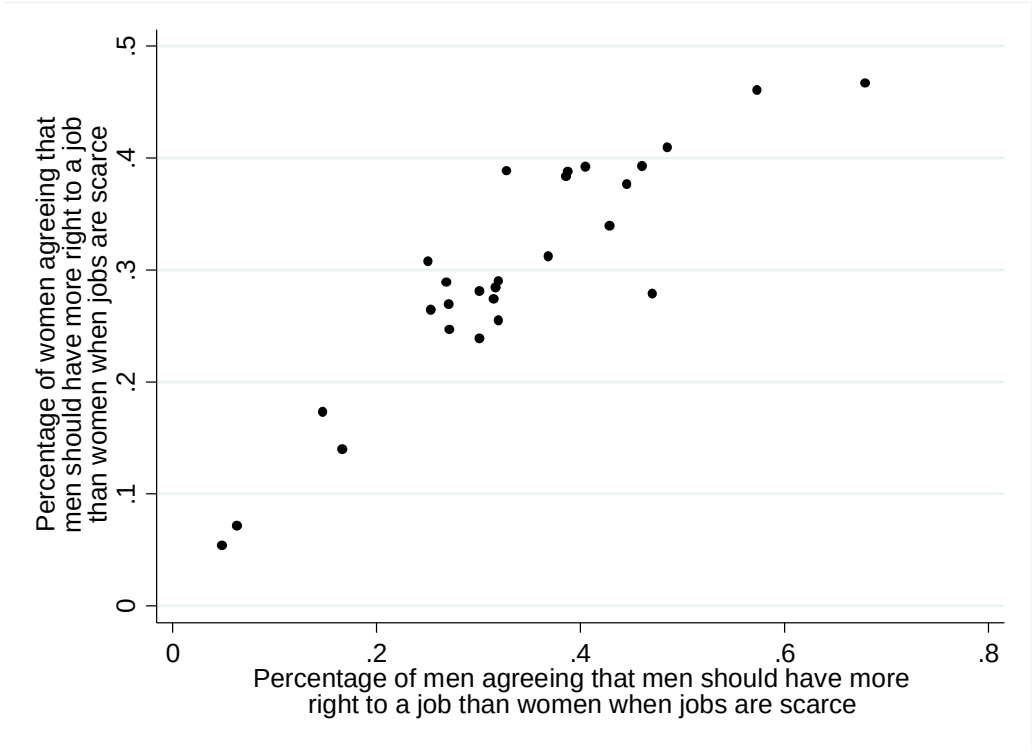

Figure S2. Correlation between gender-role attitudes of men and gender-role attitudes of women across countries.

Correlation coefficient: 0.937. Data source: WVS.

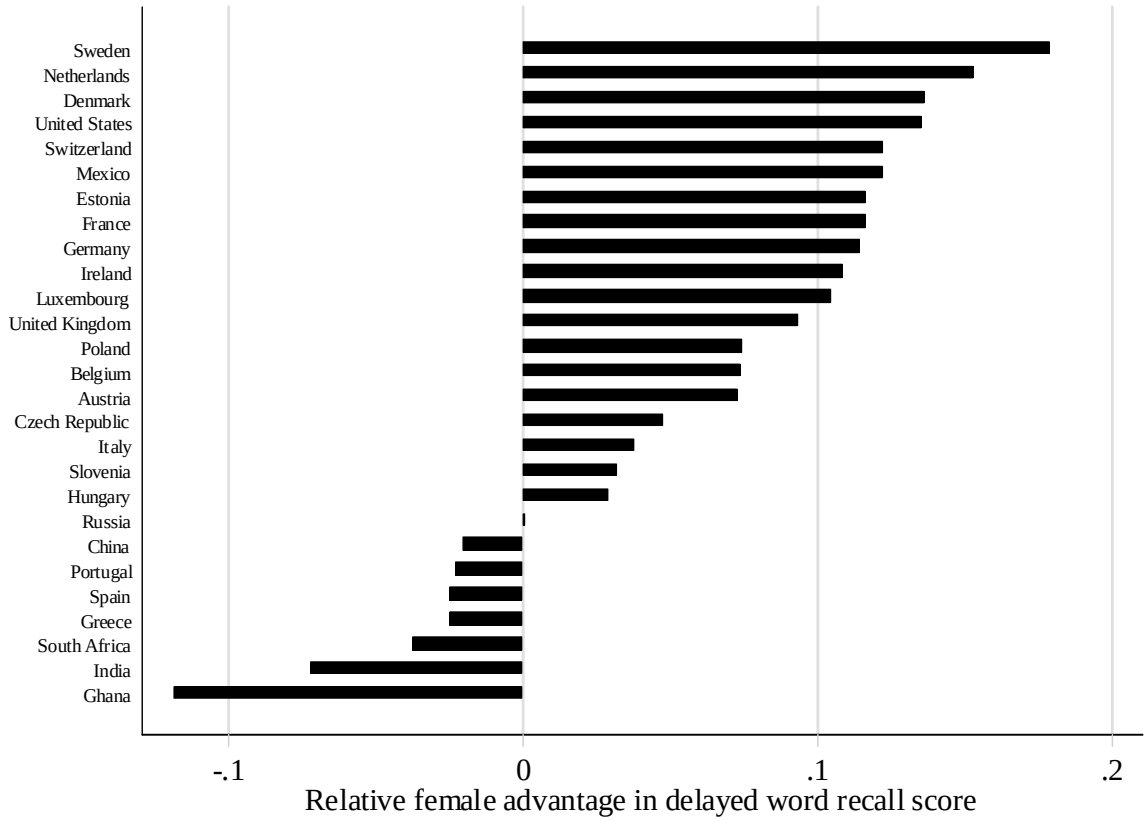

Figure S3a. Relative gender difference in delayed word recall test scores of individuals born between 1920 and 1959. Data source: SHARE, HRS, ELSA, SAGE. The relative female advantage in cognitive test score (ΔC) is equal to $(C_f - C_m)/ C_m$, with C_f and C_m are the average cognitive test score of women and men, respectively.

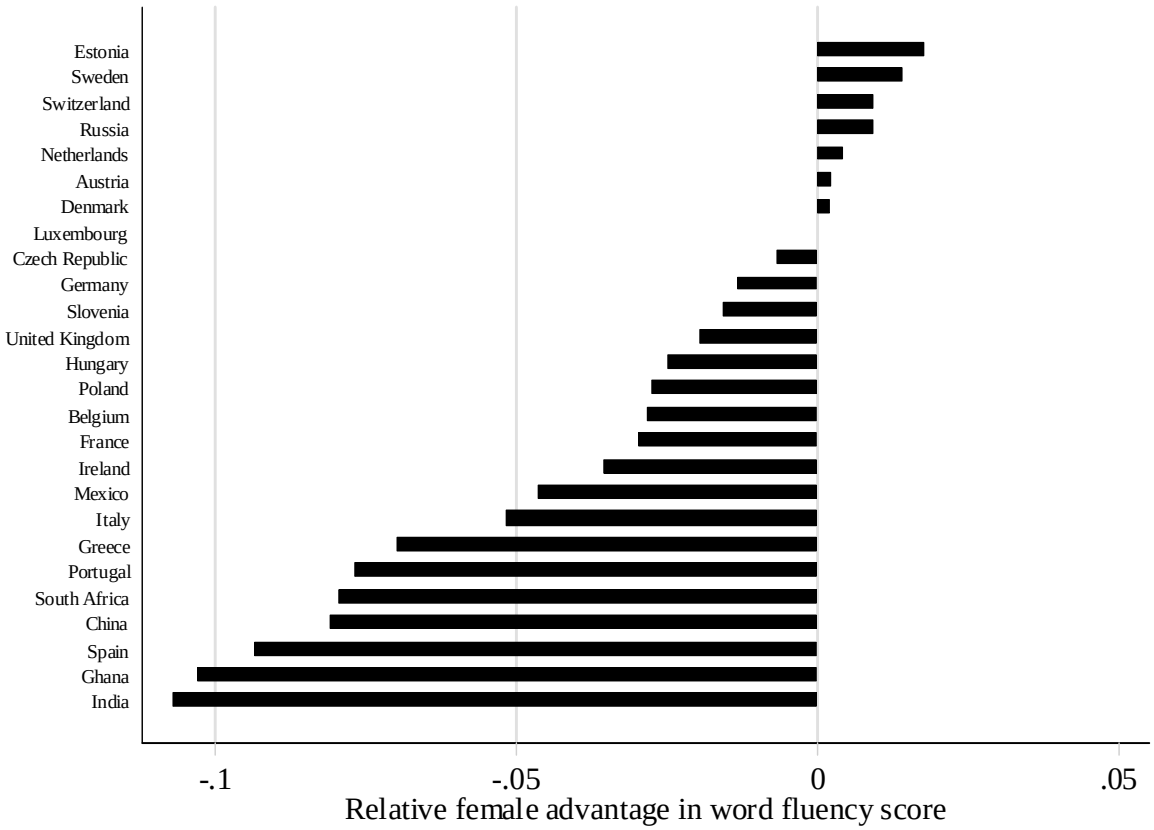

Figure S3b. Relative gender difference in word fluency test scores of individuals born between 1920 and 1959. Data source: SHARE, ELSA, SAGE. Not available for US. The relative female advantage in cognitive test score (ΔC) is equal to $(C_f - C_m)/ C_m$, with C_f and C_m are the average cognitive test score of women and men, respectively.

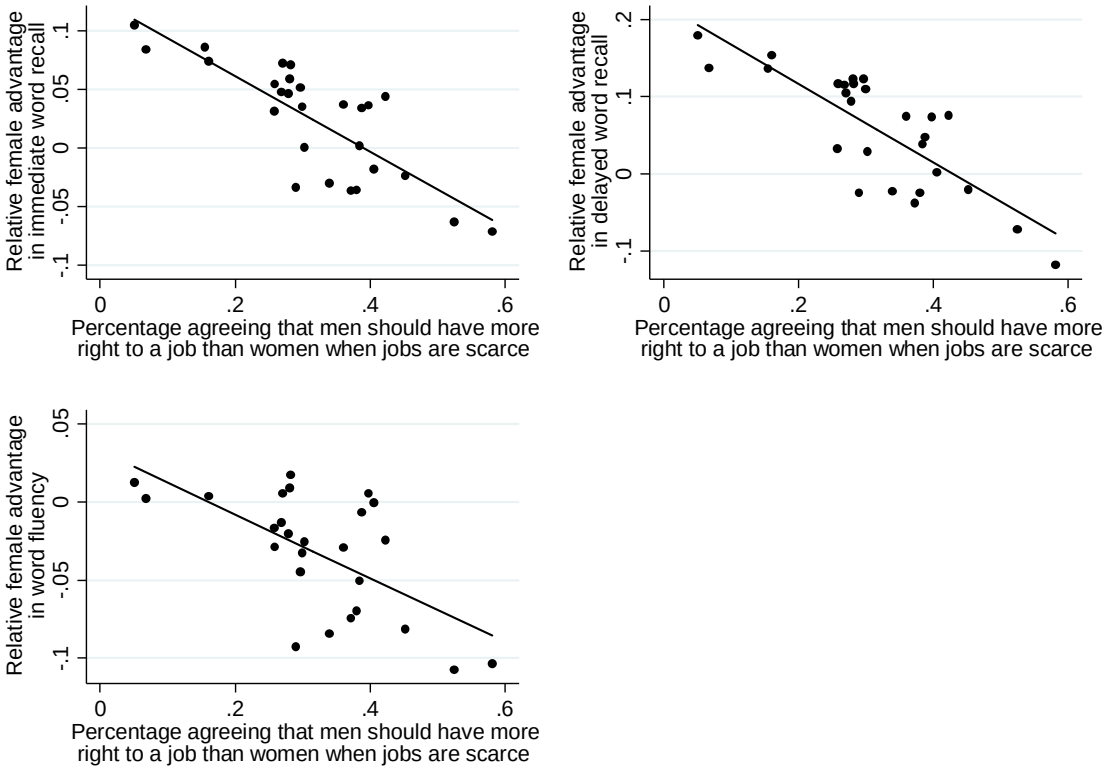

Figure S4. Negative association between relative female advantage in three different cognitive test scores (immediate word recall, delayed word recall and word fluency) and the percentage of individuals born between 1950 and 1959 agreeing with a statement that men should have more right to a job when jobs are scarce.

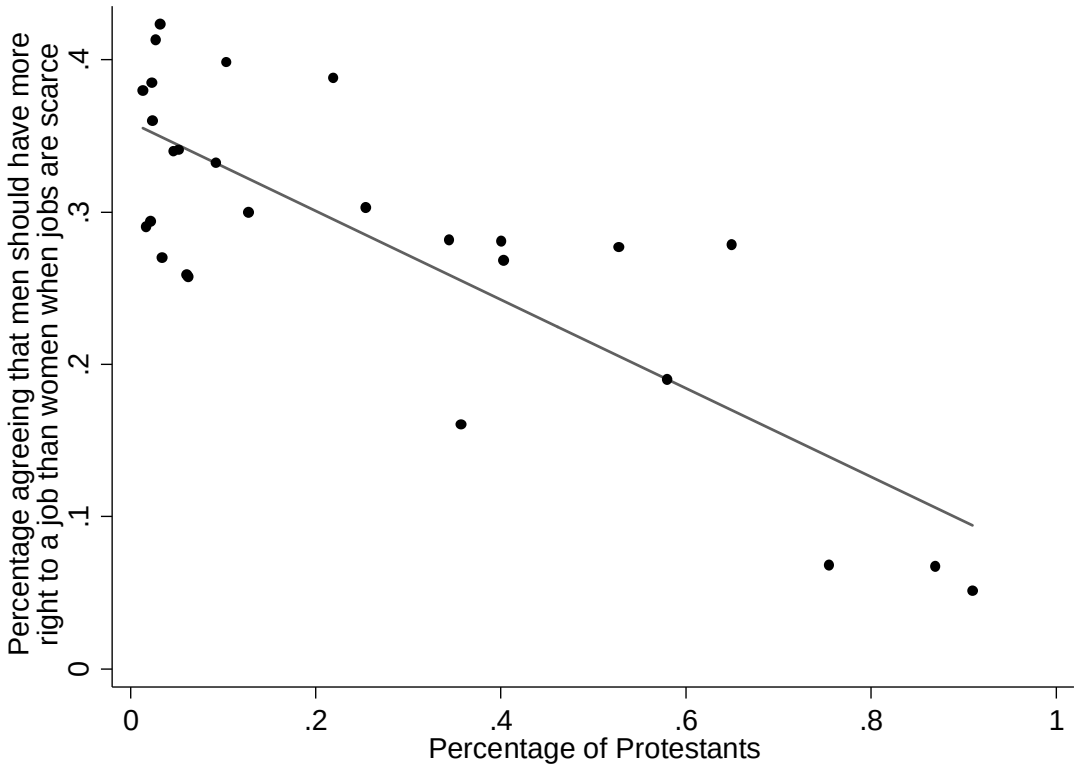

Figure S5. This is the relationship between the proportion of Protestants and gender-role attitudes, conditional on the continent fixed effects.

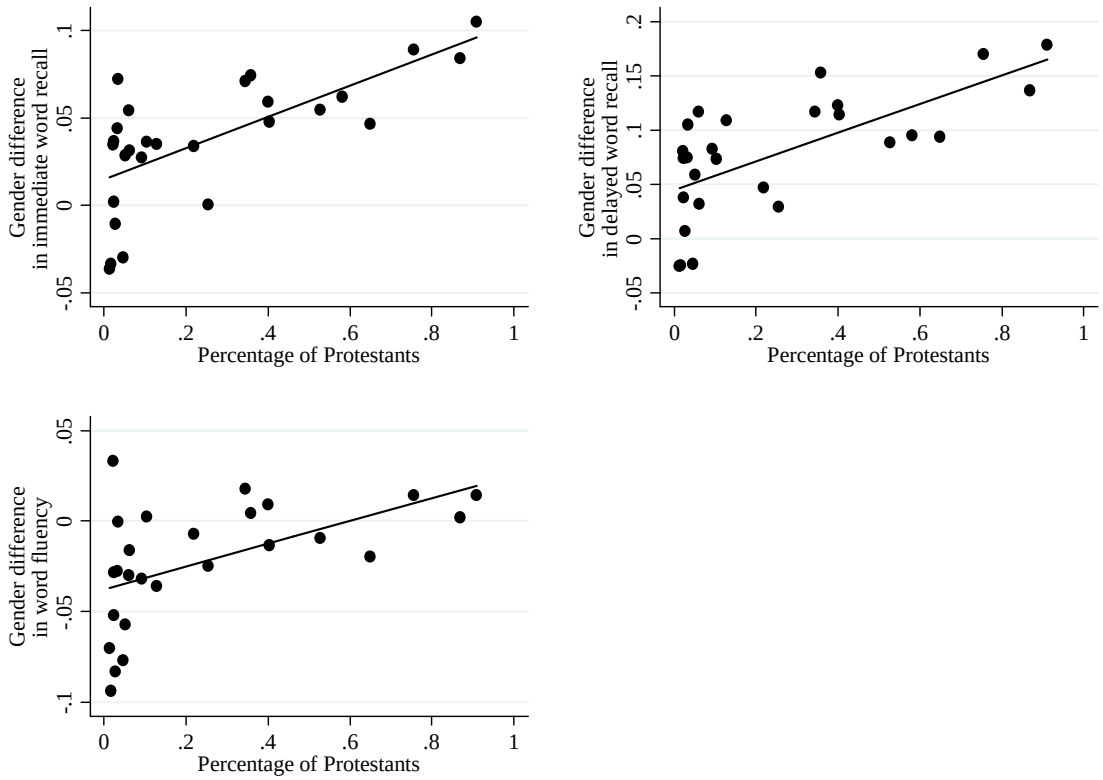

Figure S6. This is the relationship between the relative female advantage in the measures of cognitive functioning and gender-role attitudes, conditional on the continent fixed effects.