Returns to Educational and Occupational Attainment in Cognitive Performance for Middle-Aged South Korean Men and Women

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Abstract

Background: Gender differences in late middle-age cognitive performance may be explained by differences in educational or occupational attainment rates, or gender-patterned returns of similar education and occupation to cognitive reserve. We tested these competing hypotheses in the historically highly gender unequal context of South Korea. **Methods:** Data came from the 2006 wave of the Korean Longitudinal Study of Aging. We included adults aged 45–65 years. Using quantile regression decompositions, we decomposed cognitive performance differences across quantiles into differences due to rates of educational and occupational attainment and differences due to divergent returns to those characteristics. **Results:** Gender-based cognitive performance differences across deciles were driven by differences in rates of educational and occupational attainment, while the returns to these characteristics were similar for both genders. **Conclusions:** Findings suggest that educational and occupational characteristics contribute to cognitive performance similarly in men and women, but discordant rates of these characteristics contribute to performance gaps.

Introduction

A better understanding of how cognitive reserve builds across the life course is vital to delay cognitive impairment and the onset of dementia. Cognitive reserve has been hypothesized to develop through engaging in intellectually stimulating activities, and in turn, maintain cognitive performance in the face of brain pathology (Stern, 2002). Indeed, while education up to age 20 contributes a large part to the development of cognitive reserve and performance on cognitive tests later in life (Kremen et al., 2019), overall educational attainment and indicators of occupation, such as principal lifetime occupation and occupational complexity, have been shown to be relevant indicators of cognitive reserve and cognitive performance in later life (Finkel et al., 2009; Singh-Manoux et al., 2011).

Many studies have noted gender differences in the prevalence of cognitive impairment and dementia, with a higher prevalence in women, which can partly be explained by differences in health-related dementia risk factors (Azad et al., 2007). Considering the large contribution of education and occupation to cognitive performance in later life, gender gaps in later-life cognitive performance may also be driven by gender-patterned education/occupation-cognition relationships, with two competing hypotheses.

Gender Gaps in Attainment Rates

Firstly, in many developed countries, cohorts born in the first half of the 20th century whose members are now in or close to older age, women had not attended school as long as men and, if they participated in the labor market at all, did not fill similar occupational positions as men. These gender differences in educational and occupational attainment have been shown to impact later-life cognitive performance (Singh-Manoux et al., 2011). A concordance in female disadvantage in both educational and occupational attainment and later-life cognitive functioning has

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also been documented in economically less affluent and more gender unequal societies (Maurer, 2011; Nguyen et al., 2008; Zhang, 2006). Thus, gender gaps in cognitive performance may be attributed to lower female rates of educational and occupational attainment.

In South Korea, one example of a historically highly gender unequal society, men and women differed widely in their educational and occupational achievement post World War II. Still today, Korean men are in school for an average of 12.9 years, while women have on average 11.4 years of schooling (United Nations Development Programme, 2018). Enrollment rates in primary and secondary school have been largely equal between the genders since the 1980s, however, at the post-secondary level, women were represented in larger proportions in domains such as the arts, education, home economics, and in programs with shorter durations; conversely they are underrepresented in law, engineering, the natural and social sciences, and agriculture (Chung, 1994). Gender-segregation by academic discipline remains persistent in Korea and appears more problematic than in other East Asian countries despite improvements in women's participation at higher degree levels in recent years (Peng et al., 2017).

Similarly for occupational achievement and active labor market participation, a substantial gender gap remains for South Korean men and women active in the labor force, with 59% of women aged 25–64 years versus 86% of men in the same age group being active (OECD, 2013). Within the female segment of the Korean population, participation rates were similar across levels of education, in contrast with other OECD countries. Sixty-two percent of the most educated Korean women were participating in the labor force, while 56% the least educated women were. In other OECD countries, the most educated women were much more active in the labor market than the least educated, 79% versus 37% (OECD, 2013). Economic factors, such as the export-led growth strategy in Korea, has influenced the labor force structure and contributed to greater competition for fewer white-collar jobs (Brinton et al., 1995). In turn, highly educated women faced limited acceptable employment prospects and weak demand for their labor, particularly if young and married with children (Brinton et al., 1995; Lee et al., 2008).

Gender Differences in Returns to Attainment

Conversely, evidence on gender norms in educational choices points to possibly different returns to education in cognitive functioning for men and women. In more gender unequal contexts such as South Korea, achieving a certain level of education may be motivated differently for women and men. Post-secondary education for Korean women has often been seen as an investment for better prospects on the marriage market than for labor related advantages (Brinton et al., 1995; Chung, 1994; Park & Smits, 2005). Additionally, both

parental and personal expectations for success at school (e.g., in English vs. mathematics) may differ for girls and boys, with associated impacts on educational achievement (Eccles, 2011; Frome & Eccles, 1998). Further, the potential returns to schooling could be influenced by the value that is attributed to mastering different subjects at school, for example, a challenging mathematics course may be considered of high relevance if the pupil wants to pursue a STEM occupation, or of low relevance if the pupil would perceive mathematical skills less relevant for their future professional career (Pahlke et al., 2014).

Regarding returns to occupation, occupational health research has focused on gender differences in work tasks even in similar occupations. Psychosocial work characteristics, such as perceived demand or control are often gender patterned, meaning that, in similar occupations, men and women report different levels of control, demands, and other work characteristics, which are in turn associated with negative health outcomes such as risk of vascular dementia in some studies (Andel et al., 2012; Hasselgren et al., 2018). However, the absence of clear relationships between occupational conditions and cognition may be due to gender-related biases, for example, differential selection into and out of work for men and women (Ford et al., 2020).

Likewise, lower intrinsic value placed on the paid work of women may also impact the returns derived from having an occupation. In the South Korean context, the comparatively lower valuation of women's employment could be observed during the Asian debt crisis of the 1990s. Initially, women bore the brunt of layoffs and were targeted for voluntary resignation, particularly those in dual income families (Chun, 2009; Kim & Voos, 2007). During this period, standard manufacturing positions declined while nonstandard positions in the service sector increased in line with the International Monetary Fund bailout requirement for labor reform (Chun, 2009; Kim & Voos, 2007). Although numerous women initially lost their positions, many—and more so than men—were rehired but in lower paid non-standard positions that carried fewer costs and more flexibility for employers (Chun, 2009; Kim & Voos, 2007), changing the conditions of the work environment primarily for women.

To summarize, differences in cognitive impairment and dementia may be explained by differences in educational or occupational attainment rates, attributed to lower female returns to education and occupation, or a combination of the two. Lower returns to education or occupation implies that similar educational or occupational achievement translates into differential gains in cognitive reserve in men and women, for example, fewer cognitive challenges or poorer working conditions for women in similar occupations to male counterparts and the subsequent impacts on cognition. A direct test of these possible mechanisms has rarely been employed.

Social Context of Cognitive Functioning

The present study rests on the assumption that biological or structural differences in male and female brains are not the basis of observed cognitive ability differences, that these differences are rooted in the social context. In the field of cognitive psychology, Halpern and Lemay argue that any gender-based cognitive differences are malleable, reflecting the influence of social context, while maintaining that sex-based biological factors are relevant to the debate insofar as they interact with the social environment (Halpern & LaMay, 2000). No conclusive universal gender differences in general cognitive abilities are evident, though on specific sub-tests more consistent disparities have been observed (Halpern & LaMay, 2000; Hyde et al., 1990; Hyde & Linn, 1988). Small gender differences in verbal and mathematical abilities are noted; however, these have also narrowed over time (Hyde et al., 1990; Hyde & Linn, 1988).

In cross-national comparisons, gender differences in older adults' cognition varied proportionally to the general support of traditional gender-role norms in a given country, and results remained consistent after using an instrumental variable approach to address concerns about reverse causality (Bonsang et al., 2017). Moreover, gender norms around family-rearing and the division of work have limited bearing on the daily routines of celibate Catholic priests, nuns, and brothers. A longitudinal study on the cognitive performance of this population found that gender did not influence age-specific rates of cognitive decline, nor risk of incident Alzheimer's disease (Barnes et al., 2003). Collectively, the inconsistency of evidence regarding stable gender-differences in cognition over time and place is highlighted, while social circumstances as drivers of these differences offer plausible explanations for gender-based cognitive disparities.

Research Objectives

Given the particularly notable gender differences in educational and occupational opportunities for an advanced economy, the Korean context is relevant for exploring socioeconomic conditions and their impact on cognitive health in older adults. We hypothesize that gendered educational and occupational experiences may have differentiated cognitive development and resulting reserve, and in turn, impacted women's cognitive health at older ages. We explore this hypothesis using a nonparametric decomposition method. To our knowledge, only two other studies have explored socioeconomic factors and cognitive performance by gender with decomposition analyses, a relatively novel approach with later-life cognitive outcomes. Both these studies used Oaxaca-Blinder decompositions, which decomposed gender differences at mean scores on versions of the Mini-Mental State Examination (MMSE), and found that more cognitive resources over the life course, particularly education, are key drivers of gender differentials (Maurer, 2011; Yount, 2008). However, using mean differences with the MMSE may not be optimal given its known ceiling effects (Diniz et al., 2007; Gluhm et al., 2013; Glymour et al., 2012). In this study, we used quantile regression decompositions, which decompose differences across quantiles, to mitigate ceiling effects. We use this method to estimate the cognitive gender gaps across the distribution that would have persisted if Korean men had experienced Korean women's educational and occupational characteristics with data from the Korean Longitudinal Study of Aging (KLoSA).

Methods

Study Population

KLoSA's sampling frame included non-institutionalized adults aged 45 years and older, representative of all regions except Jeju Island (Korea Employment Information Service, 2015). The data analyzed here within is publicly available from the Korea Employment Information Service (https://survey.keis.or.kr/eng/). This cross-sectional study included men and women aged 45–65 years in the first wave (2006) of KLoSA ($n = 6{,}402$). The official age for retirement-eligibility is 60 years in Korea, though the average age of retirement is roughly 70 years (OECD, 2008), thus our sample reflects a period of mid to late career employment, and for some, the transitioning out of employment. Participants were further excluded from this study if they had reported brain lesions ($n = 32$), cerebrovascular disease ($n = 118$), or if they had not taken the MMSE ($n = 84$), leading to a final sample size of $n = 6{,}168$. Those excluded were older (56.5 years vs. 54.4 years; $p < .001$), and more likely to be men (54.3% vs. 45.7% women; $p = .003$).

Outcome

Cognitive ability was assessed using the Korean version of the MMSE via computer-assisted personal interviewing (Shih et al., 2012). The Korean version of the MMSE has been validated as a reliable instrument for estimating cognitive abilities of older adults, though it is relatively indiscriminate in detecting early stages of dementia (Chang et al., 2012; Kang et al., 1997). The scale runs from 0 to 30 points.

Exposures

The exposures of interest were education level, occupational class, and currently working. Education level was grouped into five categories: no formal education, primary, lower secondary, higher secondary, and post-secondary education. Previous occupational health studies using Korean data have regrouped the International Standard Classification of Occupations into categories which better reflect working cultures in South Korea

(Lee et al., 2016, 2018). Responses were regrouped into six categories in accordance with these previous studies: high skilled white-collar (legislators, senior officials, managers, and professionals), lower skilled white-collar (technicians and associate professionals), pink-collar (clerical, sales, and customer service work), green-collar (agricultural, fisheries, and forestry work), skilled blue-collar (plant and machine operators and assemblers, craft work), and unskilled blue-collar (elementary professions). A seventh category, "no paid occupation", was added to reduce missing values for those who reported never having a job.

Covariates

Adjustments were made for the natural logarithm of equivalized income—the total imputed household income divided by a weighted sum of household members. A weighting of 1.0 was given for the first adult and 0.5 for all subsequent people. Marital status was accounted for as a binary variable. Modifiable mid-life risk factors for dementia were included as binary covariates: obesity defined as a body mass index (BMI) $\geq 30\,kg/m^2$, hypertension, and hearing difficulty with daily activities (Livingston et al., 2017). Obesity and hypertension are also two chronic conditions that predict early retirement for Koreans (Lee et al., 2018), thus prematurely ending opportunities for work-based cognitive stimulation. Age centered at 45 years and centered-age squared, to allow for exponential cognitive decline, were included as continuous variables. Finally, those born in 1953 or earlier were likely exposed in some capacity to the Korean War as children or infants with potential consequences on childhood circumstances. Poor physical health in childhood can have lasting effects on socioeconomic outcomes and cognition at later stages of life (Case & Paxson, 2010); thus, we included a binary variable to account for this potential cohort effect.

Data Analysis

Quantile regression models were used to describe the relationship between the exposures of interest and cognitive performance given the noted ceiling effects of the MMSE. Quantile regression, unlike ordinary least squares regression, is not susceptible to a censored dependent variable provided the quantile of interest falls below the censoring point in the case of right-censoring (Angrist & Pischke, 2009). Models were adjusted for equivalized income, marital status, obesity, hypertension, hearing difficulties, centered-age, centered-age squared, Korean War exposure, and gender.

Quantile regression decompositions were undertaken to determine if gender gaps in cognition can be explained by differences in the distributions of characteristics by gender, or if these characteristics contribute differently to cognitive performance for each gender (i.e., differences

in coefficients). Similar to Oaxaca-Blinder decompositions, which decompose differences at the mean, this method decomposes observed cognitive differences at each quantile of the gender-specific distributions (Chernozhukov et al., 2013). Decompositions are achieved by building a counterfactual distribution of men's cognitive scores if they had women's distributions of characteristics ($F_{Y(M|W)}$), see equation (1) (Chernozhukov et al., 2013; Melly, 2005):

$$F_{Y(M|M)} - F_{Y(W|W)} = [F_{Y(M|M)} - F_{Y(M|W)}] + [\,F_{Y(M|W)} - F_{Y(W|W)}\,] \qquad (1)$$

The first square brackets represent the difference in cognitive scores due to differences in characteristics. The second square brackets represent coefficient differences, whose significance would reflect different relationships between characteristics and outcomes for each gender in their quantile functions (Chernozhukov et al., 2013). Figure 1 gives a visual representation of the above formula.

We first decomposed cognitive score differences, taking into account the three exposures of interest, along with equivalized income, marital status, obesity, hypertension, hearing difficulties, centered-age, centered-age squared, and Korean War exposure. Since quantile regression decompositions do not give information about the contributions of individual characteristics to the total characteristic effect, unlike Oaxaca-Blinder decompositions that provide the relative importance of each characteristic, we performed a series of quantile regression decompositions to better isolate the importance of our exposures of interest. Thus, a second decomposition took into account only the three exposures of interest to isolate their relevance from the other covariates. A third decomposition accounted for differences in the distributions of the two age variables, centered-age and centered-age squared, as age is considered the best predictor of dementia (Licher et al., 2018). A final decomposition with the remaining covariates was included to see if they contributed to gender gaps beyond the exposures of interest and age. Decompositions were estimated with nine quantile functions (one at each decile), and significance was interpreted using bootstrapped 95% confidence intervals (CI) with 1,000 repetitions.

Sensitivity Analysis

Common support, or covariate overlap, is needed for valid inferences (Chernozhukov et al., 2013). Prominent gender differences existed in educational and occupational characteristics for our sample. For this reason, we used a logistic regression to predict gender based on individuals' characteristic combinations. We then re-ran the first quantile regression decomposition restricting the sample to those whose characteristic combinations were not overly precise in predicting gender, those with
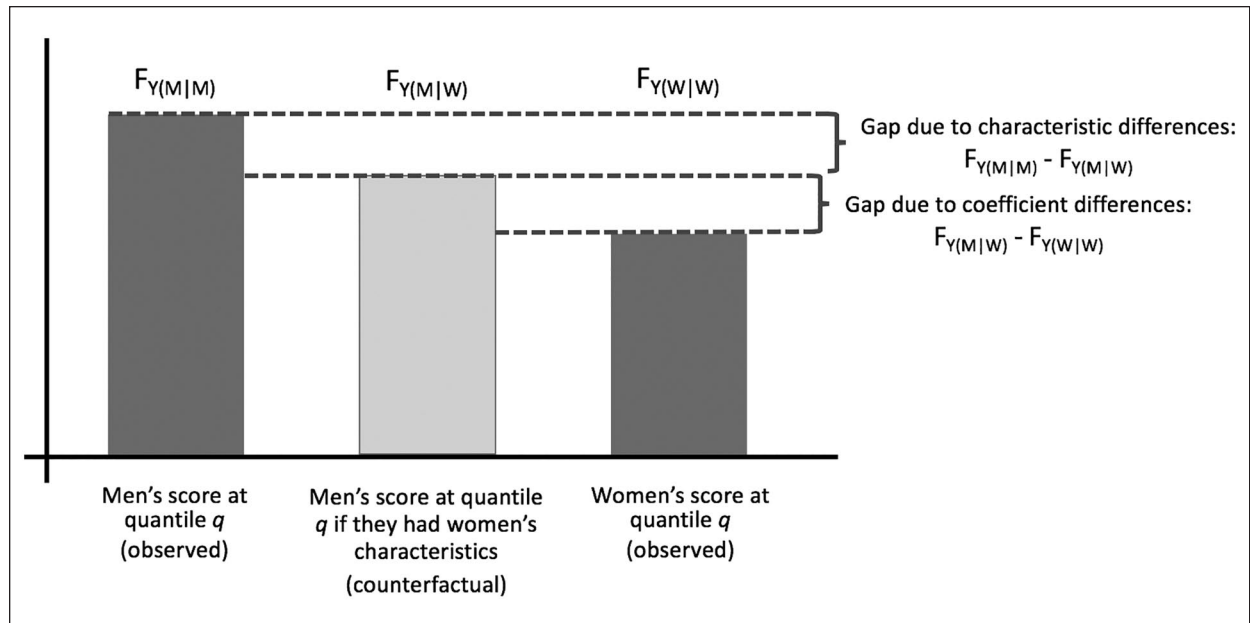
Figure 1. Illustration of a hypothetical gender difference decomposition.

≥10% probability of another gender. If characteristics are the drivers of gender-based cognitive gaps rather than coefficient differences, and the overlap in characteristics between the genders is improved, we would expect the total gender gap to be reduced in the restricted sample. All statistical procedures were performed with Stata version 13.1 (College Station, TX, USA).

Results

Descriptive details of the sample are presented in Table 1. Men and women had meaningfully different proportions at each education level, except secondary levels; in each occupational category, except pink collar work; having current work; and being obese. By meaningfully different, we mean statistical significance and a proportion that was at least a third smaller compared to the other gender. The most common occupational categories for women were pink-collar work and no paid occupation. These two categories covered 74% of the women's responses. For men, the most common categories were skilled blue-collar, pink-collar, and unskilled blue-collar occupations, covering 70% of their responses. Overall, 29% of the sample scored the full 30 points on the MMSE (34% of men and 25% of women), highlighting the known ceiling effect of this cognitive performance measure (*data not shown in tables*).

Table 2 presents β-coefficients from quantile regressions at the first, third, fifth, and seventh deciles of MMSE scores. The cognitive returns to education were progressively larger at lower deciles, while occupational characteristics were correlated with better performance in the third and fifth deciles. Coefficients were compressed in the seventh decile compared to the lower deciles, indicative of the ceiling effects which limit variability in the

upper part of the distribution (Glymour et al., 2012), while almost all of the scores in the upper three deciles were censored limiting meaningful inferences.

Using the quantile regression decomposition, women's scores were 2.2 points lower (95% CI [1.4–2.9] points) than men's at the first decile of cognitive scores in their respective distributions. The cognitive performance gaps had a narrowing trend over the deciles (Figure 2(a)). Coefficient differences did not appear to have an influential effect on cognitive gaps across the deciles (Figure 2(c)). Characteristic differences (Figure 2(b)) were the main driver of decile differences between the genders and mirrored the cognitive performance gaps between genders as seen in Figure 2(d).

Further decompositions gave an idea of the relative importance of the exposures of interest (Figure 3(b)) in relation to the age variables (Figure 3(c)), and the remaining covariates (Figure 3(d)). The distributional differences between genders in the three exposures of interest: education level, occupational class, and currently working, appear to be driving the characteristic effect on cognitive performance gaps as they best mirror the trend seen in Figure 3(a).

When optimizing the common support condition with the restricted sample, cognitive gaps were smaller but with a similar narrowing trend toward the upper deciles (Figure 4(a)). The reductions in cognitive gaps were as expected. The cognitive performance gap at the lowest decile was 1.5 points (95% CI [0.6–2.3] points). Again, coefficient differences appeared to be non-influential across all deciles (Figure 4(c)). The effect of characteristic differences (Figure 4(b)) remained the drivers of cognitive differences in the lower deciles and mirrored the trend in total differences across the distribution as seen in Figure 4(d).

Table 1. Sample Characteristics by Gender.

	Men (*N* = 2,737)	Women (*N* = 3,431)	*p*-Value[†]	Missing values
Level of education				5
No formal	2.5%	8.8%	<.001	
Primary	15.5%	29.8%	<.001	
Lower secondary	18.6%	22.4%	<.001	
Upper secondary	40.8%	31.5%	<.001	
Post-secondary	22.6%	7.5%	<.001	
Occupational category				71
Unskilled blue collar	19.2%	11.1%	<.001	
Skilled blue collar	26.1%	5.7%	<.001	
Green collar	7.2%	4.4%	<.001	
Pink collar	24.5%	26.9%	.033	
Lower skilled white collar	5.7%	2.6%	<.001	
High skilled white collar	12.7%	2.3%	<.001	
No paid occupation	4.7%	46.9%	<.001	
Currently working	76.4%	34.7%	<.001	0
Obesity (BMI ≥30 kg/m^2)	1.4%	2.8%	<.001	42
Hypertension	17.5%	20.6%	.003	0
Hearing loss	2.3%	2.2%	.834	0
Married	93.1%	83.3%	<.001	0
War exposure	58.1%	56.2%	.133	0
Equivalized income in 10,000 Korean Won				233
Median	1,000	864		
[Interquartile range]	[480–1,600]	[375–1,500]		
Age in years				0
Mean	54.6	54.4	.188[‡]	
[95% CI]	[54.3–54.8]	[54.1–54.6]		
MMSE score				0
Mean	27.9	26.9	<.001[‡]	
[95% CI]	[27.8–28.0]	[26.8–27.1]		

Note. BMI = body mass index; CI = confidence interval; MMSE = Mini-Mental State Examination.
[†]Pearson chi-squared test.
[‡]*t*-Test.

Table 2. Exposure-Cognition Coefficients at Deciles 1, 3, 5, and 7.

	Decile 1 β [95% CI]	Decile 3 β [95% CI]	Decile 5 β [95% CI]	Decile 7 β [95% CI]
Level of education (ref. no formal)				
Primary	**6.11 [5.25–6.98]**	**3.78 [3.32–4.24]**	**3.00 [2.64–3.37]**	**2.00 [1.68–2.32]**
Lower secondary	**7.90 [7.00–8.79]**	**5.18 [4.71–5.65]**	**4.22 [3.84–4.59]**	**3.00 [2.67–3.33]**
Upper secondary	**8.84 [7.95–9.73]**	**5.86 [5.39–6.34]**	**4.63 [4.25–5.00]**	**4.00 [3.67–4.33]**
Post-secondary	**9.56 [8.53–10.58]**	**6.27 [5.73–6.81]**	**5.06 [4.63–5.49]**	**4.00 [3.62–4.38]**
Occupational category (ref. unskilled blue)				
Skilled blue	0.49 [−0.19–1.17]	**0.55 [0.19–0.91]**	**0.34 [0.0–0.63]**	0.00 [−0.25–0.25]
Green	0.44 [−0.48–1.36]	0.35 [−0.14–0.83]	−0.01 [−0.39–0.38]	0.00 [−0.34–0.34]
Pink	0.49 [−0.12–1.11]	**0.45 [0.12–0.77]**	**0.26 [0.00–0.52]**	0.00 [−0.23–0.23]
Lower skilled white	0.50 [−0.55–1.54]	**0.64 [0.09–1.19]**	0.38 [−0.06–0.82]	0.00 [−0.39–0.39]
High white	0.77 [−0.16–1.69]	**0.50 [0.01–0.98]**	**0.44 [0.05–0.83]**	0.00 [−0.34–0.34]
No paid occupation	0.00 [−0.72–0.72]	**0.39 [0.01–0.77]**	**0.43 [0.12–0.73]**	0.00 [−0.27–0.27]
Currently working	0.29 [−0.22–0.81]	**0.28 [0.01–0.55]**	**0.29 [0.07–0.50]**	0.00 [−0.19–0.19]
Female	−0.07 [−0.54–0.39]	**−0.26 [−0.50–−0.01]**	−0.19 [−0.39–0.00]	0.00 [−0.17–0.17]

Note. Adjustments also made for equivalized household income, marital status, obesity, hypertension, hearing difficulties, centered-age, centered-age squared, and Korean War exposure. CI: confidence interval.
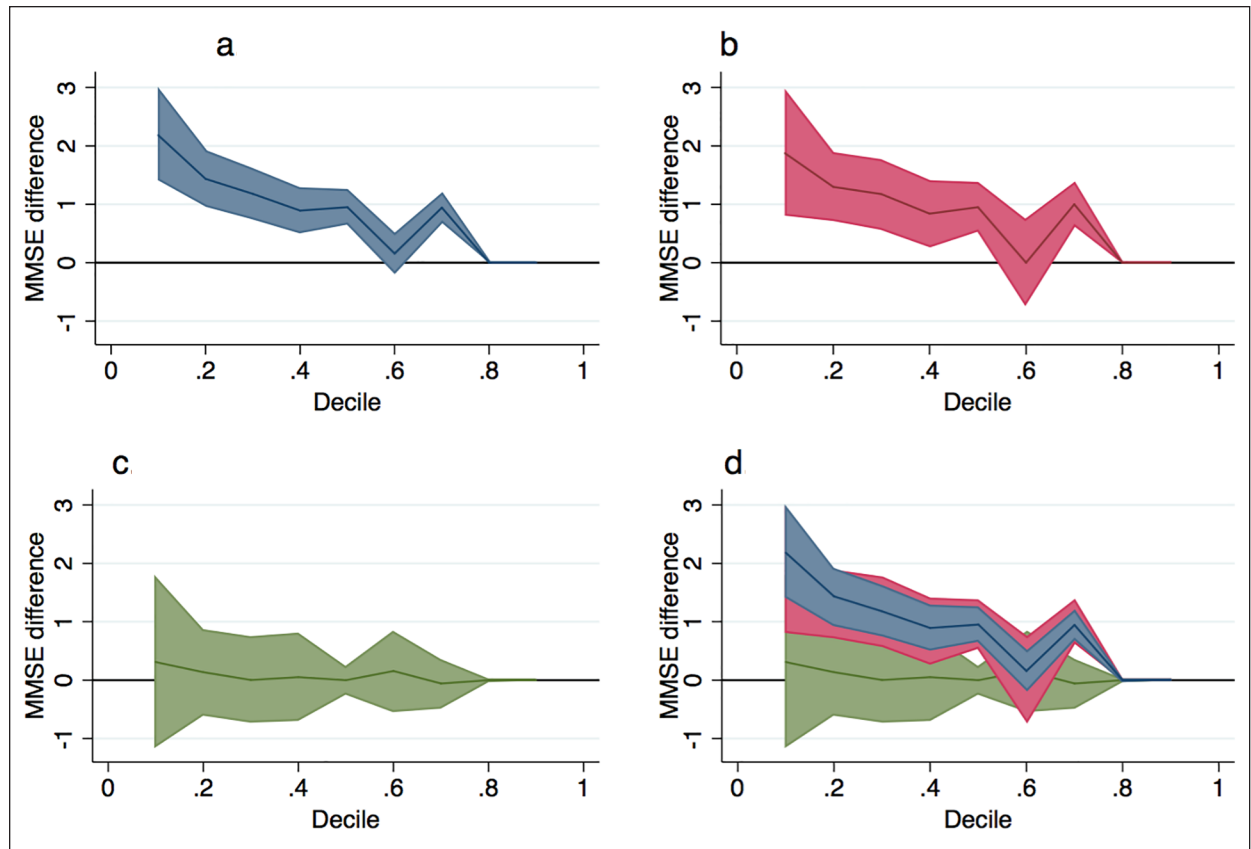Bold text indicates statistical significance based on confidence intervals.

Figure 2. Differences in MMSE scores between genders by decile (whole sample): (a) total difference, (b) difference due to characteristics, (c) difference due to coefficients, and (d) decomposition of the difference.

Discussion

Summary of Main Findings

Main finding of our study was that the observed female disadvantage in cognitive functioning at late middle-age in the South Korean KLoSA data was very likely driven by gender differences in educational and occupational attainment, and not by differential returns to education and occupation for men and women. This is in line with research in education that did not find differences in achievement between girls and boys in South Korea, despite a partly sex-segregated schooling system (Wiseman, 2008), in other words, sex-segregated schooling did not seem to impact returns to education in the Korean context.

The quantile regressions without decompositions highlight the particular importance of education across the cognitive performance distribution, but so too of certain professional domains and working status for those toward the middle of the distribution. Despite the less prominent occupation-cognition relationship relative to the education-cognition relationship, limited occupational opportunities for women may have played into stark differences in educational attainment between the genders in our sample, given women's future employment expectations are often reflected in their educational choices (Goldin, 2006). Additionally, our study found

that cognitive returns from education and occupational factors were highly similar for men and women, as indicated by the consistently insignificant coefficient effects in the decomposition analyses. Thus, our findings provide support for the hypothesis that the gender differences in educational and occupational characteristics have associations with subsequent gender differences in cognitive performance in mid to late adulthood.

The cognitive reserve concept posits that greater levels of cognitive capacity, developed through life experiences such as educational and occupational attainment, can be protective against pathological declines in cognitive functioning (Stern, 2012). The women in our sample had a third of the post-secondary education participation rate of the men, and a fifth of the men's proportion in high-skilled white-collar occupations. Furthermore, roughly half of the women had never had a paid occupation. Our findings are in line with the post-World War II evidence on gender inequalities in education, occupation in South Korea, as previously described.

South Korea's Gender Development Index—a measure of women's health, educational, and financial resources relative to men's—continues to sits lower than its counterparts in the OECD and in the East-Asia region (United Nations Development Programme, 2018). Socioeconomic inequalities between genders in South Korea, have also manifested themselves in excess
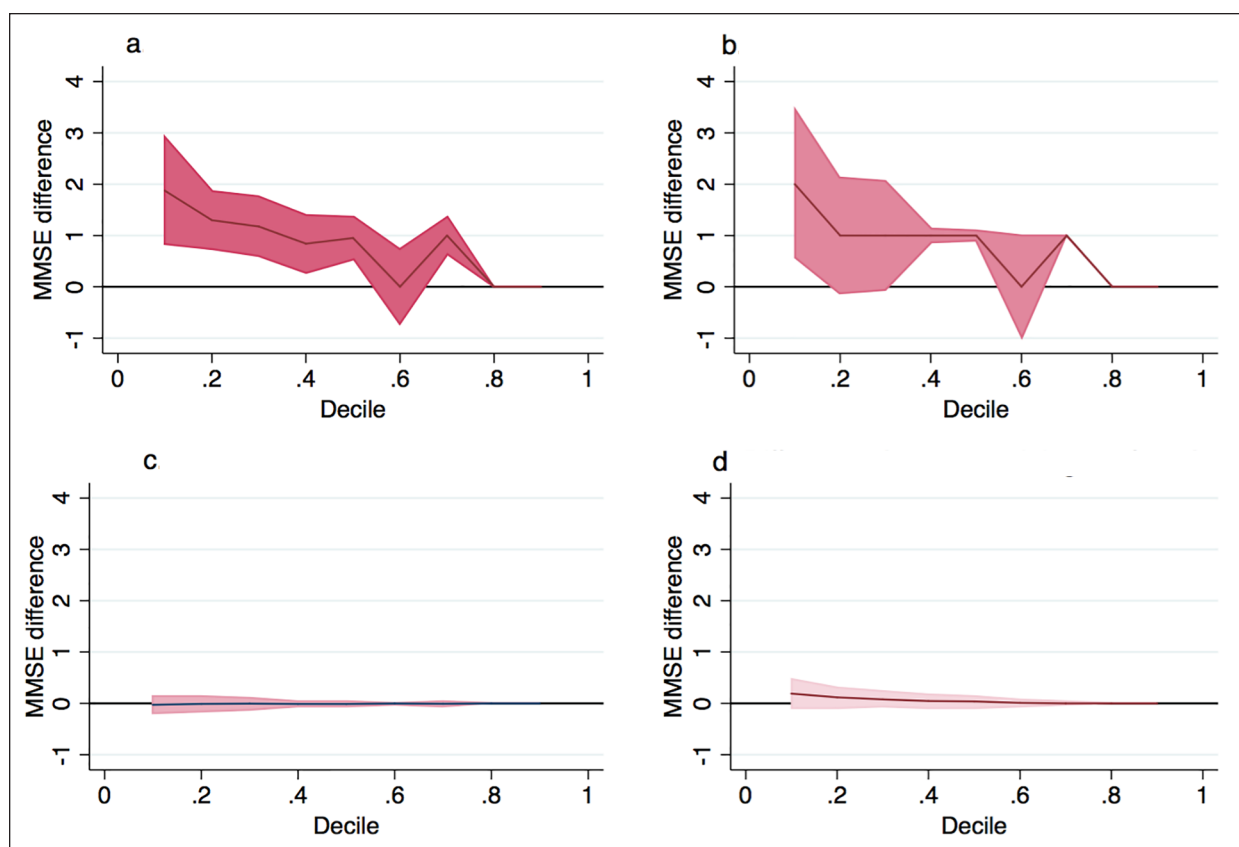
Figure 3. Breakdown of the characteristic effect into distributional differences in exposures, age variables, and remaining covariates: (a) difference due to all characteristics, (b) difference due to exposures of interest, (c) difference due to age variables, and (d) difference due to remaining confounders.
Note. Exposures of interest include education level, occupational class, and currently working; age variables include centered-age and centered-age squared; remaining covariates include equivalized income, marital status, obesity, hypertension, hearing difficulties, and Korean War exposure.

chronic disease and a burden of ill-health for women (Chun et al., 2008). While South Korea has experienced a notable economic expansion over the second half of the 20th century that has supported women's entry into the workforce, Confucian traditions—suggested to have also been important for their economic success—appear to be ongoing, though weakening, constraints on women's equality in both the domestic and occupational spheres (Sung, 2003). In turn, subsequent impacts of these inequalities on physical and cognitive health could continue to be issues for following cohorts.

Strengths and Limitations

A strength of our study was to make use of new methodological developments to test if gender gaps in cognitive functioning were due to differences in attainment rates or differential returns to attainment. To interpret effects causally with quantile regression decompositions, two key assumptions are made: (1) no unmeasured confounding and (2) the swapping of characteristic distributions does not change the function of the exposure-outcome relationship in that group (Chernozhukov et al., 2013). In other words, by exchanging the women's characteristics for men's, the relationship between cognition and

explanatory variables would not change. Under these assumptions, the differences in characteristics between the genders were responsible for a substantial extent of women's relatively lower cognitive levels, particularly at the lower ends of men's and women's cognitive distributions. However, caution is advised for causal interpretations with decomposition analyses as they only approached causal effects under very specific conditions that are rarely met (Huber, 2015). Instead decompositions should generally be considered as descriptive analyses of a given situation (Huber, 2015).

Another strength of our study was the use of a method that circumvents the known ceiling effects of the MMSE with a careful exploration of additional caveats and a sensitivity test. Our results largely confirm general conclusions in the two previous studies that used Oaxaca-Blinder decompositions on cognitive gender-gaps in older adults (Maurer, 2011; Yount, 2008), although decompositions of mean differences may not be robust to the mentioned ceiling effects. The more recent of the two studies circumvented ceiling issues by using estimated scores from Tobit models to establish trends above the ceiling threshold in their Latin American urban samples (Maurer, 2011). As the top portion of the distributions were modeled with Tobit
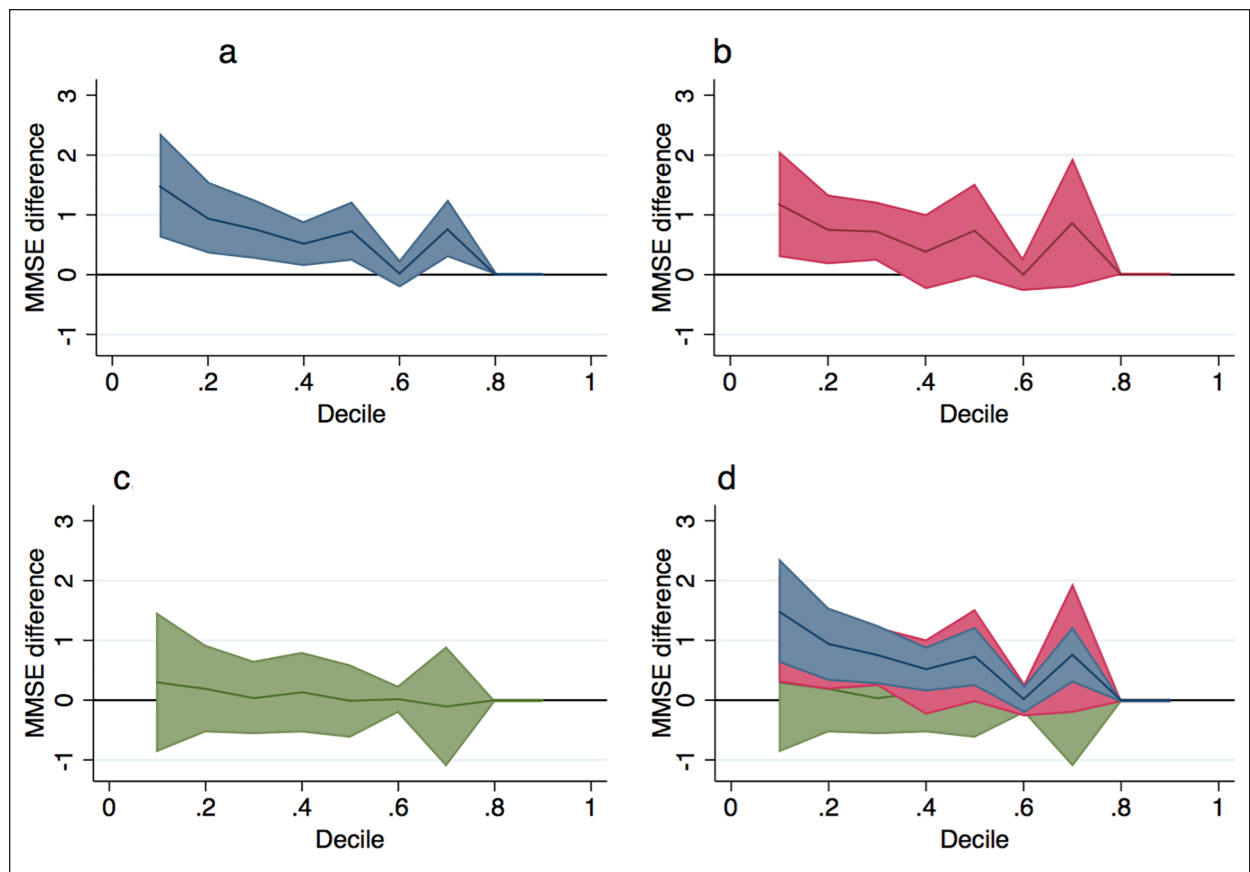
Figure 4. Differences in MMSE scores between genders by decile (restricted sample): (a) total difference, (b) difference due to characteristics, (c) difference due to coeficients, and (d) decomposition of the difference.

regressions, modeled outcomes could be subject to bias if the underlying distributions are not normal or hetero-skedastic (Austin, 2002). Furthermore, quantile regressions at the median have been shown to have better predictive accuracy than Tobit regression with censored health status variables (Austin, 2002). The other decomposition study did not address ceiling effects, though low levels of education in their Egyptian sample could have limited censored values to some extent (Yount, 2008). Despite potential biases in the statistical models used in the other studies, both found that the majority of cognitive gender gaps were explained by differences in characteristics, while coefficient differences were generally insignificant contributors (Maurer, 2011; Yount, 2008). Overall, these three studies cumulatively lend support to the notion that educational and occupational inequalities between groups limit cognitive performance for the disadvantaged group at older ages.

One limitation to inferences is the lack of information about the contribution of individual characteristics to the total characteristic effect with quantile regression decompositions. We attempted to circumvent this limitation with further decompositions using characteristic groupings of the exposures of interest, age variables, and remaining covariates, which highlighted the particular importance of the educational and occupational characteristics for cognitive performance relative to the other variable distributions.

Additionally, despite its popularity as a brief cognitive assessment tool, the MMSE is noted for its limited ability to detect age-related declines in the cognitively healthy and at early stages of dementia due in part to the small score variability with the ceiling effects (Gluhm et al., 2013; Kang et al., 1997). However, the MMSE, as a screening instrument for dementia, has been shown to perform better than other instruments when only one test is available, and is more suitable for research in community settings (Shin et al., 2011). The overall trend in our data suggested a narrowing of gender-based cognitive performance gaps over the deciles, though we cannot confirm this trend in the highest deciles. Other cognitive measures, such as the Montreal Cognitive Assessment, could potentially offer more score variability for general adult populations (Gluhm et al., 2013), which may support better inferences across the whole distribution. However, more advanced instruments were not available in this data set, so in the absence of other instruments, the MMSE can be considered useful to detect cognitive limitations reasonably well.

Lastly, this study uses cross-sectional data with potential reverse causality issues. Occupational characteristics at the moment of data collection may not reflect

employment trajectories or primary lifetime occupation, but rather lower cognitive abilities at the time of labor market entry decades earlier or later-life cognitive changes that necessitate labor market withdrawal or downgrading of occupational complexity, implying that cognitive abilities come before employment effects. However, the lower labor market participation rates of women in our study are consistent with the literature's depictions of the situation in Korea. Furthermore, educational differences appear to be the most pertinent drivers of cognitive performance at older ages across the distribution based on the quantile regressions without decomposition.

Conclusion

This study provides insight into how educational and occupational inequalities between men and women could subsequently impact cognitive performance in mid to late adulthood. The findings highlight that Korean women had fewer opportunities to build up cognitive reserve and are thus entering older age in a cognitively less healthy state. We add to previous research by using new methods robust to the ceiling effects of the MMSE, with conclusions being generally consistent with previous work, in a different cultural context with notable gender inequalities. The significance of gender in shaping socioeconomic opportunities in Korea, and the resulting cognitive performance gaps already evident in adults around retirement age, should encourage policy decisions that mitigate inequalities in these factors over the life course.

Authorship

KJF designed the study, conducted the statistical analyses, and wrote the draft. AKL suggested additional analyses and revised the paper for important intellectual content. Both authors approved the final version of the manuscript.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Code Availability

Code will be published with the analyses on github.

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Availability of Data and Material

The data analyzed in this study is publicly available from the Korea Employment Information Service (https://survey.keis.or.kr/eng/).

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