JOURNAL OF ASIAN SOCIOLOGY
Volume 49 | Number 1 | March 2020, 75-97
DOI 10.21588/jas/2020.49.1.004

Article

Gender Differences in Cognitive Decline in Korea: Age Changes and Cohort Differences*

Yujin Kim | Kangwon National University

To assess socio-cultural and gender differences in cognitive aging in Korea, I separated age and cohort effects on cognitive aging and examined gender differences in aging trajectories of cognitive function across birth cohorts. I applied growth curve models to nationally representative longitudinal data from Korea that spanned 10 years (N=5,270; 31,620 person years). The main findings are 1) cognitive aging is not only an age but also a cohort-related phenomenon (significant cohort differences found in both the levels and the rate of cognitive aging); 2) gender gaps in cognitive aging vary across birth cohorts, with smaller gender gaps in cognitive aging among recent cohorts; 3) individual socioeconomic and health status explain some cohort and gender effects on cognitive aging, but significant effects still exist when these elements are controlled for. These findings provide important policy implications for predicting the future social and economic burdens of cognitive aging-related diseases.

Keywords: *cognitive aging, cohort, gender, Korea*

*This study was supported by a 2019 Research Grant from Kangwon National University.

Increases in the aging population in South Korea (hereinafter Korea) have generated several social concerns, one of which is age-related health, including cognitive decline.[1] Although cognitive decline is a normal part of aging, it is highly correlated with cognitive impairment and dementia, including Alzheimer's disease, which is characterized by loss of memory and difficulty maintaining independent daily living (CDC 2013). Previous research in Korea has documented various risk factors for cognitive decline, such as old age, low levels of social participation and education, and being a woman (Baik 2015; Hwang, Park, and Kim 2018; Kim, Arai, and Kim 2017; Kim and Yang 2013; Lee and Kim 2017). Although there are some variations by education and social engagement, in general, cognitive function declines with age, but women have tended to decline faster than men, resulting in the largest gender gap in cognitive health occurring in older age (Lee and Kim 2017).

Though these findings are important in many respects, researchers have yet to distinguish the effects of age and birth cohorts in examining gender differences in cognitive aging. This distinction is essential because while age effects largely represent the biological processes of individuals' aging, cohort effects reflect the socio-cultural factors for health over the life course of a particular age-group (Yang 2007; Yang and Lee 2009). In the absence of cohort effects, age changes in cognitive function may not accurately reflect the social changes and varied life experiences of birth cohorts (Yang and Lee 2009). Indeed, Korea has undergone a series of historic events and substantial socioeconomic changes over the last century (Chang 2010), including World War II and the Korean War in the 1940s and 1950s, rapid economic development in the 1960s and 1970s, and political progress and tertiary educational expansion in the 1980s. These rapid changes suggest substantial cohort differences in socio-environmental processes, which may differently influence gender gaps in cognitive aging across successive birth cohorts.

Thus, in this study, I examined the following three topics: (1) whether there is cohort heterogeneity in both the levels of cognitive function and the

[1] The prevalence of dementia among people ages 65 and over in Korea was 10.3 percent in 2018 and is expected to rise to 17 percent in 2060 unless more effective methods of preventing and treating the disease are identified and implemented (KOSTAT 2018). The Korean government declared a "war on dementia" in 2008 and enacted the Dementia Management Act in 2012 (Lee, Kim, and Byun 2012). Furthermore, the government announced a new policy of national responsibility and dementia care in 2017, which increases the government's responsibility for treating dementia patients (a2017001 2017).

rates of cognitive aging; (2) whether and to what extent gender differences in cognitive aging vary across birth cohorts; and (3) what social risk factors are associated with these cohort-gender variations in cognitive aging. To do this, I studied six recent waves of the Korean Longitudinal Study of Aging (KLoSA) and followed respondents who had completed all follow-up surveys through 2016, for a total of 10 years of observation from 2006 to 2016. For the analysis, I employed growth curve models to effectively examine intra- and inter-cohort variability in cognition at baseline and over time (age).

Theoretical Background

According to its biological definition, cognitive aging refers to the shrinking of the brain and expansion of the ventricles, which are part of the natural maturational process of the brain during normal aging (Mielke, Vemuri, and Rocca 2014) and which usually accelerate around age 50 (Salthouse, 2006). Although increased age is, on average, associated with lower performance in many cognitive functions (Park et al. 2003), there are significant gender differences in the normal aging process (Salthouse 2006). Previous studies have revealed that men are more likely to have higher overall cognitive function (e.g., Mini-Mental State Exam [MMSE] scores) and that women show steeper declines in cognitive function with advancing age (Lee and Kim 2017; Matthews, Marioni, and Brayne 2012; Proust-Lima et al.2008).

Both biological and socio-cultural perspectives offer theoretical guidance for explaining gender differences in cognitive aging. Biological explanations of sex differences in cognitive aging are based on men and women's differences in brain anatomy (i.e., size, structure), genes (i.e., the ε4 allele of the apolipoprotein E), and hormones (i.e., testosterone) (Mielke et al. 2014; Park et al. 2003). In addition to biological explanations, gender differences are also understood in the context of one's socio-cultural environment. Gender, unlike sex, is intertwined with other social institutions such as socioeconomic status (i.e., education, occupation, and wealth) (Ferree 2010). Consequently, life as a woman may affect the risk of disease via health behavior, social and work-related stressors, and access to health resources and facilities (Connell 2012; McDonough and Walters 2001; Mielke et al. 2014; Umberson 1992).

Cognitive reserve theory and cumulative disadvantage theory provide explanations for gender differences in cognitive aging while reflecting on the social and cultural implications of being a woman. Cognitive reserve theory argues that higher levels of education, occupational complexity, and greater engagement in mentally stimulating activities provide higher cognitive reserve, reducing the risk of decline in cognitive functioning later in life (Stern 2002). More specifically, higher education/occupation and living an intellectual lifestyle help to maintain cognitive function and possibly even prevent cognitive decline and the onset of dementia (Stern 2002; Valenzuela and Sachdev 2006). This is because higher cognitive reserve may provide a greater capacity to cope with pathological insults to the brain, or it may take longer for persons who live these intellectual lifestyles to reach the threshold of dementia detection (Stern 2002). Men in Korea have, in general, had more opportunities for higher educational and occupational attainment, which may stimulate lifelong intellectual activities, than women. This may suggest higher levels of cognitive reserve for men, contributing to their slower decline in cognitive function (Lee and Kim 2017).

In addition, the life course perspective suggests that gender differences in cognitive aging may progress cumulatively over an individual's life course through the long-term trajectories of individual development and the enduring influences of past experiences (Elder 1994; McDonough and Walters 2001; Pearlin, Schieman, Fazio, and Meersman 2005; Ryder 1985). More specifically, women's educational and occupational attainments in their early life yield lifelong profiles of social and economic standings, which could play an important role regarding their cognitive well-being in later life (Ferraro, Shippee, and Schafer 2009; Schaie, Willis, and Pennak 2005). In other words, cognitive decline in old age may reflect cumulative disadvantages from early life and adulthood, disruptive life events, and health changes (Chen, Chiao, and Ksobiech 2014). Relatedly, it suggests that the negative influence of women's low socioeconomic status on cognitive function may be cumulative with age, resulting in the largest gender gaps in cognitive functioning in old age. Thus, it appears that women may not only have lower baseline cognitive function but also demonstrate steeper rates of cognitive decline with age than do men.

Although previous studies have revealed that women's disadvantages in regards to cognitive aging are partially due to socio-environmental factors (Lee and Kim 2017; Proust-Lima et al. 2008), it is likely that exposure to socio-environment factors and the effects thereof on cognitive aging may not be same across birth cohorts (Matthews, Marioni, and Brayne 2012). Cohort effects refer to social processes through which individuals who share a birth year move together at a particular life-course stage (Gee et al. 2007). Thus, the social, historical, and cultural forces differ for different birth cohorts, which suggests that cognitive aging will differ across birth cohorts as well (Gerstorf et al.2011).

However, the more important question is whether and to what extent gender gaps in cognitive function vary across birth cohorts, as well as what inter-cohort variations in gender gaps in both mean cognitive functioning and growth rates of cognitive aging can tell us. Though it is true that throughout the 20th century, due to social and cultural factors, individuals' cognitive function has improved with the year of birth (Alwin, Hofer, and McCammon 2006; Flynn 2007; Gerstorf et al. 2011; Schaie 2005), it is less clear whether cohort improvement in cognitive aging contributes to a reduction in gender gaps in cognitive aging. According to the preserved differentiation hypothesis (Salthouse 2006), if secular trends in social and cultural factors have occurred in parallel in male and female cohorts (Yang and Lee 2009), then gender differences in initial cognitive performance might hold with aging. That is, parallel aging trajectories for men and women by birth cohort will be maintained (Finkel, Reynolds, McArdle, and Pedersen 2007), so that women's disadvantages in cognitive aging will be less likely to further reduce their cognitive function. In contrast, based on the differential preservation hypothesis (Salthhouse 2006), if the multiple social forces that contribute to gender differences have not occurred equally across male and female cohorts but have been more favorable to recent female cohorts (Yang and Lee 2009), then gender differences in the cognitive aging trajectories may not be parallel across birth cohorts but be convergent for more recent cohorts. This implies that changes in gender-specific exposure to social factors across birth cohorts may contribute to narrowing gender gaps in cognitive aging in the future.

Korea is one of the most rapidly developed countries in the world, and, as such, women who came of age during recent decades in Korea may have experienced more favorable changes in their social, economic, and cultural conditions, which could have narrowed the gender gap in cognitive aging. One example of these rapid social changes is educational expansion in Korea: roughly half of the population aged 13 years and over was illiterate in 1945 after liberation from Japanese colonial rule (Lee et al. 2012), but by 2005, about 32 percent of those aged between 25 and 64 had a college degree (OECD 2005). More importantly, the percentage of women enrolled in college has continuously increased from 22 percent in 1965 to 32 percent in 1995 (Kang et al. 2005). Thus, favorable social changes may be contributing to the smaller gender gaps in cognitive aging for more recent female cohorts compared to earlier birth cohorts.

In sum, to address the phenomenon of gender differences in cognitive decline in Korea, I addressed the following research questions: (1) whether there is cohort heterogeneity in both levels of cognitive function and cognitive aging, with more recent birth cohorts having higher cognitive functioning and slower declines of cognitive aging; (2) whether and to what extent gender differences in the cognitive function and the decline of cognitive aging differ across birth cohorts, suggesting gender disparities in cognitive aging decrease in more recent cohorts; and (3) what social risk factors are associated with gender-cohort specific phenomena on cognitive aging.

Methods

Data

The data I used for this study came from the KLoSA, a nationally representative longitudinal survey of non-institutionalized Koreans 45 years old or older, that began in 2006 and has been conducted every two years since (KEIS 2018). Multiple birth cohorts were interviewed in 2006 (N=10,254) and monitored with five follow-up surveys, in 2008 (N=8,688), 2010 (N=7,920), 2012 (N=7,486), 2014 (N=7,029), and 2016 (N=6,618); the majority of attrition in subsequent waves is due to non-response (N=2,691) and death (N=994). In order to estimate the trajectory of cognitive aging over time, I limited the sample to those who had completed all six survey waves (a 10-year time period) and had no missing information on cognitive function, leaving 5,270 respondents for analysis (31,620 person-year observations).

The main problems of this approach relate to the loss of cases to follow-up and the sample selection bias, in that the analytic sample includes only respondents who completed all survey waves. Nonrandom selection may occur if death and non-response are related with worse health; individuals who remain in the sample and participating in cognitive testing are more likely to be healthier, be in more recent cohorts, and die later, so that the effect of socioeconomic status and birth cohort may be overestimated (Chen, Yang, and Liu 2010; Zelinski and Kennison 2007). To address this problem, I conducted a sensitivity analysis that allowed for including individuals who died or did not respond to any follow-ups. After that, I employed the same analytic method for the data for all respondents (N=10,041, 42,805 person-year observations), controlling for attrition type by including dummy variables for the deceased and non-respondents (Chen et al. 2010). I have not included the results of this sensitivity analysis in the tables and graphs presented in this article, but I address them in the text to check the robustness of the main findings.

Measures

I assessed cognitive function using the Korean version of the Mini-Mental State Examination (MMSE), the K-MMSE. The MMSE is typically employed for evaluating global cognitive health status (Folstein, Folstein, and McHugh 1975); items such as orientation, recall, language, registration, attention, calculation, and the ability to follow simple commands are tested. Total scores range from 0 to 30, with higher scores indicating higher cognition status.

Age, Gender, and Cohort. I measured age as years but centered age at 65 (mean age of the analytic sample). In addition, to capture the curvilinear association of age and cognitive decline, I added an age-squared covariate to the models. Gender is a dummy variable with male equal to 0 and female equal to 1, and for birth cohort, I grouped respondents into four 10-year birth cohorts. This cohort grouping is to reflect important historical changes over the decades: cohorts 0-3 refer, respectively, to those born during the earlier period of Japanese colonialism (before 1936), the later period of Japanese colonialism (1936-1945), the period of Korean liberation and the Korean War (1946-1955), and the Baby Boom (1956-1961).

Control Variables. To test meaningful cohort and gender effects on cognitive aging, I included variables that are known to differ between individuals and cohorts: socioeconomic status (education, income, etc.) and health conditions (chronic diseases, physical and mental health, daily activities, and health behaviors, etc.). First, level of education is expressed with a dummy variable (0=less than high school, 1=high school graduation or greater), and household income is measured with three dummy variables: low (reference: 0-32 percentile), middle (33-66 percentile), and high (67-100 percentile) income. I also included employment status (0=not currently employed, 1=currently employed), marital status (0=not currently married, 1=currently married), region of residence (0=metropolitan, 1=city, 2=rural). The health-related variables I considered were poor self-rated health (yes=1, no=0), normal instrumental activities of daily living (IADL; yes=1, no=0), normal activities of daily living (ADL; yes=1, n=0), disability (yes=1, no=0), depressed (yes=1, no=0), being obese (yes=1, no=0), sum of chronic diseases (self-reported diagnosis of hypertension, diabetes, cancer, lung disease, hepatic disease, heart disease, stroke, mental illness, and arthritis), regular exercise (yes=1, no=0), binge drinking (yes=1, no=0), and no history of smoking (yes=1, no=0). Lastly, to consider the effects of social support on cognitive function, I included frequency of contact with family members and friends (0=almost no contact, 1=1~3 times per month, 2= 1~3 times per week, 3= almost every day).

Analytic Plan

I employed growth curve hierarchical linear models to simultaneously estimate intra- and inter-cohort differences in age-trajectories of cognitive function (Raudenbush and Bryk 2002; Yang 2007). This model is conventional in estimating cohort differences in age trajectories of cognitive function using panel data with multiple age cohorts for multiple waves (Finkel et al. 2007; Miyazaki and Raudenbush 2000; Raudenbush and Bryk 2002; Zelinski and Kennison 2007), and allows for rapid accumulation of information on age for multiple cohorts (Chen et al. 2010). The panel data have two levels, with repeated measurements (wave or age) of level one being nested within individuals at level two, so I specify two-level HLMs to estimate age trajectories of cognitive function and heterogeneity in these trajectories by cohort and gender. As seen in the equation below, at level 1, the dependent variable Y_{it} for person i, time t is modeled as a function of age (A):

$$\text{Level 1 Model: } Y_{it} = \beta_{0i} + \beta_{1i}A_{it} + \beta_{2i}A^2{}_{it} + \textstyle\sum_1^p \beta_p X_{pit} + e_{it}$$

The level 1 model characterized within-individual growth trajectories with age. Both simple linear and quadratic age models are estimated by including linear term A and quadratic term A^2 of age. The coefficients β_{0i}, β_{1i} and β_{2i} represent the intercept of mean level, the linear growth rate, and the quadratic growth rate of cognitive function with age, respectively. The coefficient β_p represents within-person time-varying explanatory variables or covariates (here, household income, region, marital status, etc.) for p = 1…., P, where P is the maximum number of such covariates. The random within-person error term e_{it} is assumed to be normally distributed.

The level 2 model was for estimating whether men and women from various cohorts manifested different cognitive function levels by age. At level 2, each parameter of the age trajectories was further modeled as a function of person-level attributes: birth cohort (C), gender (= female) (F), interaction effects of cohort and gender (FC), and time-invariant covariates (Z) (here, education).

Level 2 model: for the intercept:

$$\beta_{0i} = \Upsilon_{00} + \Upsilon_{01}C_i + \Upsilon_{02}F_i + \Upsilon_{03}FC + \Sigma_1^q \Upsilon_{0q}Z_{qi} + u_{0i}$$

Level 2 model: for the linear growth rate:

$$\beta_{1i} = \Upsilon_{10} + \Upsilon_{11}C_i + \Upsilon_{12}F_i + \Upsilon_{13}FC + u_{1i}$$

Level 2 model: for the quadratic growth rate:

$$\beta_{2i} = \Upsilon_{20} + \Upsilon_{21}C_i + u_{2i}$$

In the level 2 model for the intercept, β_{0i}, Υ_{01}–Υ_{0q} are coefficients for the effects of cohort, gender, the interaction of cohort and gender, and time-invariant variables. In the model for the linear growth rate, β_{1i}, Υ_{11}–Υ_{13} are coefficients for the effects of cohort, gender (woman), and the interaction of cohort and gender on the linear rate of cognitive change with age; I ran a similar model for the quadratic growth rate, β_{2i}. I did not explicitly incorporate period effects in the analysis because the growth curve model with longitudinal data can use either age or wave for the time indicator (Chen et al. 2010; Singer and Willett 2003).

Results

Descriptive Statistics

Table 1 presents the weighted descriptive statistics for the analytic sample at baseline (Wave1, 2006) by gender. To begin, for the total sample, the average of cognitive score is 27.7,[2] indicating normal cognitive function. As expected, women tend to report lower cognitive scores compared to men. I also observe gender differences in educational attainment and employment status. About half of men had high school and above levels of education while only 30 percent of women did. As for employment status, men are more likely to

[2] I used the MMSE scores for cognitive function and cognitive function is categorized by following criteria: 17 and below is diagnosed as dementia, 18-23 implies cognitive impairment, 24 and over means normal cognitive function (Folstein et al. 1975).

Table 1
Weighted Descriptive Statistics of Analytic Sample in 2006 (N=5,270)

Variables	Total	Male	Female	Significance Test (t-test)
Cognitive Score	26.70	27.68	25.90	***
Age at 2006	57.39	56.56	58.07	
Birth Cohort				
Before 1936	9.76	7.17	11.91	*
1936-1945	24.7	22.79	26.28	
1946-1955	37.22	40.23	34.72	*
1956 and after	28.32	29.82	27.08	
Female	54.7			
Education				
Middle school and below	56.07	41.16	68.42	***
High school and above	43.93	58.84	31.58	***
Married	85.71	94.08	78.77	***
Employed	49.77	72.35	31.07	***
Income				
Low	29.83	26.11	32.90	***
Middle	34	33.75	34.22	
High	36.17	40.14	32.88	***
Region				
Metropolitan	43.29	43.53	43.08	
City	31.59	32.55	30.79	
Rural	25.12	23.91	26.13	
Frequency of Contact				
Almost no contact	14.75	14.72	14.77	
1~3 times per month	19.11	23.49	15.49	***
1~3 times per week	32.76	32.54	32.95	
Almost everyday	33.38	29.25	36.80	***
Poor Self-rated Health	23.06	14.62	30.04	***
Never Smoked	69.86	36.83	97.22	***
Binge Drinking	10.14	19.33	2.54	***
Regular exercise	40.77	43.54	38.48	***
Depressed	9.32	5.72	12.3	***
Being Obese	25.15	23.82	26.26	**
Normal ADL	98.57	98.85	98.33	
Normal IADL	91.27	88.59	93.49	***
Disability	5.05	6.36	3.96	***
Sum of Chronic Disease	0.61	0.52	0.68	***

Note.—*** Different from male and female at p <.001, ** Different from male and female at p < .01, * Different from male and female at p < .05

Table 2
Growth Curve Model Estimates of Cohort, Age, Female Effects on Cognitive Function

Variables		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
For Intercept	β_{0i}						
Intercept (age-centered)	Υ_{00}	24.410***	25.262***	26.288***	25.908***	22.918***	22.361***
		(0.10)	(0.11)	(0.15)	(0.17)	(0.22)	(0.23)
Cohort	Υ_{01}	1.079***	1.048***	0.413***	0.126	0.205*	0.200*
		(0.06)	(0.05)	(0.08)	(0.08)	(0.08)	(0.08)
Female	Υ_{02}		-1.425***	-3.159***	-2.517***	-2.223***	-2.208***
			(0.08)	(0.19)	(0.19)	(0.19)	(0.19)
Cohort*Female	Υ_{03}			1.080***	1.002***	0.853***	0.837***
				(0.11)	(0.11)	(0.10)	(0.10)
For Linear Growth Rate	β_{1i}						
Intercept (age-centered)	Υ_{10}	-0.211***	-0.167***	-0.180***	-0.173***	-0.158***	-0.156***
		(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Cohort	Υ_{11}	0.095***	0.088***	0.076***	0.076***	0.076***	0.075***
		(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Female	Υ_{12}		-0.062***	-0.036*	-0.049***	-0.050***	-0.054***
			(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Cohort * Female	Υ_{13}			0.019**	0.026***	0.024***	0.026***
				(0.01)	(0.01)	(0.01)	(0.01)
For Quadratic Growth Rate	β_{2i}						
Intercept (age-centered)	Υ_{20}	-0.002**	-0.002**	-0.002***	-0.002**	-0.000	0.000
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Cohort	Υ_{21}	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Socioeconomic Status							
High School and above					1.200***	0.972***	0.954***
					(0.07)	(0.07)	(0.07)
Region (ref. Metropolitan)							
City					-0.454***	-0.467***	-0.418***
					(0.07)	(0.07)	(0.06)
Rural					-0.578***	-0.519***	-0.516***
					(0.08)	(0.07)	(0.07)
Employed					0.295***	0.190***	0.178***
					(0.05)	(0.05)	(0.05)
Household Income (ref. low)							
Middle					0.007	-0.028	-0.038
					(0.06)	(0.06)	(0.06)
High					0.245***	0.125+	0.105
					(0.07)	(0.07)	(0.07)
Currently Married					0.198*	0.127	0.115
					(0.08)	(0.08)	(0.08)
Health-related Variables							
Poor Self-rated Health						-0.810***	-0.788***
						(0.05)	(0.05)

TABLE 2
GROWTH CURVE MODEL ESTIMATES OF COHORT, AGE, FEMALE EFFECTS ON COGNITIVE FUNCTION

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Depressed					-0.469***	-0.460***
					(0.09)	(0.09)
Normal IADL					1.093***	1.094***
					(0.08)	(0.08)
Normal ADL					2.394***	2.340***
					(0.14)	(0.14)
Disabled					-0.515***	-0.498***
					(0.12)	(0.11)
Being Obese					0.071	0.073
					(0.05)	(0.05)
Number of Chronic Diseases					-0.151***	-0.149***
					(0.03)	(0.03)
Regular Exercise					0.466***	0.450***
					(0.04)	(0.04)
Binge Drinking					-0.120	-0.114
					(0.08)	(0.08)
Never Smoked					-0.150+	-0.130
					(0.08)	(0.08)
Social Support						
Frequency of Contact (ref. almost no contact)						
1~3 times per month						0.798***
						(0.07)
1~3 times per week						0.735***
						(0.06)
Almost Everyday						0.610***
						(0.07)
Random Effects- Variance Components						
Level 1: Within-person	2.829	2.830	2.826	2.829	2.786	2.786
Level 2: In intercept	2.532	2.421	2.410	2.283	2.124	2.077
In growth rate	0.134	0.129	0.129	0.127	0.116	0.115
Correlation between Intercept and Slope	0.881	0.868	0.867	0.894	0.896	0.893
Log likelihood	-82506.7	-82351.1	-82302.8	-82054.8	-81328.3	-81245.1

Note.—Standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, + p<0.1

be currently employed than women. Health status and health-related behaviors also differ by gender. Women are more likely to report their general health as poor, to suffer from depressive symptoms, to be disabled, and/or to have higher numbers of chronic diseases. However, health-related behaviors including smoking and binge drinking are worse for men than women; men are more likely to smoke and/or to engage in binge drinking than women.

Cohort Heterogeneity in Cognitive Decline

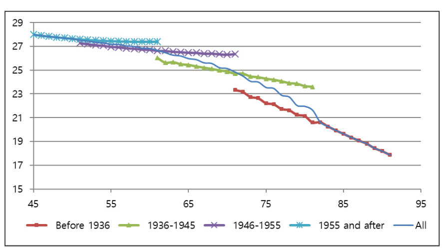
Table 2 presents the findings from estimating the HLM-growth curve models. I begin with Models 1 through 6, which successively add the variables for cohort, gender (woman), the interaction of cohort-by-gender, and control variables for the intercept and linear and quadratic growth rate models. Model 1 exhibited significant associations of age and cohort with cognitive function. Consistent with previous studies, I observed a curvilinear association between age and cognitive scores indicated by the coefficients for the linear and quadratic growth rates ($\Upsilon_{10} = -0.211$, $p < 0.001$, $\Upsilon_{20} = -0.002$, $p < 0.01$); cognitive function decreased with age but did not start to fall until very old age.

Next, there were significant cohort variations in both mean levels and growth rates of cognitive function when controlling for age effects. Specifically, more recent cohorts had higher mean cognitive scores; scores in each successive cohort were on average 1.08 points higher ($\Upsilon_{01} = 1.08$, $p < 0.001$). In addition, I expected cognitive function decline to differ considerably by birth cohort on the presumption that cognitive aging is not purely an aging effect but also is affected by social and historical contexts as defined by cohort membership. Indeed, more recent cohorts show slower declines in cognitive scores ($\Upsilon_{11} = 0.1$, $p < 0.001$), and this declining cognitive trajectory with age is further tilted by birth cohort where the initial, baseline gap in cognitive function between earlier and more recent cohorts increases with age.

Gender and Cohort Differences in Cognitive Decline

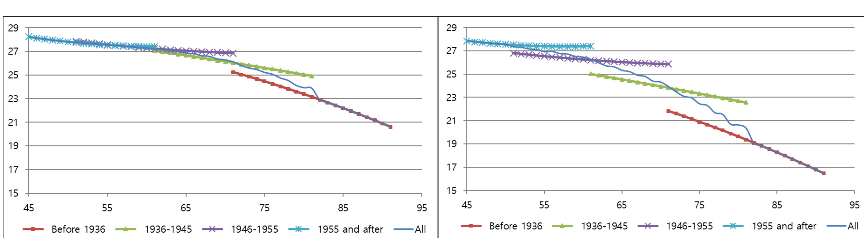
Model 2 reports significant and negative gender effects in mean cognitive function scores: women's scores were on average 1.4 points lower than men's scores ($\Upsilon_{02} = -1.43$, $p < 0.001$). This gendered disadvantage in cognitive ability for women exacerbates with advancing age, as indicated by the negative gender effects on the growth rate ($\Upsilon_{12} = -0.06$, $p < 0.001$); at age 65 (mean age of the sample), women's scores were 1.4 points lower, but at age 85, for example, the gender gap increased to 2.7 points lower ((-0.062*20) + (-1.43) = 2.7). This result suggests that a gender disadvantage for women not only presents but also escalates with age, indicating more severe cognitive deficits in women among the elderly than among the middle-aged population.

Next, Model 3 examines whether and to what extent women's disadvantages in cognitive function vary across birth cohort, which includes gender-by-cohort interaction effects for the intercept and growth rate models. As seen in Model 3, there are positive gender-by-cohort-interaction (Υ_{03} = 1.08, p <0.001) effects for mean cognitive function; this suggests cohort effects on gender difference where the larger female disadvantages are in the earlier cohorts and decrease in size in more recent cohorts. There are also positive gender-by-cohort interaction effects for the growth rates of cognitive function (Υ_{13} = 0.02, p <0.01); the significant three-way interaction (age-by-cohort-by-gender) affects gender gaps in cognitive aging growth rates that decrease across birth cohorts such that the age-associated gender



Total

Fig. 1-1.—Predicted Age Growth Trajectories of Cognitive Score by Birth Cohort



Men Women

Fig. 1-2.—Predicted Age Growth Trajectories of Cognitive Score by Birth Cohort

gaps in later-born cohorts are smaller than in earlier cohorts.

In Figures 1_1 to 1_3, the Model 3 results are shown for estimating gross cohort and gender differences in growth trajectories in cognitive aging for total, men, and women, respectively. Figure 1_1 presents the predicted cohort differences in age trajectories in cognitive functions. As seen in Figure 1_1, cohort differences in cognitive aging are substantial, indicating that each successive birth cohort does not share the same growth trajectory as they age; specifically, more recent cohorts showed, on average, better cognitive function and less steep cognitive decline with age. For example, individuals ages 71 belonging to the birth cohort of those born prior to 1936 had an average cognitive score of 22, whereas the corresponding figure for the same age was 24.6 for the 1936-45 cohort and 26 for the 1945-55 cohort.

As seen in Figures 1_2 and 1_3, however, cohort differences in cognitive aging trajectories vary by gender. In general, men do not show significant cohort differences in age-related cognitive decline, but women exhibit substantial cohort differences in cognitive aging. For example, the predicted cognitive scores of respondents ages 71 belonging to the birth cohort of those born prior to 1936 were 25 for men and 22 for women, whereas the corresponding figures for the 1945-55 cohort were 27 for men and 26 for women. This implies that while men have not experienced meaningful cognitive improvements in each consecutive birth cohort, women seem to enjoy continuous improvements in average performance and slower rates of cognitive decline in each successive birth cohort, reflecting more favorable life experiences for women in recent cohorts due to rapid social developments and changes in cultural circumstances.

Figure 2 provides a better description of different gender gaps in

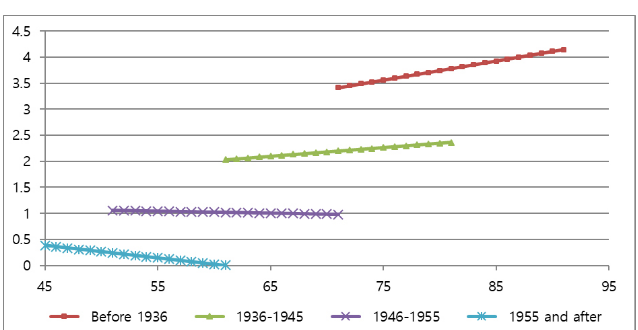


FIG. 2.—GENDER DIFFERENCES IN PREDICTED AGE GROWTH TRAJECTORIES OF COGNITIVE SCORE BY BIRTH COHORT

cognitive aging by cohort; gender gaps in age trajectories of cognitive function are not constant but vary across birth cohort. The gap first diverges with age in the earliest cohort (born before 1936) and then shows a trend of decreasing degrees of divergence in the 1936-1945 cohort before becoming almost constant in the two later-born cohorts. Overall, this reflects a trend of decreasing degrees of divergences in the aging trajectories between men and women, suggesting fewer disadvantages in cognitive aging for women belonging to later-born cohorts and in the future.

Conditional Gender and Cohort Effects in Cognitive Decline

The results from models 4~6 presented in Table 2 show that the patterns of cognitive aging by birth cohort and gender still exist after controlling for socioeconomic and health-related variables, although the magnitudes of the cohort and gender coefficients in the mean cognitive function score and growth trajectories decrease. Specifically, when adjusting for socioeconomic status (Model 4), while age effects remained similar (26.3 -> 26), cohort differences in the mean cognitive function scores declined substantially and were no longer statistically significant (0.413 -> 0.126). In addition, gender differences in mean cognitive function score decreased (-3.16 -> -2.52). This implies that being highly educated, employed, and/or married and/or living in metropolitan areas largely account for cohort and gender differences in cognitive function.

Model 5 adjusts for health status, namely, mental and physical health and health-related behaviors. As expected, poor health status associated with advancing age, including poor physical and mental health, disability, and/or high numbers of chronic disease, were significantly linked to negative cognitive function. In addition, respondents who have difficulties with daily activities are more likely to have lower levels of cognitive function than those who do not face difficulty performing daily activities. Among health-related behaviors, regular exercise works as an important protective factor for cognitive function. Holding constant health and health-related behavior variables, the mean level and growth rates of age and female effects on cognitive function diminished but are still statistically significant.

Model 6, the final model, controls for the effects of social support as well as socioeconomic status and health conditions. The results show that frequent contact with family and friends is positively associated with higher levels of cognitive function. This implies that social contact with close friends and family may increase a person's social and emotional support and social interactions, resulting in better cognitive performance. Although adjusting for these factors slightly decreased the age, cohort, and gender effects on cognitive function, female disadvantages in cognitive aging are not fully explained by women's disadvantages in socioeconomic and health-related status because female disadvantages are still statistically significant. Moreover, there are also significant gender-by-cohort effects in cognitive aging, which implies that cohort and gender effects represent different exposures to socio-environmental circumstances beyond individuals' own characteristics and/or some biological factors.

Sensitivity Analysis

For sensitivity, I conducted the same analysis using the sample with all persons with no missing information on cognitive scores (n=10,041, 42,805 person-year observations) regardless of attrition status and controlling for the attrition types (i.e., non-response, died, attrition). In this analysis, respondents who died or did not respond or did not interview at any follow-up are more likely to have low levels of cognitive scores compared to those who stayed in the sample. It also shows that the mean levels of cohort effects from the Model 1 are 5.32, while the corresponding figures from the balanced data (Table 2) are 1.08. This implies that respondents who did not follow-up are less likely to be young, be healthier, and be in a recent cohort, so that respondents who remain in the sample continuously, especially among the older cohorts are relatively healthier and have better cognitive function (smaller cohort effects). Despite these differences, the main findings were robust: 1) there are cohort differences in the mean levels and growth rate of cognitive aging, and 2) gender gaps in cognitive aging vary across birth cohorts (significant cohort-by-gender interaction effects on the trajectory of cognitive aging).

Discussion and Conclusion

From the turn of the 20th century until recently, men in Korea enjoyed higher socioeconomic status on average than women, including higher educational and occupational attainments. However, men's relative advantages in socioeconomic status have steadily declined to the extent that gender differences in socioeconomic status have become smaller for younger cohorts. It is important to investigate whether and to what extent historical contexts and social changes have influences on gender inequalities in health. Thus, I examined whether and how successive birth cohorts differ in cognitive aging and whether cohort differences in cognitive aging have contributed to reducing female disadvantages in cognitive aging in Korea. To do this, I applied growth curve models to the six waves of panel data and estimated cohort and gender differences in age-related rates of cognitive decline.

The first research question concerned whether there is cohort heterogeneity in both the mean levels and the age growth trajectories of cognitive function. Consistent with previous studies from other countries (Gerstorf et al. 2011; Schaie 2005), the results indicate that initial cohort differences are not only existent but also even exacerbated with advancing age, with slower age-related declines among individuals who were born later. This implies that cognitive decline entails the dynamic processes of aging, cohort-related changes, and their interaction effects, highlighting the importance of examining cohort effects on cognitive aging.

The second question addressed whether and to what extent gender differences in levels and growth rates of cognitive aging differ across birth cohort. I found that gender disparities in mean cognitive function scores decreased across birth cohorts, suggesting that overall cohort improvements in socioeconomic status led directly to better cognitive function for women in the most recent cohorts, thereby reducing their disadvantages in cognitive function compared with their male counterparts. I also found that the patterns of gender gap changes with age were modified by birth cohort memberships, cohort-by-gender interaction effects in the growth rates of cognitive aging trajectories; in other words, gender gaps become smaller with advancing age across successive birth cohorts. This finding indicates that women's disadvantages in cognitive aging will continue to decrease given the continuous improvements in the social and cultural circumstances for women. This finding may be due to the uniqueness of Korean society, which has become one of the fastest-changing societies in the world in recent decades; these changes enabled studying gender-by-cohort effects on cognitive aging.

Lastly, I asked what social risk factors are associated with gender-cohort effects on cognitive aging. As expected, socioeconomic status, marital status, physical and mental health, and social support reduce both age and cohort effects and gender gaps in initial cohort scores and age trajectories for cognitive function. However, the effects of cohort, gender, and the interaction between cohort and gender in cognitive aging remained significant. These findings suggest that social and historical circumstances that were not considered in the model and/or biological factors may play roles in the changes in cohort and gender effects on cognitive aging.

This study has some limitations to be considered. First, gender differences in selective survival, including life expectancy, may have an important influence on gender gaps in cognitive aging; because women live longer than men on average, relatively healthier men and unhealthier women remain in the data as they age. In addition, if gender differences in life expectancy vary by birth cohort, then gender gaps in cohort variation of cognitive aging are also likely to be affected. However, although life expectancy in Korea has increased since 1940, gender gaps in life expectancy have held steady at 6~8 years (Kostat 1957, 2017). Moreover, the results of a sensitivity analysis controlling for attrition showed that selective survival did not change the substance of main findings.

Second, although KoWePS is a nationally representative sample that includes a variety of birth cohorts over a 10-year span of time, it is impossible to observe cognitive decline for the same ages per each birth cohort. This means that cohort effects presented in this study are not purely cohort driven but partially embedded with an age effect. This current study is a beginning step for taking into account cohort effects in gender differences in cognitive aging, so when data with a longer period become available in the future, I will do a more extensive analysis, including examining cognitive aging for larger age overlaps in each birth cohort as well as adding more recent birth cohorts such as post-baby boomers and generation Xers with smaller gender differences in socioeconomic status.

Lastly, I used the K-MMSE to examine overall cognitive function, but cognitive function can be divided into specific domains (verbal and spatial ability, memory, processing speed). The effects of cohort and gender may differ by each cognitive function domain, and if there are differences, the reasons for the different influences of gender and cohort on each specific domain will also vary.

Despite these limitations, this study provides important contributions to the literature on health and social welfare policy in the era of Korea's rapidly aging society. First, by separating the positive effects of birth cohort from the processes that underlie aging in cognitive function, I determined that social and cultural efforts may result improved cognitive function and slower cognitive aging. Moreover, improvements in cognitive function have larger benefits in more recent female cohorts so that gender gaps in cognitive aging are likely to be lower in the future. This information is critical to policy makers in predicting the future social and economic burdens of cognitive impairment and Alzheimer's disease given that the prevalence and incidence of AD tend to be gender specific.

(*Submitted*: October 1, 2019; *Revised*: December 4, 2019; *Accepted*: December 6, 2019)

References

a2017001. (2017). Korea to Take More Responsibility for Dementia Patients. *The Korea Herald*: http://news.koreaherald.com/view.php?ud=20170607000559

Alwin, Duane F., Hofer, Scott M., and McCammon, Ryan J. 2006. "Modeling the Effects of Time: Integrating Demographic and Developmental Perspectives". In *Handbook of Aging and the Social Sciences (Sixth Edition)* (pp. 20-38): Elsevier.

Baik, Ok Mi. 2015. "The Trajectory and Its Predictors of the Change of Cognitive Functioning among the Elderly - a Latent Curve Analysis-". *Journal of Social Science,* 39(3): 79-103.

CDC. 2013. "The Healthy Brain Initiative: The Public Health Road Map for State and National Partnerships, 2013-2018". Alzheimer's Association and Centers for Disease Control and Prevention. Chicago, IL: https://www.cdc.gov/aging/pdf/2018-2023-Road-Map-508.pdf

Chang, Kyung-Sup. 2010. *South Korea under Compressed Modernity: Familial Political Economy in Transition*. London and New York: Routledge.

Chen, Feinian, Yang, Yang, and Liu, Guangya. 2010. "Social Change and Socioeconomic Disparities in Health over the Life Course in China: A Cohort Analysis". *American Sociological Review,* 75(1): 126-150.

Chen, Yun-Yu, Chiao, Chi, and Ksobiech, Kate. 2014. "The Effects of Mid-Life Socioeconomic Disadvantage and Perceived Social Support on Trajectories of Subsequent Depressive Symptoms among Older Taiwanese Women". *BMC Public Health,* 14(1): 384.

Connell, Raewyn. 2012. "Gender, Health and Theory: Conceptualizing the Issue, in Local and World Perspective". *Social Science and Medicine,* 74(11): 1675-1683.

Elder Jr, Glen H. 1994. "Time, Human Agency, and Social Change: Perspectives on the Life Course". *Social Psychology Quarterly,* 57(1): 4-15.

Ferraro, Kenneth F., Shippee, Tetyana P., and Schafer, Markus H. 2009. "Cumulative Inequality Theory for Research on Aging and the Life Course". Pp. 413-433, in *Handbook of Theories of Aging*, edited by Benston, V. L., Gans, D., Pulney, N. M., and Silverstein, M. New York, NY, US: Springer Publishing Co.

Ferree, Myra M. 2010. "Filling the Glass: Gender Perspectives on Families". *Journal of Marriage and Family,* 72(3): 420-439.

Finkel, Deborah, Reynolds, Chandra A., McArdle, John J., and Pedersen, Nancy L.

2007. "Cohort Differences in Trajectories of Cognitive Aging". *The Journals of Gerontology Series B: Psychological Sciences Social Sciences,* 62(5): 286-294.

Flynn, James R. 2007. *What Is Intelligence?: Beyond the Flynn Effect*: Cambridge University Press.

Folstein, Marshal F., Folstein, Susan E., and McHugh, Paul R. 1975. ""Mini-Mental State": A Practical Method for Grading the Cognitive State of Patients for the Clinician". *Journal of Psychiatric Research,* 12(3): 189-198.

Gee, G. C., Pavalko, E. K., Long, J. S. 2007. "Age, Cohort and Perceived Age Discrimination: Using the Life Course to Assess Self-Reported Age Discrimination." *Social Forces*, 86(1): 265-290.

Gerstorf, Denis, Ram, Nilam, Hoppmann, Christiane, Willis, Sherry L., and Schaie, K. Warner. 2011. "Cohort Differences in Cognitive Aging and Terminal Decline in the Seattle Longitudinal Study". *Developmental Psychology,* 47(4): 1026.

Hwang, Jongnam, Park, Sangmin, and Kim, Sujin. 2018. "Effects of Participation in Social Activities on Cognitive Function among Middle-Aged and Older Adults in Korea. *International Journal of Environmental Research and Public Health,* 15(10): 2315.

Kang Seongkook, Lee, Gwanghyeon, Park, Hyeonjeong, and Kim. Kiseok. 2005 (In Korean). *Hanggukgyoyoung 60eyeon seongjange daehan gyoyukjipyo bunseok* [*Analysis on the Growth of Korean Education for 60 Years]*. Hangukgyoyukagebarwon [Korean Educational Development Institute].

KEIS. 2018. *KLoSA User's Guide*. Korea Employment Information Service

Kim, DaeHyun, Arai, Hidenori, and Kim, SungHi. 2017. "Social Activities Are Associated with Cognitive Decline in Older Koreans". *Geriatrics and Gerontology International,* 17(8): 1191-1196.

Kim, Hye-Ryoung and Yang, Migyeong. 2013 (In Korean). "Hangugui 60se isang noinui injijangaewa wiheomyoin [Cognitive Impairment and Risk Factors among Elderly Persons Aged 60 or More in Korea]". *Hangukbogeonganhohakoeji [Journal of Korean Public Health Nursing],* 27(3): 450-465.

KOSTAT. 1957. "Annual Health Social Statistics 1955-1957". Statistics Korea: http://www.mohw.go.kr/react/jb/sjb030301vw.jsp

KOSTAT. 2017. "Life Expectancy 1970-2017". Statistics Korea: http://www.index.go.kr/potal/stts/idxMain/selectPoSttsIdxSearch.do?idx_cd=2758

KOSTAT. 2018. "The Prevalence Rate of Dementia in Korea 2012-2060". Statistics Korea: https://www.nid.or.kr/info/ub_2017.aspx?no=15157

Lee, Chong Jae, Kim, Young, and Byun, Soo-Yong. 2012. "The Rise of Korean Education from the Ashes of the Korean War". *Prospects,* 42(3): 303-318.

Lee, Jinwoo and Kim, Cheong-Seok. 2017. "Longitudinal Evidence of Social Influences on Cognitive Decline in South Korea: Focusing on the Joint Effects of Age, Gender, and Education". *Development and Society,* 46(1): 157-177.

Matthews, Fiona, Marioni, Riccardo, and Brayne, Carol. 2012. "Examining the Influence of Gender, Education, Social Class and Birth Cohort on MMSE

Tracking over Time: A Population-Based Prospective Cohort Study". *BMC Geriatrics,* 12(1): 45.

McDonough, Peggy and Walters, Vivienne. 2001. "Gender and Health: Reassessing Patterns and Explanations". *Social Science and Medicine,* 52(4): 547-559.

Mielke, Michelle M., Vemuri, Prashanthi, and Rocca, Walter A. 2014. "Clinical Epidemiology of Alzheimer's Disease: Assessing Sex and Gender Differences". *Clinical Epidemiology, 6*: 37-48.

Miyazaki, Yasuo and Raudenbush, Stephen W. 2000. "Tests for Linkage of Multiple Cohorts in an Accelerated Longitudinal Design". *Psychological Methods,* 5(1): 44.

OECD. 2005. *Education at a Glance 2005: OECD Indicators*. OECD Publishing: Paris.

Park, H. L., O'Connell, J. E., Thomson, R. G. 2003. "A Systematic Review of Cognitive Decline in the General Elderly Population." *International Journal of Geriatric Psychiatry*, 18(12): 1121-1134.

Pearlin, Leonard I., Schieman, Scott, Fazio, Elena M., and Meersman, Stephen C. 2005. "Stress, Health, and the Life Course: Some Conceptual Perspectives". *Journal of Health and Social Behavior,* 46(2): 205-219.

Proust-Lima, Cecile, Amieva, Hélène, Letenneur, Luc, Orgogozo, Jean-Marc, Jacqmin-Gadda, Hélène, and Dartigues, Jean-F François. 2008. "Gender and Education Impact on Brain Aging: A General Cognitive Factor Approach". *Psychology Aging,* 23(3): 608.

Raudenbush, Stephen W. and Bryk, Anthony S. 2002. *Hierarchical Linear Models: Applications and Data Analysis Methods* (Vol. 1): Sage.

Ryder, Norman B. 1985. "The Cohort as a Concept in the Study of Social Change". Pp. 9-44, in *Cohort Analysis in Social Research*: Springer.

Salthouse, Timothy A. 2006. "Mental Exercise and Mental Aging: Evaluating the Validity of the "Use It or Lose It" Hypothesis". *Perspectives on Psychological Science,* 1(1): 68-87.

Schaie, K. Warmer. 2005. *Developmental Influences on Adult Intelligence: The Seattle Longitudinal Study*: Oxford University Press.

Schaie, K. Warmer, Willis, Sherry L., and Pennak, Sara. 2005. "An Historical Framework for Cohort Differences in Intelligence". *Research in Human Development,* 2(1-2): 43-67.

Singer, J. D., Willett, J. B. 2003. *Applied Longitudinal Data Analysis: Modeling Change and Event Occurrence*: Oxford university press.

Stern, Yaakov. 2002. "What Is Cognitive Reserve? Theory and Research Application of the Reserve Concept". *Journal of the International Neuropsychological Society,* 8(3): 448-460.

Umberson, Debra. 1992. "Gender, Marital Status and the Social Control of Health Behavior". *Social Science and Medicine, 34*(8): 907-917.

Valenzuela, Michael J. and Sachdev, Perminder. 2006. "Brain Reserve and Dementia: A Systematic Review". *Psychological Medicine,* 36(4): 441-454.

Yang, Yang. 2007. "Is Old Age Depressing? Growth Trajectories and Cohort

Variations in Late-Life Depression". *Journal of Health and Social Behavior,* 48(1): 16-32.

Yang, Yang and Lee, Linda C. 2009. "Sex and Race Disparities in Health: Cohort Variations in Life Course Patterns". *Social Forces,* 87(4): 2093-2124.

Zelinski, Elizabeth M. and Kennison, Robert F. 2007. "Not Your Parents' Test Scores: Cohort Reduces Psychometric Aging Effects". *Psychology Aging,* 22(3): 546-557.

YUJIN KIM PhD, is an assistant professor of sociology at Kangwon National University. Her research interests include demography of aging, social and gender differentials in life course trajectories of health, and family relationships in later life. [E-mail: yjkim3@kangwon.ac.kr]