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Normative Study of the Literacy Independent Cognitive Assessment in Illiterate and Literate Elderly Koreans

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Objective The aim of this study was to provide normative data on the Literacy Independent Cognitive Assessment (LICA) and to explore the effects of age, education/literacy, and gender on the performance of this test.

Methods Eight hundred and eighty-eight healthy elderly subjects, including 164 healthy illiterate subjects, participated in this study. None of the participants had serious medical, psychiatric, or neurological disorders including dementia. Bivariate linear regression analyses were performed to examine the effects of age, education/literacy, and sex on the score in each of the LICA cognitive tests. The normative scores for each age and education/literacy groups are presented.

Results Bivariate linear regression analyses revealed that total score and all cognitive tests of the LICA were significantly influenced by both age and education/literacy. Younger and more-educated subjects outperformed older and illiterate or less-educated subjects, respectively, in all of the tests. The normative scores of LICA total score and subset score were presented according to age (60–64, 65–69, 70–74, 75–80, and ≥80 years) and educational levels (illiterate, and 0–3, 4–6, and ≥7 years of education).

Conclusion These results on demographic variables suggest that age and education should be taken into account when attempting to accurately interpret the results of the LICA cognitive subtests. These normative data will be useful for clinical interpretations of the LICA neuropsychological battery in illiterate and literate elderly Koreans. Similar normative studies and validations of the LICA involving different ethnic groups will help to enhance the dementia diagnosis of illiterate people of different ethnicities.

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Key Words LICA, Normative study, Age, Education, Literacy.

INTRODUCTION

Developments in medical science have led to continuing increases in the number of elderly worldwide, with the population aging faster in Korea than in any other country.[1] The proportion of the Korean population aged ≥65 years has reached 12.2%, and is expected to reach 38% by the year 2050.[2] Although the prevalence of dementia has drastically

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increased in parallel with the aging of the overall population, there is as yet no innovative treatment for the condition, and so prompt detection and diagnosis of dementia is very important.

In general, the performance in neuropsychological tests is influenced by educational and cultural factors.[3] Illiterate people have difficulty in responding to tests that require reading and writing skills or copying complex figures, even though they may have a normal level of cognitive function. Thus, the application rate of neuropsychological tests and accuracy of the findings are both quite low among elderly illiterate subjects and elderly subjects with a low educational level. This finding is particularly pertinent since the worldwide illiteracy rate of adults aged 15 years and older, which was as high as 16% in 2009, is expected to be around 15% by 2015.[4,5] In South Korea, the illiteracy rate was relatively low in 2008, at 5.4%;[6] however, the illiteracy and functional-illiteracy rate among those aged in their 70s was reported to be as high as 20.2% in the same year.[7] One study performed in a rural agricultural area found that the illiteracy rate was 26.4% and was associated with a higher risk of Alzheimer's dementia.[8]

The current tests for screening and diagnosing dementia in Korea are simple translation of the Western version, which do not take into consideration the presence of illiteracy in the elderly population. Accordingly, any elderly subject with little or no education but without dementia is likely to have difficulties in properly responding to some of questions of these tests. Therefore, accurate identification and diagnosis of dementia among illiterate elderly subjects is problematic when using these tests. The subjective screening tests for dementia have been developed in an attempt to resolve such inaccuracies, such as the Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE), which has been applied more widely to illiterate and less-educated subjects than has the Mini-mental State Examination (MMSE).[9,10] However, since the IQCODE is not a neuropsychological test, it cannot measure the cognitive function of each cognitive domain. Therefore, we have developed a neuropsychological test battery called the Literacy Independent Cognitive Assessment (LICA), which can be used effectively to test illiterate and less-educated Korean subjects, and have subjected it to a validation study.[11] The authors have also recently developed a short form of this tool and reported on its reliability and validity.[12] Both the LICA and its short form were confirmed as valid and reliable instruments for diagnosing dementia in either illiterate or literate elderly subjects, and were shown to have good sensitivity and specificity.[11,12]

The aim of this study was to present the normative information for this tool, which is useful for a clinical interpretation of the LICA neuropsychological battery in illiterate and literate elderly Koreans.

METHODS

Participants

Eight hundred and eighty-eight healthy elderly subjects (354 males and 534 females; aged 60–90 years) participated in this study, including 164 (18.5%) healthy illiterate participants (Table 1). Illiteracy was determined using the following procedure: All subjects were asked to read aloud two sentences: "Young-Hee was thirsty due to physical exercise. She opened a refrigerator." They were then asked to write about what would happen next. A subject who could read the sentences and write an appropriate response was determined to be literate. Subjects who were illiterate due to learning and developmental difficulties were excluded from this study.

All of the participants were at least 60 years old and had no history of significant or suggestive decline in their cognitive

Table 1. Demographic characteristics of the participants

Variables	Male (N=354)	Female (N=534)	Total (N=888)
Age (years)	72.8±6.3*	72.1±6.8	72.4±6.6
60–64	25 (7.1%)†	66 (12.4%)	91 (10.2%)
65–69	93 (26.3%)	136 (25.5%)	229 (25.8%)
70–74	106 (29.9%)	138 (25.8%)	244 (27.5%)
75–79	72 (20.3%)	110 (20.6%)	182 (20.5%)
80–	58 (16.4%)	84 (15.7%)	142 (16.0%)
Illiteracy and education (years)	8.4±5.1‡	4.5±4.3	6.0±5.0
Illiteracy	25 (7.1%)	139 (26.0%)	164 (18.5%)
1–3	44 (12.4%)	123 (23.0%)	167 (18.8%)
4–6	92 (26.0%)	139 (26.0%)	231 (26.0%)
≥7	193 (54.5%)	133 (24.9%)	326 (36.7%)

*the values are means±SD, †number (percent), ‡mean education years functions based on interviews with them and their family members. They did not have any of the 28 diseases that might involve cognitive decline such as stroke, seizures, and Parkinson's disease, as listed by Christensen et al.[13] They also had scores that were higher than the mean minus 1SD of the Korean version of the MMSE (K-MMSE) in the respective age- and education-matched population.[14] In addition, all of the subjects had an average score of 0.42 or less on the Korean Instrumental Activities of Daily Living (IADL) instrument, which is known to discriminate dementia from normal aging.[15]

The patients were either enrolled from senior welfare centers in three rural areas and four cities, or were the spouses of the dementia patients. The study protocol and informed consent form were approved by the Institutional Review Board. The literate and illiterate subjects provided written and verbal informed consent to participate, respectively, prior to the start of the study.

The LICA procedure

The LICA was developed by 3 psychiatrists, 4 neurologists, and 1 neuropsychologist, and consists of 13 subtests, with possible total scores ranging from 0 to 300. The development process, construct, sensitivity, and reliability of this tool have been reported elsewhere.[11] The LICA, K-MMSE, and Clinical Dementia Rating scale were administered at each site by trained mental-health personnel on the same day.

Statistical analysis

The relative contribution of age, education/literacy, and sex to each of the LICA subtest scores was assessed using separate bivariate linear regression analyses. Age, education/literacy, and sex were coded as categorical variables. Age was categorized into five groups of '60–64, 65–69, 70–74, 75–80, and ≥80 years'; education/literacy was categorized into four groups of 'illiteracy, 0–3, 4–6, and ≥7 years'; and sex into two groups of 'male and female,' respectively. A series of 5×4×2 analyses of variance (ANOVA) were also performed to determine any main effects and interactions of age (60–64, 65–69, 70–74, 75–80, and ≥80 years), education/literacy (illiteracy, 0–3, 4–6, and ≥7 years), and sex in the test. Normative data including mean, standard deviation, median, and range of the 25–75th percentiles estimated from age and education/literacy were calculated. All of the analyses were performed using SPSS for Windows. The cutoff for statistical significance was set at $p<0.05$.

RESULTS

Demographic characteristics of the subjects

The demographic characteristics of the 888 subjects who

Table 2. Bivariate linear regression of age, education/literacy and sex on the cognitive tests in LICA

Test	Age	Education/ literacy	Sex
Story immediate recall			
B	-0.521	0.671	0.662
SE (B)	0.103	0.112	0.262
β	-0.167	0.197	0.085
R^2	0.028	0.039	0.007
p value	<0.001	<0.001	0.011
Word immediate recall			
B	-1.035	0.779	1.218
SE (B)	0.098	0.111	0.258
β	-0.334	0.230	0.157
R^2	0.112	0.053	0.025
p value	<0.001	<0.001	<0.001
Forward visuospatial span			
B	-0.097	0.191	-0.149
SE (B)	0.024	0.026	0.061
β	-0.134	0.240	-0.082
R^2	0.018	0.057	0.007
p value	<0.001	<0.001	0.015
Backward visuospatial span			
B	-0.203	0.439	-0.612
SE (B)	0.031	0.032	0.077
β	-0.215	0.424	-0.258
R^2	0.046	0.180	0.067
p value	<0.001	<0.001	<0.001
Digit stroop test			
B	-0.495	0.678	-0.252
SE (B)	0.093	0.101	0.235
β	-0.178	0.222	-0.036
R^2	0.032	0.049	0.001
p value	<0.001	<0.001	0.284
Calculation			
B	-0.591	1.759	-1.852
SE (B)	0.114	0.112	0.284
β	-0.172	0.467	-0.214
R^2	0.030	0.218	0.046
p value	<0.001	<0.001	<0.001
Story delayed recall			
B	-0.553	0.661	0.406
SE (B)	0.104	0.114	0.266
β	-0.175	0.191	0.051
R^2	0.031	0.037	0.003
p value	<0.001	<0.001	0.127

Table 2. Bivariate linear regression of age, education/literacy and sex on the cognitive tests in LICA (continued)

Test	Age	Education/ literacy	Sex
Story recognition			
B	-0.372	0.490	0.000
SE (B)	0.057	0.062	0.147
β	-0.214	0.257	0.000
R^2	0.046	0.066	0.000
p value	<0.001	<0.001	0.999
Visual construction			
B	-0.285	0.599	-0.619
SE (B)	0.040	0.040	0.100
β	-0.234	0.449	-0.203
R^2	0.055	0.202	0.041
p value	<0.001	<0.001	<0.001
Visual recognition			
B	-0.420	0.503	-0.255
SE (B)	0.054	0.058	0.139
β	-0.254	0.278	-0.062
R^2	0.065	0.077	0.004
p value	<0.001	<0.001	0.067
Word delayed recall			
B	-0.520	0.172	0.836
SE (B)	0.057	0.065	0.148
β	-0.291	0.088	0.187
R^2	0.085	0.008	0.035
p value	<0.001	0.009	<0.001
Word recognition test			
B	-0.385	0.217	0.312
SE (B)	0.058	0.064	0.148
β	-0.219	0.113	0.071
R^2	0.048	0.013	0.005
p value	<0.001	0.001	0.036
Animal fluency			
B	-0.823	1.269	-1.567
SE (B)	0.121	0.129	0.307
β	-0.224	0.314	-0.169
R^2	0.050	0.099	0.029
p value	<0.001	<0.001	<0.001
Color and object recognition test			
B	-0.427	0.385	0.143
SE (B)	0.048	0.053	0.125
β	-0.288	0.237	0.039
R^2	0.083	0.056	0.001
p value	<0.001	<0.001	0.252
Naming			
B	-0.409	0.285	0.260
SE (B)	0.042	0.047	0.110
β	-0.313	0.199	0.079
R^2	0.098	0.040	0.006
p value	<0.001	<0.001	0.018
LICA total score			
B	-8.091	9.586	-0.811
SE (B)	0.630	0.681	1.716
β	-0.399	0.431	-0.016
R^2	0.160	0.186	0.000
p value	<0.001	<0.001	0.636
MMSE			
B	-0.766	1.954	-1.917
SE (B)	0.088	0.075	0.220
β	-0.282	0.657	-0.281
R^2	0.080	0.432	0.079
p value	<0.001	<0.001	<0.001

Independent variables; age, education/literacy and sex. Age is categorized as '60–64, 65–69, 70–74, 75–80, and ≥80 years'; education/literacy is categorized as 'illiteracy, 0–3, 4–6, and ≥7 years'; and sex as 'male and female,' respectively. LICA: literacy independent cognitive assessment, MMSE: mini mental state examination, B: regression coefficient, SE (B): standard error of B, β: standardized regression coefficient, R^2: variance explained by each variable

completed the LICA are given in Table 1. The mean age of the male subjects (72.8 years) did not differ significantly from that of the female subjects (72.1 years; t=1.45, p=0.148), but the mean number of years of education was much higher in the male group (8.4 years) than in the female group (4.5 years; t=11.8, p<0.001). The proportion of illiterate subjects differed significantly between the males (7.3%) and females (27.0%; χ^2=52.9, p<0.001).

Effects of age, education/literacy, and sex on cognitive tests in the LICA

Bivariate linear regression analyses revealed that all 15 of the cognitive tests (13 subtests plus 2 subcategories of subtests) in the LICA, the total LICA score, and the total MMSE score were significantly influenced by both age and education/literacy, as indicated in Table 2. In every test, the younger and more-educated subjects outperformed the older and illiterate/less-educated subjects, respectively.

The gender effect differed for each test (Table 2). Males performed significantly better than females in forward visuospa-

Table 3. Analyses of variance for main effects and interactions of age, education/literacy, and sex on the cognitive tests in LICA

Test	Main effect		Interaction	
	Variable	F, p value*	Variable	F, p value†
Story immediate recall	Age	F=7.64, p<0.001	Age×Edu/Lit	F=0.67, p=0.781
	Edu/Lit	F=15.19, p<0.001	Age×Sex	F=2.52, p=0.040
	Sex	F=6.42, p=0.011	Edu/Lit×Sex	F=1.00, p=0.392
Word immediate recall	Age	F=28.46, p<0.001	Age×Edu/Lit	F=0.98, p=0.464
	Edu/Lit	F=19.20, p<0.001	Age×Sex	F=0.15, p=0.965
	Sex	F=22.36, p<0.001	Edu/Lit×Sex	F=4.19, p=0.006
Forward visuospatial span	Age	F=4.95, p=0.001	Age×Edu/Lit	F=0.77, p=0.681
	Edu/Lit	F=18.78, p<0.001	Age×Sex	F=0.63, p=0.640
	Sex	F=5.98, p=0.015	Edu/Lit×Sex	F=1.29, p=0.276
Backward visuospatial span	Age	F=12.07, p<0.001	Age×Edu/Lit	F=0.71, p=0.739
	Edu/Lit	F=65.73, p<0.001	Age×Sex	F=0.46, p=0.768
	Sex	F=63.10, p<0.001	Edu/Lit×Sex	F=0.72, p=0.541
Digit stroop test	Age	F=9.81, p<0.001	Age×Edu/Lit	F=1.56, p=0.099
	Edu/Lit	F=18.08, p<0.001	Age×Sex	F=1.00, p=0.405
	Sex	F=1.15, p=0.284	Edu/Lit×Sex	F=2.29, p=0.077
Calculation	Age	F=7.98, p<0.001	Age×Edu/Lit	F=2.30, p=0.007
	Edu/Lit	F=103.79, p<0.001	Age×Sex	F=0.58, p=0.680
	Sex	F=42.60, p<0.001	Edu/Lit×Sex	F=1.09, p=0.354
Story delayed recall	Age	F=7.74, p<0.001	Age×Edu/Lit	F=0.55, p=0.882
	Edu/Lit	F=15.99, p<0.001	Age×Sex	F=2.35, p=0.053
	Sex	F=2.33, p=0.127	Edu/Lit×Sex	F=0.84, p=0.470
Story recognition	Age	F=11.23, p<0.001	Age×Edu/Lit	F=1.29, p=0.218
	Edu/Lit	F=26.21, p<0.001	Age×Sex	F=2.33, p=0.054
	Sex	F=0.00, p=0.999	Edu/Lit×Sex	F=0.65, p=0.583
Visual construction	Age	F=14.13, p<0.001	Age×Edu/Lit	F=0.91, p=0.534
	Edu/Lit	F=86.72, p<0.001	Age×Sex	F=2.46, p=0.044
	Sex	F=37.93, p<0.001	Edu/Lit×Sex	F=3.93, p=0.008
Visual recognition	Age	F=10.2, p<0.001	Age×Edu/Lit	F=0.62, p=0.829
	Edu/Lit	F=15.6, p<0.001	Age×Sex	F=0.23, p=0.923
	Sex	F=0.43, p<0.513	Edu/Lit×Sex	F=0.49, p=0.689
Word delayed recall	Age	F=20.63, p<0.001	Age×Edu/Lit	F=0.75, p=0.707
	Edu/Lit	F=4.48, p=0.004	Age×Sex	F=0.74, p=0.568
	Sex	F=32.01, p<0.001	Edu/Lit×Sex	F=0.68, p=0.566
Word recognition test	Age	F=11.23, p<0.001	Age×Edu/Lit	F=0.51, p=0.908
	Edu/Lit	F=6.13, p<0.001	Age×Sex	F=0.12, p=0.976
	Sex	F=4.43, p=0.036	Edu/Lit×Sex	F=1.14, p=0.334
Animal fluency	Age	F=12.69, p<0.001	Age×Edu/Lit	F=1.17, p=0.303
	Edu/Lit	F=37.81, p<0.001	Age×Sex	F=0.30, p=0.881
	Sex	F=26.06, p<0.001	Edu/Lit×Sex	F=0.08, p=0.972
Color and object recognition test	Age	F=60.61, p<0.001	Age×Edu/Lit	F=1.07, p=0.385
	Edu/Lit	F=22.06, p<0.001	Age×Sex	F=2.51, p=0.040
	Sex	F=1.31, p=0.252	Edu/Lit×Sex	F=0.40, p=0.756

Table 3. Analyses of variance for main effects and interactions of age, education/literacy, and sex on the cognitive tests in LICA (continued)

Test	Main effect		Interaction	
	Variable	F, p value*	Variable	F, p value†
Naming	Age	F=24.82, p<0.001	Age×Edu/Lit	F=3.24, p<0.001
	Edu/Lit	F=18.43, p<0.001	Age×Sex	F=3.12, p=0.015
	Sex	F=5.58, p=0.018	Edu/Lit×Sex	F=0.94, p=0.423
LICA total score	Age	F=41.97, p<0.001	Age×Edu/Lit	F=0.71, p=0.743
	Edu/Lit	F=75.15, p<0.001	Age×Sex	F=0.39, p=0.817
	Sex	F=0.22, p=0.636	Edu/Lit×Sex	F=1.26, p=0.287
MMSE	Age	F=20.71, p<0.001	Age×Edu/Lit	F=0.97, p=0.476
	Edu/Lit	F=245.92, p<0.001	Age×Sex	F=0.80, p=0.526
	Sex	F=76.03, p<0.001	Edu/Lit×Sex	F=5.10, p=0.002

Independent variables; age, education/literacy and sex. Age is categorized as '60–64, 65–69, 70–74, 75–80, and ≥80 years' ; education/literacy as 'illiteracy, 0-3, 4-6, and ≥7 years'; and sex as 'male and female,' respectively. *analyzed by analyses of variance (ANOVA), †analyzed by three-way ANOVA. LICA: literacy independent cognitive assessment, Edu: education, Lit: literacy, MMSE: mini mental state examination

tial span, backward visuospatial span, calculation, visual construction, animal fluency, and the MMSE. In contrast, females significantly outperformed males in story immediate recall, word immediate recall, word delayed recall, word recognition test, and naming. There were no significant differences between the genders for the digit Stroop test, story delayed recall, story recognition, visual recognition, Color and Object Recognition Test, and LICA total score.

As shown in Table 3, ANOVA tests revealed a significant interaction between age and gender for the story immediate recall, visual construction, CORT, and naming. The test performance for these story immediate recall, CORT, and naming declined more rapidly in men than in women with advancing age, however, test performance for visual construction declined more prominently in women than in men with advancing age. The education and gender had a significant interaction for word immediate recall, visual construction, and MMSE. ANOVA tests also showed a significant interaction between education/literacy and gender for the word immediate recall, visual construction, and MMSE. The test performance for these three tests increased more rapidly in women than in men with increasing education.

Normative data

The findings for the effects of demographic variables on test performance indicated that age and education should be taken into account when attempting to accurately interpret the LICA cognitive subtests. Therefore, the total group was divided into five age groups (60–64, 65–69, 70–74, 75–80, and ≥80 years) and four educational levels (illiterate, and 0–3, 4–6, and ≥7 years of education). The normative scores for each stratified cell are presented in the form of a mean and standard deviation, and a median and range from the 25th to the 75th percentile (Table 4).

DISCUSSION

To the best of our knowledge, the LICA is the first neuropsychological test that has been developed specifically for the illiterate elderly population. Although each subtest of neuropsychological batteries have been standardized for the illiterate population in several countries, a mass standardization study–examining both illiterate and literate population–has yet to be conducted on a neuropsychological test battery developed for illiterate people.[16-25]

The results of the present study suggest that older age is associated with lower performance on all cognitive tests in the LICA, indicating that the cognitive functions assessed by the LICA gradually decline with advancing age even within the elderly. This decline in cognitive function has also been shown for many other neuropsychological tests. The normative studies on the Korean version of the Consortium to Establish a Registry for Alzheimer's Disease Assessment Packet (CERAD-K) conducted in Korea found a similar impact of age on most cognitive tests.[26]

With regard to education, the present results suggest that a higher educational level is associated with a better performance in all of the LICA subtests. The duration of education affect the performance in most neuropsychological tests, as verified in a normative study of CERAD-K conducted in Korea [i.e. the duration of education significantly impacted the performance score in all of the categories (verbal fluency, Boston naming test, MMSE-KC, word list memory, constructional praxis, word list recall, constructional recall) except word list recognition].[26] Although the LICA was expected to be less significantly affected by either illiteracy or education

Table 4. LICA normative data according to age, literacy and education level

Test	Age	Illiteracy	Education (years)		
			0–3	4–6	≥7
Story immediate recall	60–64	5.9±2.6*	9.6±3.2	8.4±3.2	9.6±4.3
		6.0 (4.0–8.0)†	9.8 (7.0–11.0)	9.0 (5.0–11.0)	9.0 (7.0–12.5)
	65–69	7.2±3.6	8.0±3.6	8.1±4.0	9.5±4.2
		7.5 (4.0–9.0)	7.5 (5.0–11.0)	7.0 (5.0–12.0)	9.0 (6.0–13.0)
	70–74	6.5±2.7	7.4±3.0	7.0±3.6	8.2±4.1
		7.0 (5.0–8.0)	6.0 (5.0–9.3)	7.0 (4.0–9.0)	8.0 (5.0–11.0)
	75–79	7.2±3.3	7.9±3.3	6.6±3.7	8.7±4.3
		6.0 (5.0–9.0)	8.0 (5.0–10.0)	6.0 (4.0–9.3)	9.0 (6.0–11.0)
	≥80	6.0±3.0	6.3±2.5	6.9±4.0	7.9±4.6
		6.0 (4.0–7.0)	6.0 (4.5–8.0)	6.0 (4.0–8.0)	6.3 (4.8–10.9)
Word immediate recall	60–64	14.7±4.0	18.4±4.5	18.0±3.1	18.6±4.0
		14.0 (12.0–18.0)	18.5 (14.3–22.8)	17.0 (16.0–21.0)	19.0 (16.0–22.0)
	65–69	16.3±3.7	17.2±3.0	16.5±3.3	18.2±3.2
		16.0 (13.5–19.0)	17.0 (16.0–19.5)	17.0 (14.0–19.0)	18.0 (16.0–20.5)
	70–74	14.5±3.6	15.6±3.7	16.0±3.5	16.8±3.3
		14.0 (12.0–17.0)	15.5 (13.0–17.3)	16.0 (14.0–18.0)	17.0 (15.0–19.0)
	75–79	14.0±3.9	15.9±3.6	14.6±3.3	15.7±3.4
		14.0 (11.0–17.0)	16.0 (13.0–18.0)	14.0 (12.0–17.0)	16.0 (14.0–18.0)
	≥80	13.4±3.1	13.9±4.2	14.7±3.3	14.4±4.2
		14.0 (11.0–16.0)	14.0 (11.0–17.0)	15.0 (12.0–18.0)	13.0 (11.8–16.3)
Forward visuospatial span	60–64	4.7±0.6	4.9±0.9	5.0±0.6	5.0±0.8
		5.0 (4.0–5.0)	5.0 (4.0–5.8)	5.0 (5.0–5.0)	5.0 (4.0–5.5)
	65–69	4.6±0.8	4.8±0.9	5.0±0.8	5.3±1.0
		4.0 (4.0–5.0)	5.0 (4.0–5.0)	5.0 (4.0–5.0)	5.0 (5.0–6.0)
	70–74	4.5±0.8	4.8±0.7	5.0±1.0	5.1±0.8
		4.0 (4.0–5.0)	5.0 (4.0–5.0)	5.0 (4.0–5.0)	5.0 (4.0–6.0)
	75–79	4.6±0.9	4.6±0.8	4.6±0.8	5.0±1.0
		4.0 (4.0–5.0)	5.0 (4.0–5.0)	5.0 (4.0–5.0)	5.0 (4.0–6.0)
	≥80	4.4±0.7	4.8±0.8	4.7±0.9	5.0±0.9
		4.0 (4.0–5.0)	5.0 (4.0–5.0)	5.0 (4.0–5.0)	5.0 (4.0–5.5)
Backward visuospatial span	60–64	3.5±0.7	3.5±0.8	4.4±0.9	4.6±1.2
		4.0 (3.0–4.0)	3.0 (3.0–4.0)	4.0 (4.0–5.0)	4.0 (4.0–5.0)
	65–69	3.4±0.9	3.7±1.0	4.5±1.1	4.4±1.1
		3.0 (3.0–4.0)	4.0 (3.0–4.0)	4.0 (4.0–5.0)	4.0 (4.0–5.0)
	70–74	3.1±0.9	3.8±1.0	4.2±0.9	4.6±1.2
		3.0 (3.0–4.0)	4.0 (3.0–4.0)	4.0 (4.0–5.0)	4.0 (4.0–6.0)
	75–79	3.1±1.1	3.4±1.0	3.9±1.0	4.3±1.0
		3.0 (3.0–4.0)	3.0 (3.0–4.0)	4.0 (3.0–5.0)	4.0 (4.0–5.0)
	≥80	2.8±0.7	3.4±0.9	3.7±1.0	4.1±1.1
		3.0 (3.0–3.0)	3.0 (3.0–4.0)	4.0 (3.0–4.0)	4.0 (3.0–5.0)
Digit stroop test	60–64	19.2±8.0	22.5±2.2	21.8±3.8	23.2±1.5
		23.0 (15.0–24.0)	23.5 (21.3–24.0)	23.0 (22.0–24.0)	23.0 (22.0–24.0)
	65–69	22.0±2.5	22.5±2.9	22.6±2.4	22.6±1.8
		23.0 (21.0–24.0)	23.0 (22.0–24.0)	23.0 (22.0–24.0)	23.0 (22.0–24.0)
	70–74	20.7±4.0	22.2±3.5	22.8±1.8	22.6±1.9
		22.0 (18.0–24.0)	23.0 (22.0–24.0)	23.0 (22.0–24.0)	23.0 (22.0–24.0)

Table 4. LICA normative data according to age, literacy and education level (continued)

Test	Age	Illiteracy	Education (years)		
			0–3	4–6	≥7
	75–79	20.4±5.1	22.3±3.0	21.4±3.5	22.6±2.3
		22.0 (18.5–24.0)	23.0 (21.0–24.0)	23.0 (20.5–23.0)	23.0 (22.0–24.0)
	≥80	18.6±6.4	20.1±4.6	20.7±4.5	22.2±2.4
		21.0 (17.0–24.0)	22.0 (18.0–23.0)	22.0 (20.0–23.0)	23.0 (21.0–24.0)
Calculation	60–64	18.6±6.4	21.2±3.2	22.0±2.7	23.7±0.9
		20.0 (17.0–23.0)	22.0 (19.3–24.0)	24.0 (19.0–24.0)	24.0 (24.0–24.0)
	65–69	19.2±5.5	22.1±2.9	23.0±1.7	23.3±1.8
		21.0 (16.0–24.0)	24.0 (20.5–24.0)	24.0 (22.8–24.0)	24.0 (24.0–24.0)
	70–74	16.4±7.1	21.8±2.4	22.7±2.0	23.2±1.4
		18.0 (11.0–23.0)	23.0 (20.0–24.0)	24.0 (22.0–24.0)	24.0 (23.0–24.0)
	75–79	18.7±6.8	21.0±4.5	22.2±3.1	23.0±2.1
		22.0 (16.0–24.0)	22.0 (20.0–24.0)	24.0 (22.0–24.0)	24.0 (24.0–24.0)
	≥80	14.8±7.0	21.5±3.1	21.8±2.9	23.0±2.2
		15.0 (12.0–21.0)	23.0 (19.0–24.0)	23.0 (22.0–24.0)	24.0 (23.0–24.0)
Story delayed recall	60–64	3.2±2.1	6.6±3.7	5.4±3.4	8.1±4.4
		4.0 (1.0–4.5)	5.8 (4.0–8.0)	5.0 (3.0–8.0)	8.0 (6.0–10.0)
	65–69	5.2±3.6	6.4±3.9	5.7±3.6	7.4±4.3
		5.0 (3.0–7.5)	6.0 (3.0–10.0)	5.0 (3.0–8.0)	7.0 (4.0–11.0)
	70–74	4.1±2.9	5.6±3.3	5.3±3.3	6.2±4.6
		4.0 (2.0–6.0)	5.0 (3.0–9.0)	5.0 (3.0–8.0)	5.0 (2.0–9.0)
	75–79	5.1±3.0	5.6±3.3	4.4±3.7	6.3±4.1
		4.0 (3.0–8.0)	6.0 (4.0–8.0)	4.0 (1.0–7.0)	6.0 (3.0–9.0)
	≥80	4.2±3.5	4.2±2.1	4.3±3.1	5.4±4.2
		3.8 (1.8–6.0)	4.0 (3.0–6.0)	4.0 (2.0–5.5)	4.5 (1.8–8.3)
Story recognition	60–64	6.7±1.6	6.9±3.7	6.9±1.7	7.7±1.6
		6.0 (5.0–8.0)	7.0 (6.0–8.0)	7.0 (5.0–8.0)	8.0 (7.0–9.0)
	65–69	6.4±2.2	6.6±2.0	7.0±1.9	7.5±1.6
		7.0 (5.0–8.0)	7.0 (5.5–8.0)	7.0 (6.0–8.0)	7.0 (7.0–8.5)
	70–74	5.0±2.3	6.7±1.8	6.4±2.5	7.0±2.0
		5.0 (3.0–7.0)	7.0 (6.0–8.0)	7.0 (6.0–8.0)	7.0 (6.0–9.0)
	75–79	6.0±2.1	6.4±2.1	5.4±2.5	7.2±1.7
		7.0 (4.0–8.0)	7.0 (5.0–8.0)	5.0 (4.0–7.0)	8.0 (7.0–8.0)
	≥80	4.6±2.6	6.4±1.9	5.9±1.8	6.5±2.4
		5.0 (2.0–7.0)	6.5 (6.0–8.0)	6.0 (4.0–7.0)	7.0 (5.0–8.3)
Visual construction	60–64	8.5±1.8	9.4±1.0	9.7±0.5	9.8±0.5
		9.0 (8.0–10.0)	10.0 (9.0–10.0)	10.0 (9.5–10.0)	10.0 (10.0–10.0)
	65–69	8.5±1.6	9.4±0.9	9.7±0.8	9.9±0.4
		9.0 (7.8–10.0)	10.0 (9.0–10.0)	10.0 (9.9–10.0)	10.0 (10.0–10.0)
	70–74	8.0±2.0	9.3±1.3	9.7±1.0	9.7±0.6
		8.5 (7.0–10.0)	10.0 (9.0–10.0)	10.0 (9.6–10.0)	10.0 (10.0–10.0)
	75–79	7.3±2.7	8.8±1.8	9.4±0.8	9.7±0.9
		8.0 (5.0–10.0)	9.5 (8.0–10.0)	9.5 (9.0–10.0)	10.0 (10.0–10.0)
	≥80	7.5±2.2	8.4±1.9	9.1±1.4	9.7±0.7
		8.0 (6.0–9.6)	9.0 (7.3–10.0)	10.0 (8.5–10.0)	10.0 (10.0–10.0)
Visual recognition	60–64	14.6±2.5	15.9±1.6	16.4±1.6	16.3±1.9
		15.0 (12.0–17.0)	16.0 (14.3–17.0)	16.0 (15.0–17.0)	16.0 (15.0–18.0)

Table 4. LICA normative data according to age, literacy and education level (continued)

Test	Age	Illiteracy	Education (years)		
			0–3	4–6	≥7
	65–69	15.1±1.0 15.0 (14.0–16.0)	15.5±2.0 15.0 (14.0–17.0)	15.8±1.7 16.0 (14.0–17.0)	15.8±2.0 16.0 (14.0–17.0)
	70–74	14.5±1.8 14.0 (13.0–16.0)	15.7±1.7 16.0 (14.8–17.0)	15.7±1.7 16.0 (15.0–17.0)	16.0±1.8 16.0 (15.0–17.0)
	75–79	14.1±1.9 14.0 (13.0–16.0)	14.7±2.3 15.0 (13.0–16.0)	15.1±1.7 15.0 (14.0–16.0)	15.7±1.8 16.0 (15.0–17.0)
	≥80	13.2±2.8 14.0 (12.0–15.0)	14.4±2.0 15.0 (13.0–16.0)	14.6±2.1 15.0 (13.0–16.0)	15.2±1.8 15.0 (14.0–16.0)
Word delayed recall	60–64	5.6±2.1 5.0 (4.0–8.0)	5.8±1.8 6.0 (4.0–7.0)	6.4±1.6 6.0 (5.0–8.0)	6.0±2.0 6.0 (5.0–8.0)
	65–69	5.1±2.4 5.0 (4.0–6.5)	5.5±2.4 5.0 (4.5–7.5)	5.2±1.9 5.0 (4.0–7.0)	5.6±1.9 6.0 (4.0–7.0)
	70–74	4.6±2.1 4.0 (4.0–6.0)	4.7±2.6 5.0 (3.0–6.0)	4.8±2.3 5.0 (3.0–7.0)	5.0±1.8 5.0 (4.0–6.0)
	75–79	4.6±2.3 5.0 (3.0–6.0)	4.9±2.3 4.0 (3.0–7.0)	3.8±2.3 4.0 (2.0–6.0)	4.3±2.4 5.0 (2.0–6.0)
	≥80	3.5±1.6 3.5 (2.0–5.0)	4.5±1.7 5.0 (4.0–5.0)	3.5±2.1 4.0 (2.0–5.0)	4.4±2.0 5.0 (2.8–6.0)
Word recognition test	60–64	18.3±1.8 19.0 (17.0–19.0)	19.1±3.4 19.0 (18.0–20.0)	18.8±1.1 19.0 (18.0–20.0)	18.7±1.5 19.0 (18.0–20.0)
	65–69	17.9±2.1 19.0 (16.5–19.0)	18.3±1.6 19.0 (17.5–19.5)	18.0±2.5 18.0 (17.0–19.0)	18.2±1.7 19.0 (17.0–20.0)
	70–74	17.1±2.2 17.0 (16.0–19.0)	18.1±2.4 19.0 (16.0–20.0)	17.8±1.6 18.0 (17.0–19.0)	18.0±2.4 18.0 (17.0–20.0)
	75–79	17.3±2.3 18.0 (16.0–19.0)	17.8±2.0 18.0 (17.0–19.0)	17.0±1.9 18.0 (15.5–18.0)	17.9±2.0 19.0 (17.0–19.0)
	≥80	16.8±3.4 17.0 (16.0–19.0)	16.9±1.9 16.5 (15.3–19.0)	16.9±2.2 17.0 (15.5–19.0)	17.7±1.8 18.0 (16.8–19.0)
Animal fluency	60–64	10.8±2.9 12.0 (9.0–12.0)	14.6±3.3 14.0 (13.3–15.8)	15.2±3.5 16.0 (13.0–18.0)	17.6±4.9 17.0 (15.0–20.5)
	65–69	13.2±3.3 14.0 (10.5–15.5)	13.9±3.2 14.0 (11.0–16.5)	14.1±3.9 15.0 (11.0–17.0)	14.3±0.9 15.0 (14.0–15.0)
	70–74	13.0±3.8 12.0 (10.0–16.0)	12.9±3.7 12.0 (10.0–15.0)	14.1±3.5 14.0 (11.0–16.0)	16.8±5.5 17.0 (13.0–20.0)
	75–79	11.6±4.7 11.0 (9.0–13.0)	13.8±3.9 13.0 (11.0–15.0)	12.6±4.3 12.0 (10.0–15.5)	15.5±4.9 14.0 (12.0–20.0)
	≥80	11.6±3.6 12.0 (9.0–14.0)	12.0±4.0 11.5 (9.3–14.0)	11.6±3.4 11.0 (9.0–13.5)	13.7±4.0 13.0 (11.0–16.0)
Color and object recognition test	60–64	13.2±1.8 13.0 (12.0–15.0)	12.9±1.5 13.0 (12.0–14.0)	13.8±1.5 14.0 (13.0–15.0)	13.8±1.3 14.0 (13.0–15.0)
	65–69	12.6±2.1 13.0 (10.0–14.5)	13.3±1.7 13.0 (12.5–15.0)	13.2±1.5 13.0 (12.0–15.0)	13.5±1.4 14.0 (13.0–15.0)
	70–74	12.0±1.8 12.0 (1.0–13.0)	13.1±1.7 13.0 (12.0–14.0)	12.8±1.6 13.0 (12.0–14.0)	13.2±1.8 14.0 (12.0–14.0)
	75–79	12.3±1.8 13.0 (11.0–14.0)	12.9±2.0 13.0 (12.0–14.0)	12.3±1.6 13.0 (11.0–13.5)	12.8±1.8 13.0 (11.0–15.0)

Table 4. LICA normative data according to age, literacy and education level (continued)

Test	Age	Illiteracy	Education (years)		
			0–3	4–6	≥7
	≥80	10.7±1.7	12.2±1.8	11.8±2.0	12.9±1.9
		10.0 (9.8–12.0)	12.5 (11.3–14.0)	12.0 (11.0–13.0)	13.0 (11.0–15.0)
Naming	60–64	14.2±0.9	14.0±1.0	14.4±0.9	14.4±0.8
		14.0 (13.0–15.0)	14.0 (13.0–15.0)	15.0 (14.0–15.0)	15.0 (14.0–15.0)
	65–69	13.8±1.3	14.2±1.1	13.7±1.3	14.3±0.9
		14.0 (13.0–15.0)	15.0 (14.0–15.0)	14.0 (13.0–15.0)	15.0 (14.0–15.0)
	70–74	13.2±1.6	13.9±1.3	13.6±1.5	13.7±1.3
		13.0 (12.0–15.0)	14.0 (13.0–15.0)	14.0 (13.0–15.0)	14.0 (13.0–15.0)
	75–79	12.9±1.9	13.5±1.5	13.5±1.5	13.6±1.4
		13.0 (12.0–14.0)	14.0 (12.0–15.0)	14.0 (13.0–15.0)	14.0 (13.0–15.0)
	≥80	11.4±3.1	13.5±1.5	12.9±1.8	13.2±1.9
		12.5 (9.0–13.0)	14.0 (13.0–15.0)	13.0 (12.0–14.0)	14.0 (12.0–15.0)
LICA total score	60–64	198.8±20.1	222.9±21.5	226.2±14.7	235.0±21.9
		205.6 (179.8–215.8)	215.7 (211.5–243.8)	225.5 (219.0–235.7)	231.5 (220.8–251.0)
	65–69	206.2±21.1	218.5±22.6	219.1±18.0	228.9±19.4
		203.3 (195.1–224.6)	223.7 (205.2–234.0)	220.5 (207.0–233.0)	231.2 (214.1–241.8)
	70–74	194.7±22.3	212.5±17.5	215.0±17.1	222.5±20.4
		177.0 (193.8–211.6)	212.2 (202.5–225.4)	218.3 (202.0–227.0)	219.8 (207.6–241.2)
	75–79	192.3±26.8	208.3±22.4	201.8±18.5	218.2±22.6
		198.5 (171.8–213.0)	211.0 (201.7–220.2)	202.8 (187.0–215.9)	217.3 (200.5–235.7)
	≥80	176.6±25.0	196.9±18.2	197.2±22.5	211.9±19.9
		182.0 (159.0–191.7)	193.3 (184.8–210.3)	194.2 (184.0–210.0)	209.0 (195.7–228.8)
MMSE	60–64	21.1±4.2	25.5±2.5	26.4±2.7	28.1±1.6
		21.0 (18.0–25.0)	25.0 (23.3–27.0)	27.0 (25.0–29.0)	28.0 (27.0–29.0)
	65–69	22.6±2.7	25.9±2.7	26.5±2.1	27.7±1.6
		23.0 (20.0–25.0)	26.0 (23.5–28.0)	27.0 (25.0–28.0)	28.0 (27.0–29.0)
	70–74	21.8±3.1	24.9±2.3	26.1±2.2	27.3±1.7
		21.0 (20.0–25.0)	25.0 (24.0–26.0)	26.0 (25.0–27.0)	28.0 (26.0–29.0)
	75–79	21.1±3.1	24.0±3.4	25.9±2.0	27.4±1.7
		22.0 (19.0–23.0)	24.0 (22.0–27.0)	27.0 (25.0–27.0)	28.0 (26.0–29.0)
	≥80	19.8±2.7	23.3±3.6	25.2±2.5	26.8±2.6
		20.0 (17.8–22.0)	24.0 (22.0–26.0)	25.0 (23.0–27.0)	27.0 (26.0–28.3)

*mean±SD and †median (25–75th percentile). LICA: literacy independent cognitive assessment, MMSE: Mini Mental State Examination

level since it was developed and validated as an effective neurocognitive test battery for illiterate people,[11] the regression analysis in this study revealed that all of the subtests were significantly affected by education level. This shows that the LICA, a neuropsychological test battery that was developed especially for the illiterate group, is also affected by a subject's education level, which is an intrinsic attribute of any cognitive test. However, regardless of the finding that the LICA test performance was influenced by educational level, it remains the only currently available neuropsychological test battery for illiterate people.

When performing dementia evaluations of illiterate people, it is helpful to interview subjects and their family members using the IADL in order to obtain complimentary information. The IQCODE is particularly useful since it is not affected by the education level or the premorbid ability of subjects.[27] However, since its data are obtained from the subjects' family members and is not a neuropsychological test, it is difficult to make an accurate assessment of a subject's cognitive function and the result is affected by informant characteristics such as the presence of depression or anxiety, and also by the relationship between the informant and the subject.[28] Combining neuropsychological testing and the IADL thus likely constitutes a more accurate method of diagnosing dementia.

Literacy is associated with all neuropsychological measures, although the actual correlation between neuropsychological test scores and education level depends upon the specific test. Education and learning reinforce and modify certain fundamental abilities, such as verbal/visual memory and visuospatial/visuomotor skills.[17] Some functional imaging studies have demonstrated that literacy influences the brain and that neural networks for problem-solving and literacy not only impact the individual's daily strategies and function, but also their brain networks.[29,30] Based on such findings, literacy can be considered to substantially affect neurocognitive dysfunctions such as dementia.

In conclusion, age and literacy/education level substantially influence all the cognitive functions that are assessed by the LICA neuropsychological battery; however, this battery is the only currently specific and available neuropsychological diagnostic method for the evaluation of dementia in illiterate people. The normative data reported herein will be useful for the clinical application of the LICA in illiterate and literate elderly Koreans. Similar normative studies and validations of this tool in different ethnic groups will help to enhance the dementia diagnosis of illiterate people of different ethnicities.

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