Original Article

Exploratory Factor Analysis of the WAIS-III Thai Version in Patients with Mild Cognitive Impairment

Pongsakorn Rungwittayanuwat MSc[1], Chakrit Sukying MD[1], Pattarabhorn Wisajun MSc[1], Jiranuch Jitrathorn MSc[1], Narin Pluemchit MSc[1], Parichat Khamsamran MSc[1], Charunee Vidhyachak MSc[1], Daochompu Nakawiro MD[1], Papan Thaipisuttikul MD[1], Sanchai Kuladee MD[1], Pitchayawadee Chittaropas MD[1]

[1] Department of Psychiatry, Faculty of Medicine Ramathibodi, Hospital, Mahidol University, Bangkok, Thailand

Objective: To investigate the generalizability of the Wechsler Adult Intelligence Scale-III (WAIS-III) factors structure in a sample of mild cognitive impairment (MCI) patients.

Materials and Methods: A retrospective study of patients older than 60 years receiving treatments at the Memory Clinic in Ramathibodi Hospital between January 2015 and July 2018 was conducted. The WAIS-III Thai version was used to measure the performance. All subtests except the Vocabulary and Object Assembly subtests were included for analyses. These 12 subtests were subjected to a principal axis factor analysis with oblique rotation and four factors were specified to be retained.

Results: Out of 145 patients, 51% were female and 49%were male. The Full-Scale IQ ranged from 80 to 123 with the mean of 93.88 (SD 9.12). The mean of each subtest ranged from 7.82 (Similarities) to 10.45 (Digit Span), with the standard deviations ranging from 1.80 to 2.86. Based on the order of extraction and minimum loading criterion, results supported a four-factor solution composed of Verbal Comprehension, Perceptual Organization, Working Memory, and Processing Speed. The coefficients of congruence across groups on the four factors ranged from 0.92 for Perceptual Organization to 0.73 for Processing Speed. However, the Picture Completion subtest was found to have similar loadings between Perceptual Organization and Processing Speed, with the primary loading being on Perceptual Organization and secondary loading on Processing Speed. On the Working Memory factor, the MCI group showed areas of relatively greater divergence for Picture Arrangement, Block Design, and Digit Symbol: Coding subtests.

Conclusion: Four factors from WAIS-III could be applied to patients with MCI. The decline of cognitive functions, particular in working memory, might be the explanation for the difference in loading factor among some subtests. Therefore, it might be possible to apply other models with other factors to the same patient group in the future.

Keywords: Mild cognitive impairments; Exploratory factor analysis; WAIS-III

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The Wechsler Adult Intelligence Scale (WAIS) is an individually administered clinical instrument for assessing the intellectual ability of adults aged 16 through 89. It has been widely utilized both clinically and for research. The WAIS-III is the third iteration of this test, which consists of 14 subtests(1), each measuring a different facet of intelligence. In Thailand, the Wechsler Adult Intelligence Scale-Third Edition (WAIS-III) Thai version was developed by the department of Mental Health, Ministry of Public Health in 2011 and has been widely used and applied in testing adult intelligence for clinical and research purposes. It had been studied for its accuracy by Phattharayuttawat et al(2) and found acceptable reliability coefficients for using in Thai psychiatric groups.

From theories of Wechsler(1) and Kaufman & Lichtenberger(3), these 14 subtests can be categorized into two domains, the verbal domain and the performance domain. From 1997, the WAIS-III Wechsler Memory Scale-Third Edition (WMS-III) technical manual(4) as well as earlier studies(5-8) reported the results of a series of exploratory factor analysis of the WAIS-III by using the 13 primary subtests with the exclusion of an optional subtest, the Object Assembly. The results supported the four-factor model, which included Verbal Comprehension,

Correspondence to:

Chittaropas P.

Department of Psychiatry, Faculty of Medicine Ramathibodi Hospital, Mahidol University, 270 Rama VI Road, Thung Phaya Thai, Ratchathewi, Bangkok 10400, Thailand.

Phone: +66-2-2011478

Email: pitchayawadee.chi@mahidol.edu

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Working Memory, Perceptual Organization, and Processing Speed.

Generally, an analysis of factors will allow the researchers to construct validity of the test in question[9]. Therefore, if this test was applied to a population that differed from the population used to develop the tool such as patients with mental disorders, and the results were still in relation to the four factors mentioned previously, the researcher could have higher confidence in applying the WAIS-III test to more variety of patients with neurological and psychiatric disorders because these disorders manifest differently along each factor depending on the underlying causes[5,10,11]. Among neurocognitive disorders, memory problems especially mild cognitive impairment (MCI) was very common in the elderly population. Numerous international studies estimated the overall prevalence of MCI in the 12% to 18% range in persons over the age of 60 years[12]. People living with MCI, especially MCI involving memory problems, were more likely to develop Alzheimer's disease or other dementias than people without MCI. Progression to clinically diagnosable dementia occurred at a higher rate from MCI than from normal cognition[13,14]. The average rate of progression from MCI has been reported to be 10% to 15% per year. In the past, the WAIS-III had been widely used to help assess this condition and to monitor its progression over time[15,16]. Although it is widely used, the factor structure of the WAIS-III has never been studied in this group of patients. To study the feasibility of generalizability of factor structure of the WAIS-III in clinical populations, the authors had therefore, selected this group of patients for the present study.

The purpose of the present study was to examine the generalizability of the factors of the WAIS-III Thai version by studying patients with MCI receiving treatments at the Memory Clinic of Ramathibodi Hospital.

Objective

To examine the generalizability of the factors of the WAIS-III Thai version in patients with MCI.

Materials and Methods

Subjects

Apply a retrospective analytic study, using data from the assessments of 145 neuropsychological patients receiving treatments at the Memory Clinic of Ramathibodi Hospital medical recorded between January 2015 and July 2018.

Inclusion criteria

Patients participating in the present study were older than 60 years on the day the test was first administered. They were receiving treatments at the Memory Clinic in Ramathibodi Hospital between January 2015 and July 2018. These patients were diagnosed with MCI using the criteria from the National Institute on Aging-Alzheimer's Association workgroups on diagnostic guidelines for Alzheimer's disease[17] and Petersen et al[12], which consisted of subjective feelings of change in one's memory and at least one cognitive deficiency while still retaining the ability to lead one's daily lives normally.

Exclusion criteria

Patients who did not suffer dementia, using criteria from the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision (DSM-IV-TR)[18].

Research instruments

The WAIS-III Thai version was conducted individually. As in the technical manual analyses[4], the authors excluded the Object Assembly subtest from the study. In addition, the authors also excluded Vocabulary subtest on account of cultural distinction. Twelve subtests were used.

Protection of human subjects

To protect the privacy of the participants in the present study, the names and the personal identifications had been replaced with codes, and only the computers not accessible by anyone outside of the research team were used to store the information. The research itself would only report holistic results.

The present study was certified by Ethic Committee of Faculty of Medicine, Ramathibodi Hospital Mahidol University (MURA 2019/341).

Data analysis

The data was analyzed using the PASW Statistics for Windows, version 18.0 (SPSS Inc., Chicago, IL, USA). Data input were using descriptive statistics such as frequency, percentage, mean, and standard deviation. One sample t-test was used to compared different WAIS-III subtests between the MCI and the standardization sample. Study analyses were modeled on those reported in the technical manual of the WAIS-III standardization sample(4). For comparison reasons, the authors performed parallel analyses of the factor structure of the WAIS-III for the 55- to 74-year-old age group from the standardization sample and

Table 1. Demographic characteristics of patients with mild cognitive impairment group and the WAIS-III standardization sample

Demographics	MCI sample; n (%)	Standardization sample; n (%)
Female	74 (51.0)	322 (53.7)
Male	71 (49.0)	278 (46.3)
Age		
60 to 64 years, 55 to 64 years for standardization sample	33 (22.8)	200 (33.3)
65 to 69 years	47 (32.4)	200 (33.3)
70 to 74 years	27 (18.6)	200 (33.3)
75 to 79 years	21 (14.5)	-
≥80 years	17 (11.7)	-

Education level	Sample; n (%)
MCI sample	
≤6 years	7 (4.8)
7 to 12 years	25 (17.2)
13 to 16 years	77 (53.1)
≥17 years	36 (24.8)
Standardization sample	
≤8 years	94 (15.7)
9 to 11 years	86 (14.3)
12 years	231 (38.5)
13 to 15 years	97 (16.2)
≥16 years	92 (15.3)

MCI=mild cognitive impairment

Table 2. Mean and standard deviation of the IQ scores of patients with mild cognitive impairment group compare with the WAIS-III standardization sample

Variables	MCI; mean (SD)	C; mean (SD)	p-value
Subtests			
Information	10 (2.3)	10.1 (2.7)	0.46
Comprehension	8.3 (1.8)	10.5 (2.4)	<0.001**
Similarities	7.8 (2)	10.3 (3)	<0.001**
L-N sequencing	10.1 (2.9)	10.6 (2.3)	0.04*
Arithmetic	10 (2.3)	10.2 (2.6)	0.25
Digit Span	10.5 (2.4)	10.2 (2.5)	0.21
Picture Completion	8.1 (2.3)	10.6 (2.9)	<0.001**
Picture Arrangement	7.9 (2.1)	10.3 (2.7)	<0.001**
Block Design	9.7 (2.2)	10.3 (2.6)	0.01**
Matrix Reasoning	9.7 (2.6)	10.2 (2.7)	0.04*
Symbol Search	9.4 (2.3)	10.1 (2.7)	0.01**
Digit Symbol: Coding	8.3 (2.3)	10.2 (3)	<0.001**
Verbal IQ	95.3 (8.7)	101.4 (11.9)	<0.001**
Performance IQ	92.6 (11.4)	101.6 (12.2)	<0.001**
Full Scale IQ	93.9 (9.1)	101.7 (11.7)	<0.001**

MCI=mild cognitive impairment

** $p<0.01$, * $p<0.05$

Values in the "MCI" columns are MCI sample

Values in the "C" columns are standardization sample (n=104), age 55 to 74 years in WAIS-III WMS-III technical manual[4] refer in the stability of scores of the WAIS-III was assessed in separate studies: First Testing

used the correlations reported in the WAIS-III WMS-III technical manual[4]. This group was selected as most comparable because 74% of the MCI sample fell within this range, with approximately 26% being in the above age range.

An oblique rotation was selected, and four factors were specified. The equivalence of the factors was assessed using coefficients of congruence[10].

Results

Means and standard deviations (SDs)

The study samples were patients diagnosed with MCI. Out of 145 patients, 74 (51%) were females and 71 (49%) males, comparable to the standardization sample, which was 322 (53.7%) females and 278 (46.3%) males.

The sample population age ranged from 60 to over 80 years. The researchers selected 55 to 74 years old age group from the standardization sample to perform parallel analyses. The total standardization sample was 600. Each age group had 33% of the population. As shown in Table 1, 74% of the MCI sample in the present study fell within 60 to 74 years age range, consisted of 22.8% was in 60 to 64 years, 32.4% in the 65 to 69 years, and 18.6% in 70 to 74 years. The remaining 26% was in the age group of 75 years and over. Therefore, after considering the data, it could be seen that the age group the researchers selected from the WAIS-III was suitable to be used as a comparison in the present study.

The proportion of the number of years of education was approximately the same in these two sample groups. In the MCI sample, 75% (113 out of 145) had 12 years of education or more, whereas 70% (420 out of 600) of the standardization sample had a minimum of 12 years of education.

The mean and standard deviations for 12 subtests of the WAIS-III and the Full-Scale IQ scores are reported in Table 2. For the MCI sample group, Full Scale IQ ranged from 80 to 123, mean 93.88 (SD 9.12). Mean for each subtest ranged from 7.82 (Similarities) to 10.45 (Digit Span), the standard deviations ranging from 1.80 to 2.86. For the standardization sample group, the mean of Full-Scale IQ was 101.7 (SD 11.7).

Table 3. Results of the factor structure of WAIS-III in patients with mild cognitive impairment group compared with the WAIS-III standardization sample

Subtests: WAIS-III	Factor							
	Verbal Comprehension		Working Memory		Perceptual Organization		Processing Speed	
	MCI	C	MCI	C	MCI	C	MCI	C
Information	0.93	0.75	0.31	0.18	0.25	0.02	0.29	–0.08
Comprehension	0.50	0.76	0.22	0.00	0.31	0.13	0.07	–0.02
Similarities	0.63	0.74	0.36	–0.06	0.37	0.18	0.20	0.02
L-N sequencing	0.38	0.07	0.71	0.60	0.21	–0.05	0.42	0.18
Arithmetic	0.33	0.16	0.69	0.56	0.46	0.19	0.28	–0.03
Digit Span	0.16	0.02	0.48	0.68	0.25	–0.04	0.23	0.00
Picture Completion	0.27	0.23	0.14	–0.16	0.52	0.53	0.51	0.16
Picture Arrangement	0.28	0.26	0.37	–0.06	0.47	0.50	0.22	0.04
Block Design	0.18	–0.05	0.32	0.03	0.54	0.73	0.29	0.07
Matrix Reasoning	0.36	0.02	0.27	0.26	0.60	0.63	0.34	–0.07
Symbol Search	0.16	0.02	0.39	0.07	0.33	0.22	0.73	0.59
Digit Symbol: Coding	0.22	–0.01	0.40	0.07	0.36	0.03	0.49	0.68
Eigenvalues	3.68		1.43		1.17		0.95	
% Variance	30.69		11.93		9.77		7.90	
Pearson R age 55 to 74 years		0.85		0.79		0.92		0.78
Coefficient of congruence between age 55 to 74 years		0.88		0.77		0.87		0.73

WAIS-III=Wechsler Adult Intelligence Scale-Third Edition; MCI=mild cognitive impairment

Values in the "MCI" columns are MCI sample.

Values in the "C" columns are comparison sample, which is the 55- to 74-year-old age group from the WAIS-III standardization sample in WAIS-III WMS-III technical manual[4]

Mean for each subtest ranged from 10.1 (information and symbol search) to 10.6 (L-N sequencing and Picture Completion). When comparing the WAIS-III performance from these two groups, it would be found that in the MCI group, the mean scores were lower than the standardization group for most of the subtests, and there also was a greater variety of scores obtained in each subtest than the standardization group as well. These suggested that the sample in the MCI group had a clear level of neurocognitive deficits compared to the standardization sample, a spectrum of neurological disorder, but not yet dementia.

Table 3 shows the pattern loadings for the four-factor solution following oblique rotation. Each rotated factor was considered to be composed of subtests with loadings greater than 0.40. Analysis with The Kaiser-Meyer-Olkin (KMO) value was 0.79, Bartlett's test of sphericity showed statistical significance of <0.001. Therefore, the conclusion was that each subtest was related. Based on the order of extraction and minimum loading criterion, the factor structure of the 12 subtests of the WAIS-III could be categorized into four factors. Factor I, composed of information, similarities, and comprehension, accounted for 30.69% of the total variance, and was labeled as Verbal Comprehension. Factor II, composed of L-N sequencing, Arithmetic and Digit Span, accounted for 11.93% of the total variance, and was labeled as Working Memory. Factor III, composed of Matrix Reasoning, Block Design, Picture Completion, and Picture Arrangement, accounted for 9.77% of the total variance, and was labeled as Perceptual Organization. And Factor IV, composed of Symbol Search and Digit Symbol: Coding, accounted for 7.9% of the total variance, and was labeled as Processing Speed.

The lower part of Table 3 compares the level of similarity in each factor structure between the original WAIS-III study and the MCI group. The first factor structure, Verbal Comprehension, had the Pearson R value of 0.85 and coefficent of congruence of 0.88. The second factor structure, Working Memory, had Pearson R value of 0.79 and coefficient of congruence of 0.77. The third factor structure, Perceptual Organization, had Pearson R value of 0.92 and coefficient of congruence of 0.87. The fourth factor structure, Processing Speed, had Pearson R value of 0.78 and coefficient of congruence of 0.73. Even though the levels of similarity for Working Memory and procesing speed were lower than those of Verbal Comprehension and Perceptual Organization, this was due to differences in the weights of subtests Digit Span and Digit Symbol: Coding. Regardless, the levels of similarities for these two factors were within an acceptable range.

Discussion

This is the first analysis of the WAIS-III factor structure in MCI patients and the results were also compared with parallel analysis for the 55 to 74-year-old age group from the standardization sample of the WAIS-III. In terms of cognitive abilities, MCI group from the present study had well-documented neurocognitive deficits, while standardization group from the WAIS-III was supposed to be preserved in cognitive performance. This is because all potential standardization participants for the WAIS-III were screened with a self-report questionnaire and would be disqualified from the status of standardization sample if they had a history of seeing a doctor or other profession of a memory problems, or if they had a medical or psychiatric condition that could potentially affect cognitive functioning(4). The results concerning the WAIS-III performance from the present study revealed that the overall performances in the MCI group were lower than that of the standardization group. Although there was a difference in the level of neurocognitive functioning, the present study showed that the magnitude and pattern of subtest loadings derived through exploratory factor analysis for the MCI sample appeared consistent with those reported for the standardization sample in the WAIS-III WMS-III technical manual(4). Generally, the WAIS-III model proposed that performance on the wildly used intelligence scale depends on abilities in domains of Verbal Comprehension, Perceptual Organization, Working Memory, and Processing Speed. Thus, the current results provided support for the WAIS-III Model, which meant that the four-factor model also worked well for the standardization sample as well as for the people with MCI. This might suggest that the four-factor model could generalize across clinical boundary. Past studies(5,10,11,19-23) also reported the generalizability of their WAIS-III factor structure in clinical populations. Ryan et al(5) performed an exploratory factor analysis of the WAIS-III in a mixed patient sample of 152 patients with substance use disorders, medical or neurological conditions or psychiatric disorders and found that the four-factor structure were identical to those in the standardization sample of the WAIS-III. Dickinson et al(10) examined the parallel analyses of the factor structure of the WAIS-III in 120 outpatients of chronic schizophrenia and schizoaffective disorder and concluded that, in terms of the basic structure of the WAIS-III performance, the schizophrenia sample was very similar to the overall WAIS-III standardization sample and the results seemed likely to be generalized.

Despite the congruence between the present study results and the WAIS-III report, there still were areas of discrepancies between the WAIS-III performance, derived through exploratory factor analysis, in the present study MCI and the standardization sample.

First, the subtest Picture Completion showed similar loadings between Perceptual Organization and Processing Speed, with the primary loading being on Perceptual Organization and secondary loading on Processing Speed, different from the population of the WAIS-III, which had primary loading on Perceptual Organization and secondary loading on Verbal Comprehension. This suggested that the skills used by patients with MCI in these tests were evenly distributed between Perceptual Organization and Processing Speed. This might mean that the decline of cognitive functions among these particular patients might affect the balance in skills used in the tests, resulting in other skills being emphasized to compensate. Basically, in someone without the impairment, Picture Completion is a skill that require both visual reasoning and visual scanning process. Additionally, the subtest for Picture Completion takes time to completion into account, which is why the Processing Speed factor is related to skills in this subtest. Ward et al(7), also showed correlation between Processing Speed and Perceptual Organization using the population from the WAIS-III and found that subtests in the Processing Speed factor tend to show loading in Perceptual Organization more than those in Processing Speed itself.

Second, even though there are similarities in primary loadings between patients of MCI and the population from the WAIS-III, there are differences in secondary loading in the next factor. In particular, the subtest for Picture Arrangement and Block Design clearly showed primary loading in Perceptual Organization, the secondary loading was instead Working Memory. For the population in the WAIS-III, the secondary loading for Picture Arrangement is Verbal Comprehension and for Block Design is only in

Perceptual Organization. Additionally, in the subtest Digit Symbol: Coding, patients with MCI showed primary loading in Processing Speed and secondary loading in Working Memory, while the population in the WAIS-III showed loading only in Processing Speed. The possible explanation was the difference might be due to cognitive impairment's effect on the balance of skills used in various functions. Various past studies among MCI population[24-28] have found clear correlations between degredation in Working Memory and cognitive impairment. In all three subtests (Picture Arrangement, Block Design, and Digit Symbol: Coding), as the subjects were able to see the pictures at all times while taking the subtests for Picture Arrangement and Block Design, or see the symbols at all times while taking Digit Symbol: Coding, they needed to rely on working memory to complete the subtests. They needed to process and retain memories while taking the subtest Picture Arrangement, retain and correct memories in Block Design, and retain memories while distinguishing between numbers and symbols in Digit Symbol: Coding. Degradation in working memory in patients with MCI may result in needing to utilize even more working memory skills, as clearly shown when comparing patients with MCI to ones without impairment. Additionally, all three subtests, Picture Arrangement, Block Design, and Digit Symbol: Coding, fall under fluid intelligence, not crystalized intelligence. That is, they all primarily require problem solving skills instead of relying on knowledge or memory from past experiences. Neuropsychological studies in the past had also provided preliminary findings about working memory that working memory was a leading indicator of one's ability to learn using fluid reasoning[29-31].

Limitation

In general, analytical studies of factors aim to show correlations between different variables, therefore, the sample size is an important input. The present study's sample size is considered small, which may affect its findings and resulting conclusions. Future research should utilize larger homogeneous sample. Apart from the number of the sample size, excluding the Vocabulary subtest might affect the interpretation of the results as well, even though the Comprehension subtest might be sufficient to adequately measure the Verbal Comprehension construct[5]. Future research might need to clarify whether this exclusion has any clinical significance.

Conclusion

From the data and theories presented earlier, the present study can conclude that the four factors from the WAIS-III can be applied to patients with MCI. However, the degradation in working memory might be the possible explanation for the divergence in secondary loading of subtests that required this function to complete the performance. Therefore, further research should focus on the possibility to apply other models with other factors to this same cognitively impaired patient group.

What is already known on this topic?

Previous studies regarding generalizability of the WAIS-III factor structure have employed a broad range of patient samples such as schizophrenic disorder, substance use disorders and medical or neurological conditions, and found the factor structures corresponded reasonably well with those identified for the standardization sample.

What this study adds?

The present study focused particularly on generalizability of the WAIS-III among mild cognitively impaired population. The results suggested that the four factors model was able to apply to patients with MCI. However, there was also found that impaired working memory function might be the possible explanation for the divergence of secondary loadings for some subtests.

Conflicts of interest

The authors declare no conflict of interest.

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