신경재활치료과학 제 7 권 제 4 호
Therapeutic Science for Neurorehabilitation
Vol. 7. No. 4. 2018.
https://doi.org/10.22683/tsnr.2018.7.4.031

Development of Computerized Screening Test Items for Mild Cognitive Impairment

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Abstract

Objective: This study was to develop computerized screening test items for mild cognitive impairment.

Methods: Through literature reviews, items from computerized tests for screening mild cognitive impairment were extracted. A panel of professional experts validated that the items were important and fit to screen for mild cognitive impairment.

Results: A total 37 items were extracted from 12 computerized tests and 11 new items were added through the first panel review. After that, 18 items were removed via the second panel review. Finally, 16 items were selected by analyzing content validity ratio. 16 items consisted of memory, attention, and executive function areas.

Conclusions: A total of 16 computerized test items were developed. It is urgent to validate them to screen mild cognitive impairment. Moreover, standardization studies for this test are required in the future.

Key words: Cognitive testing, Item development, Mild cognitive impairment, Screening

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|| 접수일: 2018.09.06. || 심사일: 2018.10.30.
|| 게재승인일: 2018.11.03.

Ⅰ. Introduction

The importance of the early detection of Alzheimer's disease (AD) has been emphasized, since it may be possible to slow down the progress of AD or improve the symptoms(Cummings, Vinter, Cole, & Khachaturian, 1998). Thus, there has been a growing interest in screening for mild cognitive impairment (MCI), which is the prodromal stage of AD (Roberts, Clare, & Woods, 2009).

The commonly used paper-based screening tests for MCI, including the Mini-Mental Status Examination and the Montreal Cognitive Assessment (MoCA) only use a total score. Although they do not measure the reaction time of respondents, these tests can still be used to screen for MCI (Phillips, Rogers, Haworth, Bayer, & Tales, 2013). It should also be noted that these tests can be influenced by the degree of training the administrator has received or the test environment (Wouter et al., 2014).

To overcome these limitations, computerized screening tests were developed since the early 2000s. These tests include the Cognitive Assessment and Reference Diagnoses System (CARDS), CogState, and MicroCog tests (Zygouris & Tsolaki, 2015). Most computerized screening tests, however, focus on detecting dementia. Some studies indicated that in comparison to paper-based tests, computerized tests are less sensitive for MCI screening (De Lepeleire, Heyrman, Baro, & Buntinx, 2005). This is because MCI and dementia show different characteristics of cognitive decline (Silveri, Reali, Jenner, & Piopolo, 2007). In addition, existing computerized cognitive function test systems do not give more weight to memory scores, and some of the items that are included do not reflect the cognitive characteristics of elderly adults with MCI (Park & Park, 2016). Thus, there is a need to develop and validate a computerized screening test, which focuses on the cognitive characteristics of MCI.

Ⅱ. Method

This study was approved by the institutional review board of Yonsei University (1041849-201611-BM-060-01). Three subsequent stages of the study had to be conducted successfully to develop the computerized screening test. In the first stage, the items currently used in computerized screening test were extracted through a literature review. During the second stage, preliminary items were selected through an expert panel review. Finally, a feasibility study was conducted to select final items for the test in the third stage.

1. Item extraction

1) Literature review

During the month of June 2016, we first conducted a literature search on items that are currently used in test to screen for MCI, with using PubMed, Google scholar, Embase, PsyINFO, and the Cochrane Library database. The search terms were: ("computerized" OR "computer-based") AND (cognitive assessment" OR "screening test") AND ("mild cognitive impairment"). From this search, we set up a list of all the existing items that are currently used in computerized tests to screen for MCI.

2) Item selection

An expert panel consisting of eight occupational therapists and two occupational therapy professors reviewed the computerized screening test items during July and August 2016, to select the preliminary items. The general characteristics of the expert panel are outline in Table 1.

(1) First panel review

An expert panel review was conducted to investigate the opinions of the experts regarding the supplementation of the candidate items using open questions.

(2) Second panel review

Using the following exclusion criteria, the expert panel deleted items selected in the previous step that were: (1) not suitable for computerization, (2) too simple to reflect the level of cognitive function of MCI, (3) too complicated to understand, and (4) duplicate or combined items that were similar in nature.

(3) Third panel review

A third panel review was conducted to further refine the items selected in the previous steps. In this panel review, the items were assessed for the following: (1) fitness of MCI screening items and (2) importance of the items. Fitness and importance of the items were rated on a 5-point Likert scale as follows: 5 = strongly agree; 4 = agree; 3 = neither/nor agree; 2 = disagree; and 1 = strongly disagree.

The results of fitness and importance of the items were analyzed using the content validity ratio (CVR).

Table 1. Demographic characteristics of the expert panel (N=10)

Characteristics		Number	Percentage (%)
Sex	Male	7	70.0
	Female	3	30.0
Age	30–34 years	6	60.0
	35–39 years	2	20.0
	More than 40 years	2	20.0
Education level	Bachelor's degree	3	30.0
	Master's degree	5	50.0
	Doctoral degree	2	20.0
Clinical or educational experience	5–9 years	7	70.0
	More than 10 years	3	30.0
Workplace	University	2	20.0
	University or General hospital	3	30.0
	Rehabilitation hospital	3	30.0
	Dementia care center	1	10.0
	Other	1	10.0

Based on the criteria presented by Lawshe (1975), the items with a CVR of less than 0.62 were deleted.

3. Data analysis

Descriptive statistics, regarding the general characteristics of the expert panel and verification of the items' content validity, were generated using SPSS 20.0.

Ⅲ. Results

1. Item extraction

1) Literature review

A total of 1057 studies were identified, 12 of which were selected after the exclusion of 1045 studies (Figure 1). The following selection criteria were used: (1) studies using computerized screening tests for MCI, (2) studies investigating test methods and

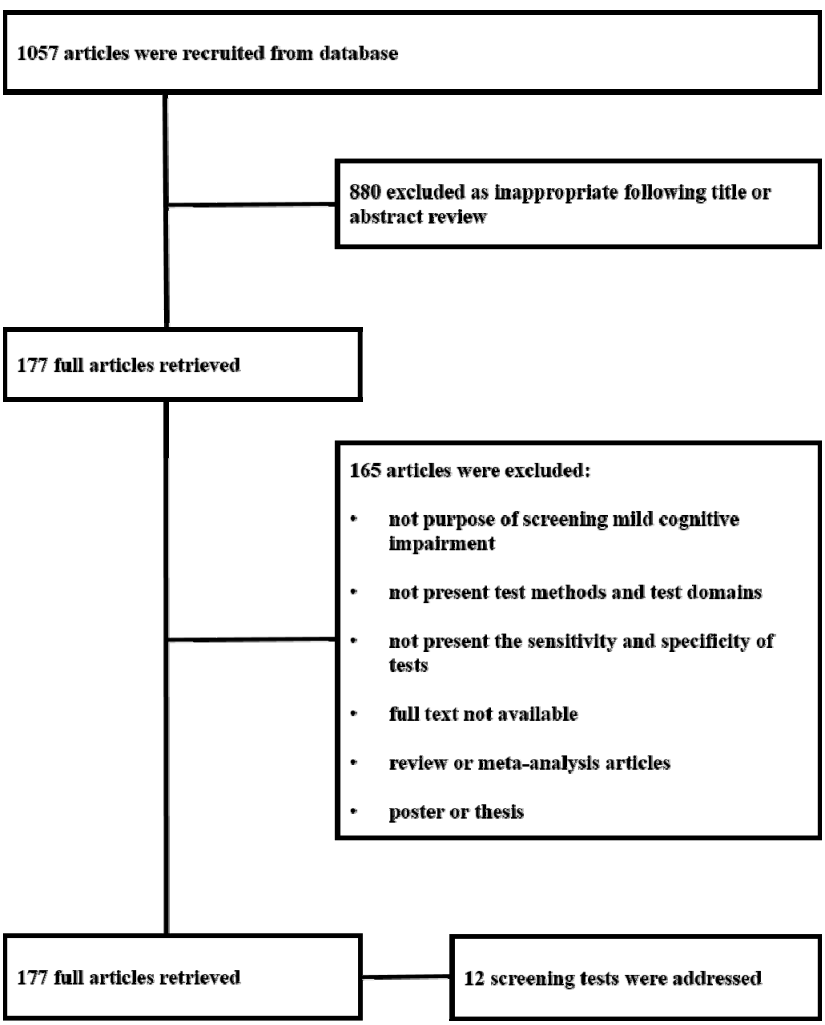

Figure 1. The literature search process used in the current study

test domains, (3) studies reporting on the sensitivity and specificity of tests, and (4) studies written entirely in English or Korean. The exclusion criteria were as follows: (1) review and meta-analysis studies, (2) academic theses, posters, contribution pieces, and meeting minutes, and (3) studies missing the main body. There were 10 computerized screening tests addressed in the 12 studies, with a total of 37 test items, excluding duplicated tests.

2. Item selection

1) First panel review

A panel with 10 experts generated 11 new items, excluding duplicated items. Thus, a total of 48 screening test items were collected, including 37 test items listed in current computerized screening tests and 11 items generated from the survey at the first panel review.

2) Second panel review

Based on a second set of criteria, 18 items of the potential 48 test items were removed, yielding an initial item set of 30 screening test items.

3) Third panel review

Based on the third set of criteria and the CVR analysis, 14 items of the 30 remaining items were eliminated because they had fitness or importance CVR of 0.62 or less(Table 2). A total of 16 computerized screening test items for MCI, including 8 items for memory, 4 items for attention, and 4 items for executive function(Table 3), were finally selected.

The necessary number of panel reviews was determined through the stability of panel review. Generally, a stability of less than 0.5 indicates that a high level of consensus has been reached (Choi & Suh, 2011). In the current study, the stability of fitness and importance during the third panel review were less than 0.5, indicating that no additional panel reviews were required.

Table 2. Results from the third expert review

Memory					
No.	Item contents	Fitness CVR	Fitness stability	Importance CVR	Importance stability
1	Remember the nine pictures on the screen and indicate where on the screen the pictures were presented[a]	0.00	0.29	0.60	0.14
2	After you remember the picture, identify the content of the picture	0.80	0.23	0.80	0.15
3	Remember the 10 words on the screen and indicate the words you remember in the 20 words presented next[a]	-0.40	0.23	-1.00	0.20
4	Remember the three pictures and indicate what they represented	0.80	0.15	0.80	0.15

Table 2. Results from the third expert review

No.	Item contents	Fitness CVR	Fitness stability	Importance CVR	Importance stability
	Memory				
5	Indicate what the three pictures you remembered 3 min ago represented	0.80	0.15	0.80	0.15
6	Listen to these three sounds and remember what they sound like	0.80	0.15	0.80	0.15
7	Remember the numbers you hear in exact order	0.80	0.14	0.80	0.14
8	Remember the numbers you hear in reverse order	0.80	0.21	0.80	0.21
9	Recall as many of the 10 words you heard 3 min ago as possible[a]	0.00	0.29	0.00	0.29
10	Remember the order in which the shape was drawn, and draw it in order[a]	-0.40	0.30	0.00	0.29
11	After remembering the faces on the screen, find the faces you remember[a]	-0.40	0.14	0.20	0.14
12	Listen to the story then indicate what you heard in the story	0.80	0.21	0.80	0.15
13	Find the location where the painting has changed	0.80	0.15	0.80	0.15
14	Press the keyboard arrow buttons according to the direction of the arrow on the screena	-0.40	0.27	0.40	0.12
15	Press the keyboard button as soon as you see two different pictures overlappinga	0.60	0.18	0.20	0.20
16	Find where the moving object is hidden	0.80	0.15	1.00	0.11
17	Press the keyboard button as soon as a number or a picture appears on the screena	0.00	0.21	0.00	0.21
18	Match the shapes of the two different objects and draw them as they move	1.00	0.11	0.80	0.15
19	Make a path in numerical order from 1 to 15	0.80	0.20	1.00	0.10
20	Find all objects with shapes that are different from those shown in the example	0.80	0.15	0.80	0.15
	Executive function				
21	Solve the Hanoi Tower puzzle according to the rulesa	0.20	0.17	0.20	0.17
22	When the blue circle appears on the screen, press the keyboard button as soon as possible. Note that a red circle may appear instead of a blue circle	0.80	0.15	1.00	0.11
23	Ignore the meaning of the letter and indicate the color of the letter as soon as possiblea	1.00	0.11	0.00	0.14
24	Indicate whether the shape matches the example when you rotate ita	-0.40	0.23	-0.20	0.30

	Executive function				
25	Observe the order of the figures listed according to a certain rule, and choose the on that should come next	0.80	0.15	0.80	0.14
26	Make categories of the most similar objects and explain	1.00	0.10	0.80	0.21
27	Arrange the pictures on the screen in the correct order of time	0.80	0.15	0.80	0.11
28	Complete the ladder so that it reaches its destinationa	0.20	0.20	0.20	0.19
29	Provide as many words as possible starting with the letter that will be presented nexta	0.20	0.17	-0.20	0.14
30	Imitate what you see in the picture on the screena	0.00	0.14	0.60	0.11
a Item that was removed due to a low content validity ratio (CVR)					

Table 3. Preliminary computerized screening items for mild cognitive impairment

No.	Item contents
	Memory
1	After you remember the picture, identify the content of the picture.
2	Find the location where the painting has changed
3	Remember the numbers you hear in exact order
4	Remember the numbers you hear in reverse order
5	Listen to these three sounds and remember what they sound like
6	Listen to the story then indicate what you heard in the story
7	Remember the three pictures and indicate what they represented
8	Indicate what the three pictures you remembered 3 minutes ago represented
	Attention
9	Find where the moving object is hidden
10	Match the shapes of the two different objects and draw them as they move
11	Make a path in numerical order from 1 to 15
12	Find all objects with shapes that are different from those shown in the example
	Executive function
13	Arrange the pictures on the screen in the correct order of time.
14	Observe the order of the figures listed according to a certain rule, and choose the on that should come next.
15	Make categories of the most similar objects and explain.
16	When the blue circle appears on the screen, press the keyboard button as soon as possible. Note that a red circle may appear instead of a blue circle.

Ⅳ. Discussion

This study generated and validated computerized screening test items that focus on MCI, in preparation to develop a valid test for MCI. Potential computerized screening test items relevant to MCI were identified through a literature review. Using pre-established criteria, an expert panel review, in addition to calculating the content validity ratio, yielded a final list of 16 computerized screening test items. This selection approach is valid and reliable, and is like the approach used to develop the paper-based screening test tools (Cho, Lee, Kim, & Cha, 2016).

Potential items that were too easy (several orientation items), were duplicates (memory items), or deems too difficult (several executive function items) were deleted. The experts also suggested eliminating items that simply tested the orientation of time, place, and person, since the cognitive characteristics of MCI do not include orientation impairment (Petersen, 2004).

In addition, items evaluating visuospatial and linguistic ability were also removed. Visuospatial ability items that evaluate form consistency through visual stimulation presented on the screen were removed because it is impossible to assess visuospatial ability by simply looking at visual stimuli and selecting correct answer using a computerized method. A previous study suggested drawing a picture with a pencil or using a direct object to construct a model for testing visuospatial ability (Lindsay et al., 2002). Linguistic ability items were deleted because the patient's performance on these items could be influenced by academic ability (Roselli, Tartaqlione, Federico, Lepore, Defazio, & Livrea, 2009). Therefore, it seemed appropriate to remove linguistic ability items to minimize the influence of academic background.

The proportion of items in the memory domain was high. The most prominent feature of elderly adults with MCI is that they do not completely recall events that have recently happened (Petersen, 2004). Therefore, screening tests for MCI should include items for testing episodic memory (Albert, Moss, Tanz, & Jone, 2001). However, in the MoCA-K, which is most commonly used to test for MCI, episodic memory items only represent 5 out of 30 possible points. Moreover, in existing computerized screening tests, the proportion of memory items does not differ from the proportion items from other cognitive domains, which makes these tests inadequate for screening MCI (Ahmed, Arnold, Thompson, Graham, & Hodge, 2009).

Further, the items in the attention domain included items to measure reaction time. Measuring the reaction time introduced a difference to paper-based screening test items for MCI (Park and Park, 2016). The ability to accurately measure reaction times is one of the advantages of computerized tests. Moreover, several studies reported that reaction time is an important factor in screening for MCI (De Jager, Schriinemaekers, Honey, & Budge, 2009; Memoria, Yassuda, Nakano, & Forlenza, 2014). Thus, the items presented here will be well suited for inclusion in a screening test for MCI.

This study, however, had a few limitations that must be noted. First, the number of the items could be limited, since articles published in other languages, besides English and Korean, were not included in this study. Second, the characteristics that

affect content validity may be present when the items are computerized. Therefore, in the future, a feasibility study on computerized screening test, consisting of the items presented here, is required to validate the clinical usefulness of this test to screen for MCI.

V. Conclusion

In this study, the 16 computerized screening items for mild cognitive impairment were developed. Even though a feasibility study with the items was not implemented yet, the items weighted in memory could reflect cognitive characteristics of mild cognitive impairment compared with existing paper-based items for screening mild cognitive impairment, which would be more sensitive in screening mild cognitive impairment. In the future, the computerized screening test with the items need to be conducted to validate sensitivity and specificity of the test.

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국문초록

경도인지장애 선별을 위한 전산화 평가 항목 개발

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목적 : 본 연구는 경도인지장애 선별을 위한 전산화 평가 항목을 개발하는 것이다.

연구방법 : 문헌고찰을 통해 경도인지장애 선별을 위해 사용되는 기존의 전산화 평가에서 항목들을 추출하였다. 이후 델파이 기법을 실시하였으며, 전문가 패널들의 의견을 취합하여 추출된 항목들을 수정 및 보완하고 최종적으로 중요도 및 적합도를 판단하여 평가 항목들을 선택하였다.

결과 : 문헌고찰을 통해 12개의 전산화 평가에서 37개의 항목을 추출을 하였고 1차적으로 전문가들의 의견을 통해 11개의 항목을 추가하였다. 이후 2차 전문가 모임을 통해 48개의 항목에서 경도인지장애 선별에 부적합한 18개의 항목이 제거되었다. 마지막으로 내용타당도 분석을 실시한 결과, 30개 항목에서 12개 항목이 제거되어 최종적으로 16개의 항목이 선택되었다. 최종 16개의 항목은 주의력, 기억력, 실행기능 영역으로 구성되었다.

결론 : 경도인지장애 선별을 위한 16개의 전산화 평가 항목이 개발되었다. 추후 이 항목들을 이용하여 타당성 연구를 실시하여 경도인지장애 선별에 적합한지 확인할 필요가 있다. 또한 이 전산화 평가를 정상 노인 및 경도인지장애 노인에게 실시하여 전산화 평가에 대한 표준화 연구를 진행하여 임상에서 사용할 수 있도록 해야 할 것이다.

주제어 : 경도인지장애, 선별, 인지평가, 항목개발