

# Development and Standardization of a New Cognitive Assessment Test Battery for Chinese Aphasic Patients: A Preliminary Study

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## Abstract

**Background:** Nonlinguistic cognitive impairment has become an important issue for aphasic patients, but currently there are few neuropsychological cognitive assessment tests for it. To get more information on cognitive impairment of aphasic patients, this study aimed to develop a new cognitive assessment test battery for aphasic patients, the Non-language-based Cognitive Assessment (NLCA), and evaluate its utility in Chinese-speaking patients with aphasia.

**Methods:** The NLCA consists of five nonverbal tests, which could assess five nonlinguistic cognitive domains such as visuospatial functions, attention test, memory, reasoning, and executive functions of aphasic patients. All tests are modified from the nonverbal items of the current existed tests with some changes to the characteristics of Chinese culture. The NLCA was tested in 157 participants (including 57 aphasic patients, 50 mild cognitive impairment (MCI) patients, and 50 normal controls), and was compared with other well-established relative neuropsychological tests on the reliability, validity, and utility.

**Results:** The NLCA was fully applicable in the MCI patients and the normal controls, almost working in the aphasic patients (57/62 patients, 91.9%). The NLCA scores were  $66.70 \pm 6.30$ ,  $48.67 \pm 15.04$ , and  $77.58 \pm 2.56$  for the MCI group, the aphasic group, and the control group, respectively, and a significant difference was found among three groups ( $F = 118.446$ ,  $P < 0.001$ ). The Cronbach's alpha of the NLCA as an index of internal consistency was 0.805, and the test-retest and interrater reliability was adequate ( $r = 0.977$  and  $r = 0.970$ , respectively). The correlations of the cognitive subtests and their validation instruments were between 0.540 and 0.670 (all  $P < 0.05$ ). Spearman's correlation analysis indicated that the coefficient of internal consistency of each subtest itself was higher than other subtests. When choosing the Montreal Cognitive Assessment score of  $< 26$  as the diagnostic criteria of cognitive impairment, the area under the curve for all participants in the control and MCI groups was 0.942 (95% confidence interval: 0.895–0.989), and an optimal cutoff point of 75.00 seemed to provide the best balance between sensitivity and specificity. Age ( $r = -0.406$ ,  $P < 0.001$ ) was the main influence factor for the NLCA.

**Conclusions:** The NLCA could efficiently differentiate the cognitive impairment patients from the normal controls and is a reliable and valid cognitive assessment test battery to specially find nonlinguistic cognitive function for aphasic patients.

**Key words:** Aphasia; Beijing Version of the Montreal Cognitive Assessment; Cognitive Impairment; Nonlanguage Cognitive-based Cognitive Assessment; Test Battery

## INTRODUCTION

Cognitive impairment is common in aging population and patients with neurological disorders. Attention, memory, executive functions, language, reasoning, and visuospatial abilities are six main domains of cognitive impairment, which are always assessed by standardized neuropsychological tests. Aphasia, defined as a loss or impairment of verbal communication, is a consequence of brain dysfunction and usually complicated by stroke or other injuries to the left

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The early results of this study had been published in *International Journal of Cerebrovascular Diseases* 2013;21:282-87.

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cerebral hemisphere. Recently, the concurrence of aphasia and nonlinguistic cognitive deficits, such as attention, memory, and visuospatial functions, has been confirmed in many studies.<sup>[1]</sup> It plays an important role in the recovery of aphasic patients.<sup>[2-5]</sup> Nowadays, many language therapists and aphasic clinicians have a consistent view that the status of neuropsychological dysfunction, especially cognition impairment in aphasic patients, constitutes the first step toward a well-founded language therapy. Furthermore, more and more neuropsychologists pay attention to the importance of the standard nonlinguistic cognitive examination and the detection and treatment of nonlinguistic cognitive impairment in aphasic patients.<sup>[6]</sup>

Unfortunately, many commonly used neuropsychological assessment tests need linguistic processing and/or production demands; thus, there are no unified tests for the cognitive assessment of aphasic patients. For example, the earlier cognitive assessment tests, such as the Benton Visual Retention Test,<sup>[7]</sup> the standard progressive matrices,<sup>[8]</sup> and working memory: looking back and looking forward,<sup>[9]</sup> are used in investigating the relationship between the nonlinguistic cognitive impairment and aphasia,<sup>[3,7]</sup> which include only one or two cognitive domains. In 2005, Kalbe *et al.*<sup>[10]</sup> considered three cognitive domains – memory, attention, and reasoning function – as part of aphasic assessment, and developed the aphasia check list (ACL). Recently, more comprehensive cognitive tests such as the cognitive linguistic quick test (CLQT)<sup>[11]</sup> and the Global Aphasic Neuropsychological Battery (GANBA),<sup>[11]</sup> which contain four or five nonlinguistic cognitive domains, have been developed. In addition, the Loewenstein Occupational Therapy Cognitive Assessment (LOTCA) Battery-Second Edition has been used in evaluating cognitive function in Chinese poststroke patients with aphasia by some researchers.<sup>[12]</sup> Nevertheless, these comprehensive cognitive tests are not suitable for Chinese aphasic patients due to the culture difference or application requirement. For example, the LOTCA is administered by a specific computer program which cannot make targeted jumps in clinical application. The lack of picture instructions in some subtests made it unsuitable for patients with severe disturbance of comprehension, such as Wernicke's aphasia. Therefore, a simple, efficient, and specialized screening tool is necessary to identify the cognitive impairment of aphasic patients, especially in Chinese patients.

According to the aforementioned considerations, this study aimed to develop a new test battery: the Non-language-based Cognitive Assessment (NLCA) to assess the cognitive impairment in Chinese aphasic patients. All tasks in this test are nonverbal to overcome the influence of linguistic process in the assessment, and it contains five main cognitive domains such as visuospatial function, reasoning, memory, attention, and executive functions. This study described the construction of the NLCA and evaluated the validity and reliability of this test in 157 participants.

## METHODS

### Ethical approval

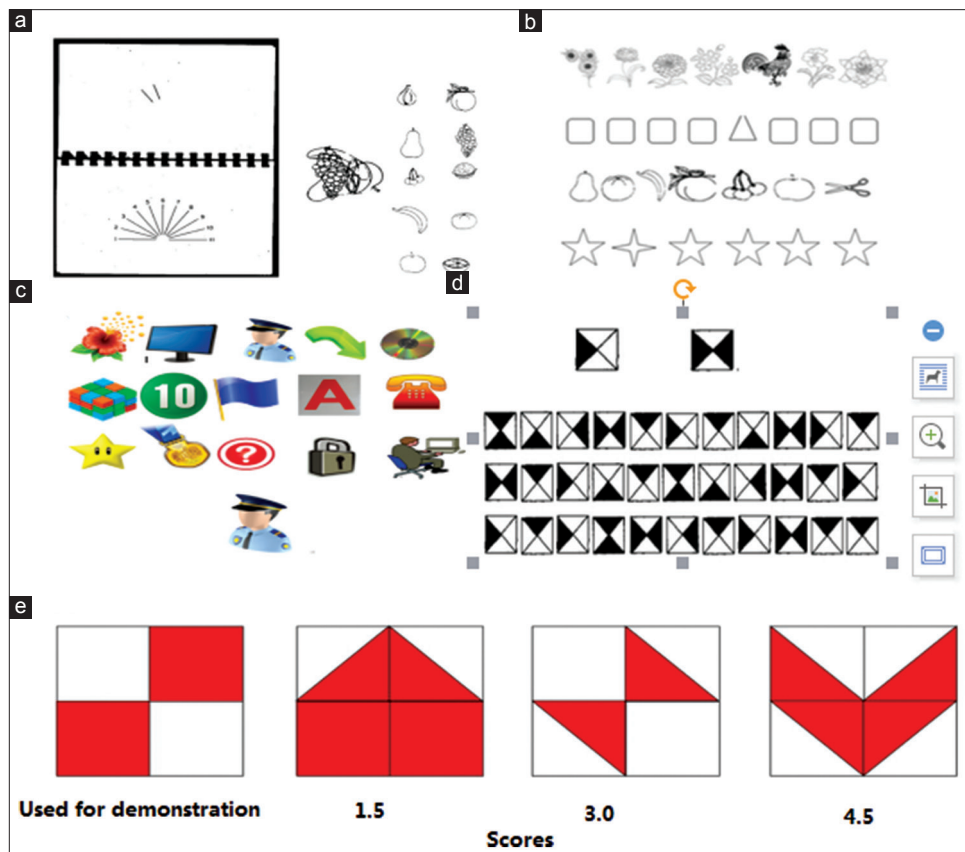
The study was conducted in accordance with the *Declaration of Helsinki* and was approved by the Local Ethics Committee of Nanfang Hospital. Informed consent was obtained from all participants or their legal representatives, and the research aims, procedures, and confidentiality requirements were fully disclosed to them by the researchers.

### Test construction

The NLCA consists of five main cognitive domains except for language: part (A) visuospatial function test, part (B) reasoning test, part (C) memory test, part (D) attention test, and part (E) executive functions test. It was designed based on the following three principles: (1) nonverbal patterns in the form of pictures or operational tasks are adopted in all tests; (2) the assessor shows the test rules and requirements to the participants and guides them by demonstrating how to operate the test rather than verbal instructions; and (3) the evaluation contents and stimulus figures in each part are administered from less to more and easy to difficult. All subtests of the NLCA are adopted from the nonverbal items of the current existed tests, which have been verified with good reliability and validity. In addition, some modifications were made according to the characteristics of Chinese culture. The common used figures are changed according to the daily life in the nonverbal memory test. Furthermore, the materials shown in the reasoning test are choosing according to Chinese culture. In general, the interpretation and evaluation of the entire test takes approximately 30 min. All instructions are easy to understand and the example tasks are shown in Figure 1.

#### Part (A) visuospatial function subtest

This part consists of two subtests (the spatial orientation test and the Ghent overlapping figure test). The spatial orientation test is a visuospatial judgment tool created by Benton *et al.*<sup>[13]</sup> in 1978. It is a task discriminating the direction of lines. The stimuli are 11 lines numbered from 1 to 11 with the same length and the same interval angles. They are drawn in a fan-like array. In the test, participants have to indicate, by naming or pointing out the two lines with the same angles and locations as the two stimulus lines in the response-choice display without time limit (“pointed in the same direction”). Before the test items, five practice items with the full-length lines are administered. Finally, a typical 5-item task was selected in this study in consideration of economic administration time. And, the total scores are five points. The Ghent overlapping figure test is adopted from the same series of drawings used by De Renzi *et al.*<sup>[14]</sup> Based on the established test paradigms, this study constructed 3 cards, one for the practice and demonstration and the other two for the formal test which contains 3 or 5 overlapping figures. Participants are requested to point to the identical figures drawn separately on the display board interspersed with other object figures belonging to the same category rather than naming the objects presented on the display board. The



**Figure 1:** Stimulus material and templates for five subtests of the Non-language-based Cognitive Assessment: (a) visuospatial function subtest: Spatial orientation (left side) and the Ghent overlapping figures (right side); (b) reasoning subtest: One example column and three of the test task columns (below side); (c) memory subtest: Stimulus (below side) and templates for the short-delay recognition task (upside); (d) attention subtest: Target items and example (below side); (e) executive function subtest: Target graphical models (right side) and example task (left side).

total scores are 8. Therefore, the total scores of visuospatial functions test are 13 [Figure 1a].

### Part (B) reasoning subtest

It assesses both the recognize regularities and reasoning functions of aphasic patients. The stimuli in this study are similar to the series of drawings used by Kalbe *et al.*<sup>[10]</sup> The test includes nine rows of figures, one for practice and the others for the formal test. Each row follows a specific rule and the sign which breaks the rule has to be recognized and crossed out. The number of correctly solved lines is scored and the maximum scores are 8 [Figure 1b].

### Part (C) memory subtest

In this part, 15 common used figures in daily life are selected for recognition, including portrait, words, and symbol. Participants are asked to memorize specific figures (the stimulus consists of 4 pairs, each pair is assembled in two different orders considering statistical heteromorphosis, and the stimulus numbers of pairs proceed from 1 to 4 figures) in a set of 15 figures within 10 s and then recognize the specific figures among 15 figures. It is based on the established test paradigms of the Wechsler Memory Scale-Revised<sup>[15]</sup> and the visual recognition memory task.<sup>[10,16]</sup> In addition, some modifications and improvements were made according to the characteristics of Chinese culture. The test is scored as subtracting incorrect

recognition of distractor figures from the correct recognition ones. The maximum scores are 20 [Figure 1c].

### Part (D) attention subtest

The cross-out paradigm task to assess both the speed and the quality aspects of selective attention in this part is adopted from Kalbe *et al.*<sup>[10]</sup> Participants have to cross out the specific figures within similar figures in the response columns. The number of correctly selected figures is scored, which is the main evaluation index. And, the maximum scores are 30. In addition, another two parameters are analyzed in the task: the total number of processed signs and the total number of processed signs minus errors (missed and incorrect items) indicating the speed aspect and the accuracy of attention, respectively. However, they are only as a reference, not included in the total score [Figure 1d].

### Part (E) executive function subtest

It is assessed by the Place blocks test following the Aphasia Battery of Chinese (ABC).<sup>[17]</sup> In this test, participants are asked to place blocks correctly according to the graphical models designed in advance. There are 4 models in total, the first one is for demonstration and the other three are for the formal test, they follow the principle of easy to difficult and scoring 1.5, 3, and 4.5, respectively. The maximum scores of this subtest are 9 [Figure 1e].

All tasks are nonverbal to minimize overlapping with aphasic symptoms (although even in nonverbal tasks verbal processing generally cannot be excluded). The total scores of NLCA test are 80.

## Neuropsychological assessment

### Validation instruments

The NLCA was validated in the mild cognitive impairment (MCI) participants as there were no united criteria for the cognitive impairment in aphasic patients. For this purpose, this study compared the NLCA measures with performance in well-established neuropsychological test instruments. The overall performance of NLCA was compared with the Beijing version of the Montreal Cognitive Assessment (the MoCA-BJ).<sup>[18]</sup> It is one of the most widely used Chinese versions of MoCA in the current study. In addition, the memory, visuospatial function, attention, and executive function and reasoning subtests of NLCA were validated with the subtest visual reproduction I and II of the Wechsler Memory Scale-Revised,<sup>[15]</sup> the subtest of Rey Complex Figure Test,<sup>[19]</sup> the Digit Span Forward Subtest of the Chinese version of the Wechsler Adult Intelligence Test,<sup>[15]</sup> the Color-word Matching Stroop Task,<sup>[20]</sup> and the Raven's Standard Progressive Matrices Test, respectively.<sup>[21]</sup>

### Participants and procedures

Totally, 157 voluntary participants were recruited in the study between January 2013 and June 2015. They were assigned to three groups: the aphasic group (57 patients), the MCI group (50 patients), and the normal controls (50 healthy adults). All patients were recruited from the Outpatient Neuropsychological Clinic and Inpatients of the Neurology Department in Nanfang Hospital. Participants of the control group were the family members, the caregiver of the patients, or the residents nearby. The participants were excluded from this study if they met the following criteria: (1) less than 18 years of age; (2) pregnant women, lactating women or people with mental disorders; (3) with physical disability or suffering from severe systemic disease; or (4) uncooperative with the research evaluated by a clinician.

The diagnosis of MCI was based on the Mayo Clinic's criteria.<sup>[22,23]</sup> And, it could be classified into amnesic and nonamnesic or single and multiple impaired domains. In this study, there were 35 amnesic patients, 15 nonamnesic patients, while 32 were single-impaired domain and the other 18 were multiple-impaired domains. Patients diagnosed with MCI also met the core clinical criteria for MCI as described in the recently published recommendation of the new diagnostic criteria.<sup>[24,25]</sup> The 57 aphasic patients suffered from the first or second stroke and had aphasia with different etiology and different stages. All aphasic patients were right-handed, and according to the ABC test, they were classified as mixed transcortical aphasia ( $n = 7$ ), Wernicke aphasia ( $n = 9$ ), Broca aphasia ( $n = 37$ ), global aphasia ( $n = 2$ ), and crossed aphasia ( $n = 2$ ).

Inclusion criteria for MCI and aphasic patients were as follows: (1) patients with stroke must be confirmed by

computed tomography or magnetic resonance imaging; (2) patients must keep a stable mood and stay clear-headed; (3) patients must be willing to cooperate for conditional visits; (4) the patients' aphasia needs to be identified and put into categories according to the ABC; (5) patients with integrated visual field and without neglect had good enough movement skill that can successfully complete the tests.

Exclusion criteria were as follows: (1) patients in coma, unconscious/vegetative state, or other serious condition, who were unable to complete the assessments; (2) patients' condition developed rapidly and acutely, and was deteriorated with signs of latest cerebral infarction or intracerebral hemorrhage, or internal organ dysfunction and failure; and (3) patients with current or history of drug abuse and psychosis according to ICD-10 (World Health Organization, 1994).

All participants were selected by a psychologist with a standard questionnaire including a complete sociodemographic questionnaire, an interview of current clinical health status, past habits, and medical history. And, the related neuropsychological tests included the Mini-Mental State Examination (MMSE), the MoCA-BJ, the Clinical Dementia Rating (CDR) scale,<sup>[26]</sup> and the Activities of Daily Living (ADL) scale.<sup>[27]</sup> All patients did not have any medication treatment which might influence their cognition during the task.

As a control group, 50 normal controls were classified as unimpaired cognition according to the CDR and were independent in ADL. Inclusion criteria were as follows: (1) normal general physical status; (2) no memory complaints and CDR = 0, independent in ADL; (3) free of past or present neurological and psychotic disorders or cognitive symptoms, no thyroid gland disorders, drug abuse, or other diseases that may result in cognitive impairment; and (4) basic demographics data such as age, gender, and educational level matched with MCI and AP patients as much as possible.

Three months after the initial visit, 20 participants (10 normal controls and 10 MCI patients) were asked to a retest to assess the test-retest reliability and another 20 participants were asked to test the interrater reliability by two different assessors (both of them were postgraduates of our study and had received specialized training before the study to guarantee the procedure for quality control).

### Statistical analysis

All statistical analyses were carried out by Statistical Package for the Social Sciences (SPSS, version 20.0; America IBM Corp., Armonk, New York, USA). Descriptive statistics were used for the sample's characterization. Parametric methods (two-sample *t*-test, analysis of variance with one factor and the Tukey's Honestly Significant Difference and Bonferroni *post hoc* test) were used for normally distributed data. The Cronbach's alpha and Pearson correlation coefficients were used to verify the reliability and validity of the test battery. The nonparametric receiver operating characteristics (ROC) curve analysis was used to assess the predictive diagnostic

value of the NLCA for cognitive impairment and identify the optimal balance between sensitivity and specificity.<sup>[28]</sup> In case of significant deviations from the normal distribution tested with the Kolmogorov-Smirnov test, nonparametric methods were used (Mann-Whitney *U*-tests, Wilcoxon tests, Friedman tests). Multivariate linear regression analysis was used to evaluate the influencing factors. A  $P < 0.05$  (two tailed) was considered statistically significant.

## RESULTS

### Demographic and neuropsychological details of the participants

Table 1 summarizes the characteristics of all participants, including gender, age, educational level, NLCA scores, and MoCA-BJ scores. There were no significant differences in gender ( $F = 0.988, P = 0.375$ ), age ( $F = 1.855, P = 0.160$ ), and education level ( $F = 1.012, P = 0.366$ ), but had significant difference in NLCA scores ( $F = 118.446, P < 0.001$ ) among three groups. While in MoCA scores, significance difference ( $F = 278.064, P < 0.001$ ) was also found between the control group and the MCI group.

The NLCA was fully applicable in MCI and control groups and most in aphasic group (57/62 patients, 91.9%). The administrated time ranged from 20 to 30 min which depended on the education level and severity of cognitive symptoms. The

scores in each subtest of the control group, MCI group, and aphasic group decreased in sequence and further analysis of the NLCA subtests performance found significant differences among three groups in each subtest [Table 2].

### Reliability and validity evaluation

#### Reliability evaluation of the Nonlanguage Cognitive-based Cognitive Assessment

The Cronbach's alpha of the NLCA as an index of internal consistency was 0.805 for the total study sample. Correlations of the cognitive subtests and their validation instruments were between 0.540 and 0.670 (all  $P < 0.05$ ). The test-retest reliability and interrater reliability data were collected for subsample of 20 participants (10 controls and 10 MCI patients) separately. According to the spearman correlation analysis displayed in Table 3, the test-retest reliability and the interrater reliability of the total scores between the two evaluations were 0.977 and 0.970 respectively, and each subtest scores of the two evaluations were also significant correlation.

#### Validity evaluation and the optimal cutoff value of Nonlanguage Cognitive-based Cognitive Assessment

Compared with the control group, the scores of all five subtests of the NLCA in the MCI group were lower (all  $P < 0.001$ ). The Spearman correlation analyses of all subtests are displayed in Table 4. From the result, we found that the coefficient of internal consistency of each subtest

**Table 1: Demographic and neuropsychological characteristics of all participants in this study**

Characteristics	Control group (n = 50)	MCI group (n = 50)	Aphasic group (n = 57)	$P_a$	$P_b$	$P_c$
Gender, n				0.996	0.621	0.478
Male	30	29	40			
Female	20	21	17			
Age group, n				0.362	0.981	0.235
≤49 years	5	4	12			
50–64 years	25	23	26			
≥65 years	20	23	19			
Educational level, n				0.432	0.958	0.713
≤6 years	22	26	27			
7–11 years	15	13	18			
≥12 years	13	11	12			
NLCA scores, mean ± SD	77.58 ± 2.56	66.70 ± 6.30	48.67 ± 15.04	<0.001	<0.001	<0.001
MoCA-BJ scores, mean ± SD	28.04 ± 1.23	22.46 ± 2.02	–	<0.001		

$P_a$ : Control group versus MCI group;  $P_b$ : Control group versus aphasic group;  $P_c$ : MCI group versus aphasic group; MCI: Mild cognitive impairment; NLCA: Non-language-based Cognitive Assessment; MoCA-BJ: Beijing version of the Montreal Cognitive Assessment; SD: Standard deviation; –: Not applicable.

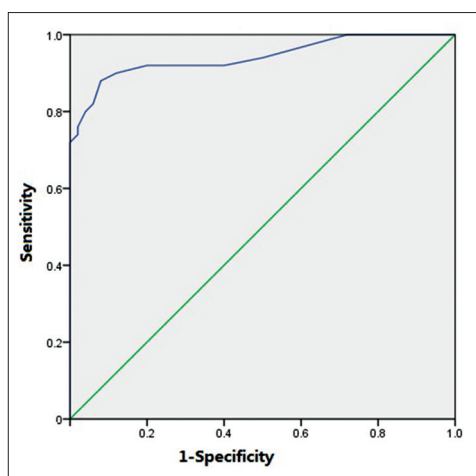
**Table 2: Performance of NLCA subtests among three groups**

Test scores	Maximal score	Control group (n = 50)	MCI group (n = 50)	Aphasic group (n = 57)	F	P
Memory	20	19.88 ± 0.48	15.86 ± 2.68	12.81 ± 5.39	51.690	<0.001
Attention	30	29.14 ± 1.34	26.06 ± 2.28	18.77 ± 7.27	71.449	<0.001
Reasoning	8	7.38 ± 0.73	6.80 ± 0.93	4.95 ± 1.76	56.028	<0.001
Executive functions	9	9.00 ± 0.00	7.26 ± 2.17	3.07 ± 3.45	86.062	<0.001
Visuospatial functions	13	12.18 ± 0.98	10.72 ± 1.57	9.07 ± 3.23	26.399	<0.001
Total scores	80	77.58 ± 2.56	66.70 ± 6.30	48.67 ± 15.04	118.446	<0.001

The data are shown as mean ± SD. MCI: Mild cognitive impairment; NLCA: Non-language-based Cognitive Assessment; SD: Standard deviation.

itself was higher than other subtests, which meant good construct validity of the NLCA.

To verify the accuracy of the NLCA for the recognition between cognitive impairment patients and the normal controls, the ROC analysis was performed. While choosing the total scores of MoCA-BJ was <26 as the diagnostic criteria of cognitive impairment, for all participants in control and MCI groups, area under the curve was 0.942 (95% confidence interval: 0.895–0.989; Figure 2). As shown in Table 5, the sensitivity and specificity of the NLCA to discriminate MCI patients and normal controls were 88.0% and 90.0% while choosing cutoff point as 74.50 and 80.0%



**Figure 2:** The receiver operating characteristics of Non-language-based Cognitive Assessment for the recognition of cognitive impairment patients while choosing Beijing version of the Montreal Cognitive Assessment as the diagnostic criteria.

and 92.0% for cutoff point as 75.50. From the above, an optimal cutoff of 75.00 point seemed to provide the best balance between sensitivity and specificity.

### Analysis of influencing factors

In addition, this study checked the impact of other related factors such as gender, age, educational level, and the general cognitive status (ADL and MoCA-BJ scores) on the outcome of the NLCA. The further analyses showed that, among all the factors, gender ( $r = 0.060$ ,  $P = 0.553$ ) and educational level ( $r = 0.132$ ,  $P = 0.191$ ) were negatively associated with the total scores of NLCA, while MoCA-BJ scores ( $r = 0.812$ ,  $P < 0.001$ ) and age ( $r = -0.406$ ,  $P < 0.001$ ) were highly and positively associated with the total scores of NLCA.

To verify whether the assessors' nonverbal demonstrations of how to operate the test guided by the assessor could be successfully understood by all participants, we fortunately invited two deaf-and-dumb males with cerebral ischemia and their deaf-and-dumb wives to our study. All of them performed the NLCA well individually and the results showed that the NLCA scores of the 2 males (64, 68) were lower than their wives (79, 77).

### DISCUSSION

Due to the important role of the nonlinguistic cognitive impairment in aphasic patients, it is urgent to have practical neuropsychological cognitive assessment tests in population with non-English speaking, like Chinese. The new test battery, NLCA, was developed according to the cognition part of ACL to assess the cognitive impairment in Chinese aphasic patients.<sup>[10]</sup> Although the ACL includes an elaborate language

**Table 3: Spearman correlation coefficient of test-retest reliability and interrater reliability in the NLCA**

Items	Test-retest reliability				Interrater reliability		
	Correlation coefficient	Wilcoxon tests		Correlation coefficient	Wilcoxon tests		
		Z	P		Z	P	
Memory	0.907*	-0.299	0.765	0.904*	-0.194	0.846	
Attention	0.894*	-0.425	0.671	0.873*	-0.596	0.551	
Reasoning	0.994*	-0.554	0.580	0.955*	-1.732	0.083	
Executive functions	0.840*	0.000	1.000	0.840*	-1.414	0.157	
Visuospatial functions	0.893*	-0.350	0.726	0.931*	-0.218	0.827	
Total scores of the NLCA	0.977*	-0.343	0.732	0.970*	-0.632	0.527	

\* $P < 0.01$ . NLCA: Non-language-based Cognitive Assessment.

**Table 4: The spearman correlation analysis of all subtests in the NLCA**

Items	Memory	Attention	Reasoning	Executive functions	Visuospatial functions	Total scores of the NLCA
Memory	1					
Attention	0.708*	1				
Reasoning	0.290*	0.389*	1			
Executive functions	0.405*	0.500*	0.245 <sup>†</sup>	1		
Visuospatial functions	0.536*	0.592*	0.556*	0.268*	1	
Total scores of the NLCA	0.829*	0.898*	0.572*	0.579*	0.761*	1

\* $P < 0.01$  (two-tailed); <sup>†</sup> $P < 0.05$  (two-tailed). NLCA: Non-language-based Cognitive Assessment.

**Table 5: Sensitivity and specificity of NLCA for MCI while choosing MoCA-BJ as the diagnostic criteria**

Cutoff point	Sensitivity (%)	Specificity (%)
68.50	100.0	60.0
69.25	100.0	68.0
69.75	100.0	72.0
70.25	98.0	74.0
70.75	98.0	76.0
71.50	96.0	80.0
72.50	94.0	82.0
73.50	92.0	88.0
74.50	88.0	90.0
75.50	80.0	92.0
76.50	72.0	92.0
77.50	60.0	92.0
78.50	50.0	94.0
79.50	28.0	100.0

MCI: Mild cognitive impairment; NLCA: Non-language-based Cognitive Assessment; MoCA-BJ: Beijing version of the Montreal Cognitive Assessment.

part and a shorter cognitive part, comparing with the ACL, the NLCA is more comprehensive and suitable for Chinese aphasic patients. The cognitive part of the ACL consists of three tasks including memory, attention, and reasoning domains. All tasks are nonverbal and the instructions are easy to understand, but only assess three selected cognitive domains, such as memory, attention, and reasoning. However, the dysfunction of other cognitive domains, such as attention and executive function, is also found in many aphasic patients.<sup>[4,29]</sup> Furthermore, culture difference limits the use of ACL in other country, especially in non-English-speaking countries. As shown in this study, the NLCA overcomes these two main shortcomings. Specially, all tasks in NLCA are designed with fully consideration of Chinese culture; it is not only suitable to Chinese patients but also a good reference to Japanese and Korean patients, who use the similar language characters.

Except for ACL, there are some other cognitive assessment tests for aphasic patients such as the Raven's progressive colored matrices,<sup>[21]</sup> the CLQT,<sup>[30]</sup> and the GANBA.<sup>[10]</sup> However, the Raven's progressive colored matrices cannot exactly assess the cognitive impairment of aphasic patients since it only targets one type of cognitive behavior (the visual analogic thinking). The CLQT assesses more cognitive domains and consists of ten tasks. Four nonverbal tasks assess the cognitive functions such as attention, memory, executive function, and visuoconstructive function. They could be performed in most aphasic patients but lack of further study in its application. The GANBA was specifically designed in 1992 for patients with severe aphasia. It targets the areas of attention/concentration, memory, intelligence, visual recognition, and nonverbal auditory recognition. However, it is rarely used due to lack of enough data about its reliability and validity.

This study applied the NLCA in all MCI patients and normal controls, and most aphasic patients (57/62, 91.9%). The failure of the NLCA applied in other 5 aphasic patients

mainly because of massive brain infarction, impaired consciousness, or severe motor deficits. The results of the 2 deaf-and-dumb couples showed that the NLCA scores of the 2 males were significantly lower than their wives and were supposed to have cognitive impairment according to the optimal cutoff point. These special cases helped exclude the bias due to the language disorder in understanding the demonstration of the tasks, instead of cognitive impairment. Thus, this study provided evidence to the feasibility of the NLCA in aphasic patients.

The NLCA was a test with good reliability and validity. The optimal cutoff point to distinguish cognitive impairment patients from the normal controls was 75.00. The psychometric properties of the NLCA including internal consistency, test-retest reliability, interrater reliability, content validity, construct validity, and empirical validity were verified in details separately. Normative data have been acquired with a certain amount of MCI and normal samples as well. In total, 89.5% ( $n = 51$ ) patients of the aphasic group in the study showed nonlinguistic cognitive impairment, which was in accordance with the results of an earlier study.<sup>[31]</sup> However, the question whether their performance restricted in the non-language tasks are due to cognitive dysfunction or the cognitive dysfunction occurred as a consequence of language impairment, or both reasons, could not be answered with our data and must be a matter for future research. Furthermore, the outcome of the NLCA was found mainly influenced by age, but independent of educational level and gender. It was different from the commonly used cognitive screening tests such as the MMSE and the MoCA, in which the educational level is the main influence factor. A possible reason is that all tasks in this study adopted nonlinguistic patterns in the form of pictures or operational tasks, but without involvement of language, these properties of nonlinguistic patterns definitely weaken the affection of education level. Besides, the contents of pictures or operational tasks in these properties appear more often to young people than the aged. Thus, it is worth to include more suitable contents for different age-bracket in the future study. While some of the results were different from our previous study,<sup>[32]</sup> such as the optimal cutoff point and the influence factors of the NLCA. The possible reasons for these differences might be as follows: (1) the included subjects and sample size of this study were different from those of previous study; and (2) the influence of educational level on cognitive function might decrease gradually due to the impairment of language function in aphasic patients. This study suggested that we should not only pay attention to the impairment of language function in aphasic patients, but also pay more attention to the recognition and intervention of cognitive function in aphasic patients. As the samples size of the present study was larger and more reasonable than that of the previous study, we were more likely to regard 75.00 as the optimal cutoff point. However, due to lacking enough samples in both studies, we are still unsure whether the educational level is one of the main influence factor for the NLCA. It's one of the key problems, which should be solved in further research.

There are some limitations of this study. First, only five subtests were used in this study, which might lead to some difficulty in characterizing cognitive impairment phenotypes of aphasic patients. Second, sample size may not be large enough to make accurate optimal cutoff points. Finally, although the NLCA was developed for aphasic patients specially, its sensitivity and specificity for other dementia syndromes, such as Alzheimer's disease, Parkinson's dementia, and vascular dementia, remain to be addressed. Taking these into consideration, the NLCA should be regarded as an efficient screening instrument for cognitive impairment in aphasic patients rather than diagnostic assessments. Future research may focus on investigating feasibility, applicability, and the development of normative data of the NLCA performance in aphasic patients with a larger samples size, multiple centers, and different culture. In addition, more attention should be pay to the ability of the NLCA in detecting longitudinal alterations in cognitive and behavioral function. Moreover, a suitable and advisable network electronic version of the NLCA could be made if possible, which can be more convenient and effective for aphasic patients.

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### Conflicts of interest

There are no conflicts of interest.

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