Reliability and validity of A Quick Test of Cognitive Speed (AQT) in Iranian older adults

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Research article

Keywords: Aged, Cognition Disorders, Mental Status, Dementia Tests.

DOI: https://doi.org/10.21203/rs.3.rs-80986/v1

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Abstract

Background: Cognitive disorders are one of the most important issues in old age. They may remain hidden in the early stages. There are many cognitive tests, but some variables affect their results (e.g., age and education.) This study aimed to evaluate the reliability and validity of A Quick Test of Cognitive Speed (AQT) in Iranian older adults.

Methods: This study aimed to test the psychometric properties of AQT. 114 older adults participated in the study and were divided into three groups (46 with mild cognitive impairments (MCI), 24 with dementia, and 45 without MCI and dementia) based on the diagnosis of two geriatric psychiatrists. Participants were assessed by AQT and Mini-Mental State Examination (MMSE). Data were analyzed using Pearson correlation, independent t-test, and ROC curve by SPSS v.23.

Results: There was no significant correlation between AQT subscales and age and no significant difference between the AQT subscales in male and female, educational levels, and marital status. The test-retest correlations (r) were significant for Color (C) 0.84, Form (F) 0.91 and Color-Form (CF) 0.94. Convergent validity was significant between MMSE and AQT. Its correlation was with Color -0.78, Form -0.71, and Color-Form -0.72. The cut-off point for Color was 43.50 s, Form 52 s, and Color-Form 89 s were based on sensitivity and specificity for differentiating older patients with MCI with controls. The cut-off point for Color was 62.50 s, for Form 111 s, and Color-Form 197.50 s based on sensitivity and specificity measures for differentiating older patients with dementia and MCI.

Conclusion: The findings of this study showed that A Quick Test of Cognitive Speed (AQT) is a suitable tool for assessing cognitive function in older adults.

1. Background

An increase in the aging population is associated with a higher prevalence of diseases and syndromes in older people, one of which is cognitive disorders. Cognitive impairment is a common neurological disorder in old age and includes a wide range of conditions from mild cognitive impairment (MCI) to advanced dementia [1]. MCI is a precursor to dementia and is a transition from age-related cognitive decline to more severe cognitive disorders [2]. Different mechanisms such as amyloid deposition, inflammation, and increase in free radicals, loss of synapses and neurons, and dysfunction of neurotransmitters lead to dementia [1]. There are about 50 million people in the world with dementia, and ten million new cases are added each year. It is estimated that the number of people with dementia will reach 152 million by 2050 [3]. About 70 percent of dementia cases are related to Alzheimer’s disease (AD), which is expected to reach about 115 million patients by 2050 [4]. AD is a neurodegenerative disorder that is associated with diffuse functional and structural abnormalities in the brain and leads to progressive cognitive and behavioral deficits [5].

The definitive diagnosis of AD is possible only by histopathological examination of brain tissue after death, therefore, most cases are diagnosed based on clinical information [6]. Clinical paradigms that assess cognitive function range from short memory tests to comprehensive assessment scales [7]. Cognitive disorders are generally assessed by broader neuropsychological tests [8]. Traditional cognitive status scales show little sensitivity in distinguishing between the normal range of cognitive function and cognitive impairments [7] and are influenced by culture, language, and education [9]. The Mini-Mental State Examination (MMSE) and the Clock Drawing Test (CDT) are diagnostic tests for dementia, whose accuracy is still questionable, and which limits the ability to diagnose patients with early-stage dementia and MCI [10]. In contrast, the use of visual-verbal scales such as A Quick Test of Cognitive Speed (AQT) that are not influenced by factors such as gender, formal education beyond the acquisition of literacy (Grades 5 to 8), and culture, can distinguish between normal aging and cognitive disorders caused by disease [11].

The processing-speed theory of adult age states that the decrease in processing-speed is due to cognitive decline, not to the reduction in or lack of information [12]. Rapid Automatized Naming (RAN) is the ability to perceive a visual symbol such as letter, Color, and Form, or retrieve it quickly and accurately. Stroop in 1953 designed the first RAN test, the Stroop Color and Word Test. This test involves, among others, the ability to consistently read the names of colors printed in contrasting colors, thus inhibiting responses to distracting features. Denckla and Rudel in 1976 used continuous naming of numbers, shapes, letters, and colors to evaluate RAN speed. Wiig (1984) designed a Color (C), Form (F), and Color-Form (CF) processing-speed test to probe RAN abilities in children with language disorders [13]. A Quick Test of Cognitive Speed (AQT) was later designed by Wiig et al. to compare processing speed in adults with clinical diagnoses of dementia and neuropsychological tests [14–17]. AQT is a visual-verbal processing speed test that evaluates aspects of executive function and can be used in a variety of languages and cultures [7, 11, 18]. AQT measures the speed of perception, retrieval, and naming of basic colors and forms in single-word naming and cognitive speed associated with central executive functions (attention, working memory, and set shifting) in dual-dimension naming of color-form combinations. Studies showed that a decline in the speed of perception and cognition precedes a decline in linguistic-cognitive abilities in mild to moderate severity of AD [10].

AQT has been tested in many languages and findings indicate that processing speed varies with the symbolic structure of words in a given language or family of language. In English, Danish and Swedish (Germanic languages), the syllable lengths of the stimulus words are essentially the same and processing-speed times do not differ significantly. For speakers of Italian and Spanish (Romance languages) may of the stimulus words are multisyllabic and the processing speed measures are longer. To account for linguistic differences, the authors have suggested that AQT should be norm-referenced for speakers of other languages (e.g., Arabic, Farsi, and Urdu). Therefore, this study aimed to evaluate the reliability and validity of A Quick Test of Cognitive Speed (AQT) for older Iranian adult speakers of Farsi.

2. Methods

This study was designed to evaluate the psychometric properties of A Quick Test of Cognitive Speed (AQT) in Iranian older adults. We selected the participants from the psychiatric clinic of the Hazrat Rasoul Akram Hospital and the memory clinic of the School of Behavioral Sciences and Mental Health (Tehran Institute of Psychiatry) of Iran University of Medical Sciences.
2.1. Participants

We recruited 114 participants divided into three clinical groups: controls (n = 44), mild cognitive impairment (MCI) (n = 46), and dementia (n = 24) based on cognitive status. The sampling method was census which was performed from May 2018 to Feb 2019. Inclusion criteria in the control group include age over 60 years, no complaints of memory, or any other cognitive symptoms, normal cognitive function, no cognitive disorders as approved by two geriatric psychiatrists. Inclusion criteria in the MCI group include age over 60 years, the complaint of memory problems, or any other cognitive symptoms, and confirmation by two geriatric psychiatrists of the presence of MCI. Inclusion criteria in the dementia group include age over 60 years, mild to moderate dementia (any type) based on DSM-V criteria and approved by two geriatric psychiatrists. Exclusion criteria included visual problems. We obtained written consent from all study participants, if they were able, or from their families after explaining the objectives and methods of study.

2.2. Measurements

We collected data using the AQT and MMSE screening tests. We used a stopwatch to record the time used for completing each of the three AQT tests. The time was recorded in seconds from the beginning of the test to its end. We used the test-retest method to evaluate the reliability of AQT after one month.

- A Quick Test of Cognitive Speed (AQT) is a screening tool for identifying cognitive impairments. It consists of three subtests: Color (C), Form (F) and Color-Form (CF). The time used for rapid automatized naming of the forty visual stimuli in each subtest is measured in seconds. The Color (C) and Form (F) tests measure reaction, retrieval and response time (perceptual processing) and the Color-Form (CF) combination test assesses visual working memory and active attention [19, 20]. The Color-Form (CF) test is appropriate for examining changes in cognitive function related to neurological or psychiatric disorders and the effectiveness of pharmacological therapies (9). Naming the combinations activates the bilateral parietotemporal regions and the subcortical region of the brain, including the hippocampus, and examines central executive functions [15, 21]. Administering the three tests in succession takes from 3–5 minutes. The visual stimuli for AQT are presented on three test plates. The first features eight lines of colored squares (black, blue, red, and yellow) and the second eight lines of black forms (circle, line, square, and triangle) that are repeated randomly. The third page consists of eight lines of color and form combinations (Fig. 1). The patient is allowed to use other names to describe colors and forms, and time is recorded in seconds according to the test instructions [14]. In previous studies, the sensitivity and specificity of this test have been 0.78 and 0.67, respectively and was higher than for MMSE (0.61) and CDT (0.46) [10]. The test-retest reliability ranges from r = 0.84 to 0.96. Naming times were not dependent on sex or formal education after establishing literacy. The cut-off point (in seconds) for average-normal performance was set at one standard deviation above the mean (+1SD), for slower than normal between +1 and +2 standard deviations, and for abnormal performance at more than +2 standard deviations for English and Swedish [16, 17].

- Mini-Mental State Examination (MMSE): This examination was developed by Flocsetin in 1975. Its maximum score is 30 and a score below 25 is a sign of cognitive impairments. MMSE examines the cognitive state within five areas: time and place orientation, memory, attention, calculation, and language. Its test-retest reliability was reported as 0.89 [22]. In Iran the MMSE psychometric properties showed that the test-retest reliability is 0.78 and its cut-off point is 21. With a sensitivity of 0.90 and a specificity of 0.84, this tool should be interpreted according to age and education [23].

2.3. Data analysis

The results were analyzed with descriptive statistics (including mean and standard deviation, sensitivity and specificity) and data analysis used Pearson correlation (r), paired and independent t-tests and ANOVA, and Receiver Operating Characteristics (ROC curve). SPSS v.23 software was used for all data analyses.

3. Results

As shown in Table 1, the number of neurotypical controls was 44 (mean age: 69.24 ± 7.34), with mild cognitive impairment 46 (mean age 74.22 ± 6.21), and with dementia 24 (mean age: 78.54 ± 5.38). There was a significant difference between the ages of the control group and the elderly with MCI (P = 0.001) and the old patients with dementia (P < 0.001). There was no significant correlation between age and AQT time for all three subscales in the control group and among elderly with MCI (P > 0.01). For the older patients with dementia, a significant weak negative correlation was shown between age and shape subscale (r = 0.40, P = 0.05). Regression analysis resulted in the equation: y = 801.34−7.59 (age). Table 1 also shows comparative data for the variables gender, marital status, and levels of education.
Table 1
Demographic variables in three groups of control, with MCI and dementia

|                        | Controls (n = 45) | Older patients with MCI (n = 46) | Older patients with dementia (n = 24) | P value |
|------------------------|------------------|----------------------------------|--------------------------------------|---------|
|                        | n    | %    | n    | %    | n    | %    |         |         |
| Sex                    |      |      |      |      |      |      |         |         |
| Male                   | 19   | 42.22| 34   | 73.91| 12   | 50   | P = 0.007|
| Female                 | 26   | 57.78| 12   | 26.09| 12   | 50   | Df = 2  |
| Marital status         |      |      |      |      |      |      |         |         |
| Married                | 32   | 71.1 | 26   | 56.5 | 9    | 37.5 | P = 0.01|
| Widow/widower          | 8    | 17.8 | 9    | 41.3 | 13   | 54.2 | Df = 4  |
| Divorced               | 5    | 11.1 | 1    | 2.2  | 2    | 8.3  |         |         |
| Education              |      |      |      |      |      |      |         |         |
| Illiterate             | -    | -    | 11   | 23.9 | 9    | 37.5 | P < 0.001|
| Grade school           | 4    | 8.9  | 24   | 52.2 | 9    | 37.5 | Df = 8  |
| Middle school          | 6    | 13.3 | 2    | 4.3  | 2    | 8.3  |         |         |
| Upper school           | 11   | 24.4 | 7    | 15.2 | 4    | 16.7 |         |         |
| University education   | -    | -    | 11   | 23.9 | 9    | 37.5 |         |         |

Table 2 shows the time differences between the subscales of AQT based on demographic characteristics. There is a significant difference in the Color subscale measures between the two sexes in the elderly group with mild cognitive impairment. In other groups, there is no significant difference in any subscale of AQT with demographic variables.
The cut-off points for performance on the AQT subtests were determined with the gold standard (i.e., diagnosis by two geriatric psychiatrists) for the participants in the control, MCI and dementia groups (Tables 4 and 5).
## 4. Discussion

The findings showed that AQT has suitable levels of reliability and validity for screening for cognitive impairments among elderly Iranians. Test-retest reliability showed that the correlation of all subscales after two weeks is above 0.80, which indicates an appropriate level of reliability for AQT. As a
The three groups of controls, elderly with MCI and dementia were significantly different in the demographic variables of age, sex, educational level, and marital status. However, these differences were not observed for all three subscales Color, Form, and Color-Form. The only significant correlation between age and AQT measures occurred for Form naming among old patients with dementia. In comparison, a study by Nielsen et al. (2006) indicated no difference in time measures between the two sexes, but the AQT time measures were shorter for literate than for illiterate old people [18]. In a study that evaluated the relationship between the AQT measures and neuropsychological test scores, no relationship was found between age and AQT naming time [8]. In this study, there were no significant associations between age, education level and AQT naming times, indicating that AQT, like MMSE, was not affected by age and education. A psychometric study of MSSE scores among the elderly reported significant correlations between MMSE scores and age and education [23]. The Abbreviated Mental Test Score (AMTS) also shows significant associations with the variables education and sex, and therefore, the role of these factors should be considered in the interpretation [24]. Montreal Cognitive Assessment (MoCA) is another tool for screening for MCI, but it uses classified scores and interpretations are based on age and level of education [25, 26]. These findings suggest that AQT was more effective than other screening tests (e.g. MMSE, AMTs, and MoCA).

Convergent validity for AQT was assessed with MMSE, which is a standard questionnaire used to assess cognitive status in its various domains. Our findings showed that all AQT subscale measures had a significant correlation with MMSE (r > -0.70). Because the scoring for these two tests are opposite in value, less time on AQT indicates better cognitive status, whereas higher scores in MMSE indicate optimal cognitive status. In comparison, Nielsen (2007) assessed the relationship between AQT and MMSE and found significant negative correlations between tests that ranged from -0.60 to -0.72 (P = 0.01) [8]. Similar findings were obtained in a study of Italian adults by Petrazzuoli et al [7].

Means and standard deviations for AQT Color, Form, and Color-Form naming times indicate a significant difference between the control, MCI, and dementia groups. Andersson (2007) also found significant differences between naming times for healthy participants and groups with dementia (18). Moreover, for participants with dementia with Lewy Bodies, the AQT times were longer than for patients with AD [14]. The group differences in this study proved greater than those reported by Andersson. One reason could be that we did not distinguish between different types of dementia. A study by Takahashi (2012) of elderly Japanese found that the mean AQT times for the healthy control group were two times shorter than for the group with MCI and three times shorter than for the group with dementia [20]. These differences can be related to many factors such as characteristics of the Japanese language or different levels of severity of the disease.

We used the gold standard (i.e., diagnosis by two geriatric psychiatrists) to determine the cut-off point based on the ROC curve. The cut-off point for distinguishing healthy elderly from elderly with MCI was 43.50 seconds for the Color subscale with a sensitivity of 0.95 and specificity of 0.73. It was 52 seconds with a sensitivity of 0.98 and specificity of 0.89 for the Form subscale and 89 seconds with a sensitivity of 0.98 and specificity of 0.62 for the Color-Form subscale. Takahashi (2012) also used the MMSE scores to determine the cut-off points. The diagnostic cut-off point for the Color-Form subscale for early-stage dementia was approximately 71 to 72 seconds with a sensitivity of 0.85 and a specificity of 0.76 [20].

In this study, the cut-off point for the Color subscale for differentiating elderly with MCI and dementia was 62.50 seconds with a sensitivity of 0.87 and a specificity of 0.78. The cut-off point for Form naming of was 111 seconds with a sensitivity of 0.96 and a specificity of 0.46, and the cut-off point for Color-Form naming was 197.50 seconds with a sensitivity of 0.91 and a specificity of 0.41. A Swedish study with 81 patients of the usefulness of different screening tests for dementia in primary care settings reported that for MMSE the sensitivity was 0.58 and specificity 0.91, for the CDT sensitivity was 0.26 and specificity 0.88, and for AQT the sensitivity was 0.78 and specificity 0.67 [10]. The authors concluded that the findings supported the usefulness of AQT in Swedish primary care centers.

5. Conclusion

The findings of this study indicate that A Quick Test of Cognitive Speed (AQT) is a suitable tool for assessing the cognitive status of older adults in primary care settings in Iran. AQT does not require literacy and is not language dependent for speakers of dialects and languages belonging to the same family. Therefore, AQT can be used for the initial assessment of the cognitive status of the elderly in all care centers.

Abbreviations

AQT: A Quick Test of Cognitive Speed; MCI: Mild cognitive impairment; MMSE: Mini-Mental State Examination; AD: Alzheimer’s disease; CDT: Clock Drawing Test; RAN: Rapid Automatized Naming; ROC: Receiver Operating Characteristics; AMTs: Abbreviated Mental Test Score; MoCA: Montreal Cognitive Assessment.

Declarations

Acknowledgments

We thank all the seniors, who participated in this study, as well as all the officials who made the study easier through their support.

Authors’ contributions

PFA and EHW were involved in the original conception and design of the study. Data acquisition and statistical analysis was conducted by PFA, SKM, BS, and VR. PFA drafted the initial manuscript which has been revised with input from all other listed authors. The final manuscript has been reviewed by all authors and approved for submission/publication.
Funding

This study is not funded by a specific project grant.

Availability of data and materials

The datasets used during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

This study has been approved by the Research Ethics Committee of the Iran University of Medical Sciences. We first explained the study objectives to the participants and then obtained informed written consent from them.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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