Development and Standardization of a Multiple-Choice Test of Auditory Comprehension for Aphasia in Russian

Brooke Hallowell and Maria V. Ivanova

School of Hearing, Speech and Language Sciences, Ohio University

Running head: Development of an Auditory Comprehension Test in Russian

Contact author: Brooke Hallowell
School of Hearing, Speech and Language Sciences
Ohio University
Grover Center, W218,
Athens, OH 45701
hallowel@ohio.edu
Phone: 740-593-1356
Fax: 740-593-0287

Abstract

There is a lack of standardized aphasia batteries available in the Russian language. The primary aims of the study were to: 1) develop a new aphasia test of auditory comprehension in Russian; 2) describe the psychometric properties of this test by analyzing data collected on a large sample of participants with and without aphasia; 3) identify needs for further validation and standardization of the test; and 4) provide a preliminary evidence base for clinicians and investigators wishing to use this test. A Russian version of the Multiple-Choice Test of Auditory Comprehension (MCTAC) was developed and administered to 103 participants without brain injury and 75 participants with aphasia. All were native speakers of Russian. The MCTAC's brevity of administration, ease of scoring, sensitivity, specificity, inter- and intra-rater reliability, internal consistency, validity, and lack of bias according to age and education support the clinical strength of this test for determining the severity of auditory linguistic comprehension deficits in Russian-speaking adults with aphasia. Strengths and limitations of the test are discussed.

Background

Standardized norm-referenced tests are an important tool for speech-language pathologists working with adults who have aphasia. Such tests allow clinicians and researchers to draw subtle distinctions between normal and impaired functioning (Allen & Yen, 2002; Spreen & Risser, 2003), help elucidate patterns of deficits, inform treatment planning (Murray & Chapey, 2001), and permit documentation of reliable gains made in therapy (Robey, 1998). Additionally, standardized norm-referenced tests are essential to reliable inclusion/exclusion criteria, patient classification, and quantification of observed linguistic deficits in research on aphasia (Fishman & Galguera, 2003; Spreen & Risser, 2003). Although standardized aphasia tests have been developed in several languages, none exist to date in the Russian language.

Traditional aphasia assessment practice in Russia is based on the Lurian neuropsychological framework, which has a long tradition of qualitative rather than quantitative analysis (Luria, 1976; Homskaya, 2005). There are two tests of language processing for aphasia in Russian that permit quantitative measurement of language impairment. One, The Quantitative Language Assessment in Patients with Aphasia (Cvetkova, Axytina, & Pulaeva, 1981), lacks published normative data. Also, the test's reliability and validity have not been substantiated to date. The other is the Russian version of the Bilingual Aphasia Test (Paradis, 1987; Paradis & Zeiber, 1987), which also lacks normative and reliability data and includes problematic stimuli (Ivanova & Hallowell, in press). The Multiple-Choice Test of Auditory Comprehension (MCTAC) in Russian has been developed and standardized to help address the lack of aphasia assessment tools in the Russian language.

Construct validity of the MCTAC was originally based on the principles supporting the development of the traditional Revised Token Test (RTT; McNeil & Prescott, 1978; Porch, 1967) and has been further substantiated in the literature (Odekar & Hallowell, 2005, 2006). An eye tracking version involving computer-projected images of the MCTAC visual stimuli, paired with the MCTAC auditory verbal stimuli, has been shown to be sensitive to capturing receptive language abilities in individuals with and without aphasia in English and in Russian (Hallowell, Wertz, & Kruse, 2002; Hallowell, Kruse, Shklovsky, Ivanova, & Emeliyanova, 2006; Ivanova, Hallowell, Kruse, Shklovsky, & Emeliyanova, 2007).

In the current study, The MCTAC was translated into Russian and its psychometric properties were systematically explored. The primary aims were to: 1) develop a new test of auditory comprehension for aphasia in Russian; 2) describe the psychometric properties of this test by analyzing data collected on a large sample of participants with and without aphasia; 3) identify needs for further validation and standardization of the test; and 4) provide a preliminary evidence base for clinicians and investigators wishing to use this test.

Methods

Participants without language impairment. The MCTAC was administered to a total of 103 participants (mean age 41 years, range: 17-77; mean education 16.1 years, range: 11 – 21; M:F = 45:58) without brain injury recruited in Moscow, Russia.

To be included in the study participants had to meet each of the criteria below.

1) Pass a visual screening based on guidelines by Hallowell (in press), including:
    a. Correct identification of all four images in the *Color vision testing made easy* (Waggoner, 1994) color contrast screening task;
    b. Demonstrated near visual acuity (Hyvärinen, Näsänen, & Laurinen, 1980) for 100% accuracy in identifying .5-inch-square pictures of common objects presented at a distance of 12 to 24 inches, with or without glasses or contact lenses;
    c. No sign of drainage, swelling, redness, nystagmus, visual neglect, or visual attention deficit, based on experimenter observation; and
    d. Peripheral vision within normal limits per a peripheral finger counting task.
2) Pass a hearing acuity screening at 500, 1000, and 2000 Hz at 30 dB SPL.
3) Report no history of brain injury or psychiatric illness.
4) Report or demonstrate no concomitant language or cognitive disorders (e.g., dementia or learning disability) that might confound their performance on the test.

Participants with aphasia. Aphasia in this study is defined as an acquired neurogenic language, characterized by an impairment of language in any or all modalities (listening, speaking, reading, and writing), not attributable to a psychiatric disorder, confusion, or motor, sensory, or general intellectual deficits (Darley, 1982; Goodglass, 1993; Hallowell & Chapey, 2008;).

Participants with aphasia were recruited from the Federal Center of Speech Pathology and Neurorehabilitation in Moscow, Russia. A total of 75 adults with aphasia (mean age 47.4 years, range: 17-74; mean education 13.7 years, range: 8 – 19; M:F = 55:20) participated. Exclusion criteria included history of psychiatric illness, learning disability, or cognitive disorders (other than those associated with stroke and aphasia). Aphasia was diagnosed by the second author of the study (a neuropsychologist in Russia) and confirmed by two speech-language pathologists from the rehabilitation center. Computer tomography and/or magnetic resonance imaging scans verified presence of brain injury in the left hemisphere along with additional subcortical damage in some participants with aphasia. For inclusion, participants with aphasia had to pass the same vision and hearing screening tests as participants without aphasia.

Participants with aphasia were at least one month post-onset (mean time post-onset 1 year 9 months, range: 1 month – 11 years 10 months). Forty-six of the participants with aphasia (61%) had ischemic strokes, 11 (15%) hemorrhagic strokes, four (5%) ruptures of aneurysms, 12 (16%) traumatic brain injury, one (1.5%) herpes encephalitis, and one (1.5%) meningoencephalitis. Forty (53.3%) had an anterior type of aphasia (Broca's or transcortical motor), and 35 (46.7%) had a posterior type of aphasia (Wernicke's, transcortical sensory, or conduction). All were native speakers of Russian; none were bilingual from birth. Given that all aspects of the study involved only the Russian language, knowledge of additional languages was not controlled. Thirty-four (45%) had right-sided hemiparesis. All were right-handed.

Language abilities of participants with aphasia were assessed with the modified version of the Bilingual Aphasia Test (BAT, Paradis, 1987) (Ivanova & Hallowell, in press). The BAT is a well-known published aphasia battery that is used to assess expressive and receptive language abilities in individuals with aphasia. The test was administered in Russian only; participants are not expected to be bilingual to take this test.

Severity of language impairment was rated by two speech-language pathologists who provided treatment to the patients on a daily basis. Participants with aphasia were classified into four broad categories according to subjective ratings of their combined receptive and expressive language impairment: mild (27%), moderate (41%), severe (25%), and very severe (7%).

Test stimuli. The MCTAC is a multiple-choice test based on an adaptation of the RTT (McNeil & Prescott, 1978) designed by Hallowell (2008). The traditional RTT is a standardized test for the assessment of auditory comprehension for adults with neurogenic language disorders. Patients are instructed to touch or manipulate plastic tokens that vary in color, shape, and size. The test consists of ten subtests with verbal stimuli that vary in length and complexity. An example of a simple command is “Touch the red circle”. An example of a more complex command is “Put the white square to the right of the green circle.” Execution of every element of the command is scored on a 15-point categorical “multidimensional” scale. In addition to its strengths as a valid and reliable test of auditory comprehension, the test items are relatively “culture free” (McNeil & Prescott, 1978). That is, it does not require participants to understand culturally specific or unfamiliar words, or to interpret images of objects or actions with which they may not be familiar.

To create the multiple-choice version (Hallowell, 2008), the first eight subtests of the RTT were modified. Verb phrases such as "touch" and "put" were eliminated. Rather than be asked to manipulate items, patients are instructed merely to point to a target image corresponding to the verbal stimulus. Subtests analogous to subtests 9 and 10 of the traditional RTT were not developed because it was not possible to create multiple-choice displays corresponding to items in those subtests. As in the RTT, squares and circles are used as shapes; black, green, red, blue, and white are used as colors; and big and little correspond to the size of the shapes. An image is located at each corner of a test page. One of the four images serves as a target corresponding to the verbal stimulus; the other three serve as non-target foils. Non-target images differ from the target in terms of visual characteristics representing semantic elements of the verbal stimulus, such as shape, color, size, and spatial orientation. The location of the four images in each of the four quadrants of each visual array is counterbalanced. An example is presented in Figure 1.

[Insert Figure 1 about here.]

Based on recommendations for a shortened form of the RTT (Arvedson & McNeil, 1985; Park, McNeil, & Tompkins, 2000), five items were created for each of the eight subtests. The verbal stimuli vary in length and complexity from subtest one to subtest eight. Scoring is binary (correct/incorrect). The subtests and the test overall are scored in terms of the percent of correct items out of the total number of items for each subtest and the overall test.

The visual stimuli for the Russian version are identical to those in the English-language version of the test. The verbal stimuli (described above) were translated into Russian by the second author; the translation was verified by another Russian neuropsychologist. Examples of verbal stimuli in both languages from each subtest are provided in Table 1.

[Insert Table 1 about here.]

Procedure. The MCTAC was administered by two Russian neuropsychologists: the second author of this study or a neuropsychologist employed by the rehabilitation center. Visual stimuli were presented in a test manual. Participants were instructed to point to the picture corresponding to the spoken words. The verbal stimuli were given only once for each multiple-choice item. Participants were not limited in the time they had to select an appropriate image. The examiner marked the participant's responses on a scoring sheet; binary scoring was utilized.

To evaluate inter-rater reliability, performance of the final 15 participants with aphasia was scored at the same time by the two examiners. These 15 participants were also tested twice over a period of one to three days to examine intra-rater reliability.

Results

Description of participants' performance

On average, the MCTAC took approximately 10 to 15 minutes to complete for participants without language impairment and 20 to 30 minutes for participants with aphasia.

There was minimal variability in performance of participants without language impairment (M=99.47% SD=1.09%; range: 95% - 100%); mean subtest scores ranged from 98.8% (subtest 5 and 6) to 100% (subtests 1, 2, and 3). Among participants without aphasia, 80% achieved a perfect score on the 40-item test; 20 individuals (19%) had one error; only one individual (1%) made two errors. At most an individual item was incorrectly comprehended by two participants (2%). Demographic and presence of medical history factors (e.g., history of hypertension, atherosclerosis, cataract, and heart attack) were not related to performance of participants without language impairment (age $r(101)=-.12$, $p=.211$; education level $r(101)=.4$, $p=.396$; medical factors $F(1, 101)=1.29$, $p=.258$, $\omega^2=.003$). Percentile scores[1] for participants without aphasia for each subtest and overall are presented in Appendix A.

There was considerably more variance in performance of participants with aphasia on the test compared to controls. The distribution of individual overall scores is presented in Figure 2. Only two participants with aphasia scored below 30%; one obtained a perfect score; two obtained a score within two SD of the language-normal group. Detailed descriptive statistics of performance of participants with aphasia across subtests are summarized in Table 2. Also, percentile scores for each subtest and for the test overall are presented in Appendix B. Demographic characteristics, time since post-

[1] The method of weighted average at $X_{(n+1)p}$ was used to compute percentiles. The percentile value was calculated as the weighted average of X_i and X_{i+1}, where i is the integer part of $(n + 1)p$, n is the total number of all nonmissing cases, p is the specified percentile divided by 100, and X_i is the value of the ith case when cases are ranked in ascending order.

onset and etiology of lesion were not related to performance of participants with aphasia (age $r(73)=-.14$, $p=.232$; education level $r(73)=.04$, $p=.766$; time post-onset $r(73)=-.134$, $p=.252$; etiology $F(2, 72)=0.745$, $p=.478$, $\omega^2=.001$).

[Insert Figure 2 about here.]

[Insert Table 2 about here.]

Internal consistency

Internal consistency, as indexed by Kuder-Richardson correlation, and the standard error of measurement for the patient data are presented in Table 3. Internal consistency could not be computed for the control group alone because of the lack of sufficient variability in the data. It was possible to evaluate internal consistency for the combined control and patient data (see Table 3). Internal consistency for combined data was equal to or above .7 for all subtests.

[Insert Table 3 about here.]

Subtest differences

Scores on the eight subtests of the MCTAC for participants with aphasia were significantly different, $F(7, 497) = 48.7$, $p < .001$, $\eta^2 = .41$. Post-hoc paired-samples t-tests, incorporating a Holms procedure to control for family-wise alpha level of .05, demonstrate that that results for each subtest are significantly different from results for any other subtest (see Table 4). Only the following subtests were not significantly different from each other: subtest 2 from subtest 3; subtest 4 from subtest 7; and subtest 5 from subtest 6.

[Insert Table 4 about here.]

Inter- and intra-rater reliability

The 15 participants with aphasia tested for inter- and intra-examiner reliability did not differ significantly from the rest of the patient sample by age or education level (age $F(1, 73)=0.181$, $p=.672$, $\omega^2=.001$; education $F(1, 73)=2.121$, $p=.15$, $\omega^2=.02$). Scores completed at the same session by the two examiners were perfectly correlated, $r(13)=1$, $p<.001$. Test-retest reliability was also high overall and across subtests (see Table 5). There was no significant difference between the two testing sessions across subtests and overall, $t(14)=0.361$, $p=.723$.

[Insert Table 5 about here.]

Validity

Scores (percentage correct) across subtests of the MCTAC for participants with and without aphasia are presented graphically in Figure 3.

[Insert Figure 3 about here.]

Univariate F-tests were used to investigate differences between patient and control groups. All eight subtests and the overall test were effective in discriminating between performance of participants with and without aphasia (Table 6). Since the patient and the control groups differed significantly in age $F(1, 176)=6.7$, $p<.05$, $\omega^2=.03$ and years of education $F(1, 176)=55.89$, $p<.001$, $\omega^2=.23$, with the control group being younger and achieving a higher education level, these two factors were included in the analysis of variance as covariates. The results remained unchanged (Table 6). Further, examination of percentile norms for each of the groups (Appendices A and B) indicates minimal (5%) overlap in percentiles for the overall score.

[Insert Table 6 about here.]

Concurrent validity of the test was examined through its correlation with the auditory comprehension items of the Russian modified short form of the BAT (Ivanova & Hallowell, in press). The scores of participants with aphasia on the modified BAT (reported as percentage correct) across subtests are summarized in Table 6. Correlations between the auditory comprehension items from the modified BAT and the subtests of the MCTAC were significant ($p\leq.001$ for each); results of the analysis are presented in Table 7. The strongest correlation was obtained for the overall test.

[Insert Table 7 about here.]

[Insert Table 8 about here.]

Across all subtests of the test there was a significant difference between groups of participants with aphasia having different levels of subjectively rated severity of overall language impairment, $F(3, 71)=29.7$, $p<.001$, $\omega^2=.54$. Post-hoc analysis revealed that the total score on the auditory comprehension test decreased linearly with severity of language impairment, linear-trend contrast, $F(1, 71)=78.12$, $p<.001$.

It was not possible to investigate differences in performance among participants with specific subtypes of aphasia due to insufficient representation within some subtypes. Overall, there were no significant differences in performance between those with posterior aphasia subtypes (averaging an overall mean of 69.26%) and those with anterior aphasia subtypes (averaging an overall mean of 65.95 %), $F(1, 73)=.498$, $p=.482$, $\omega^2=.01$. Scores (percentage correct) on the auditory comprehension test for participants with different types of aphasia and various levels of subjectively rated severity of language impairment are summarized in Table 9.

[Insert Table 9 about here.]

<u>Item analysis</u>

The mean score obtained on an item across all participants can be regarded as an indication of its level of difficulty, with higher scores indicating easier items. Item analysis was not performed on control group data due to a lack of variability. The frequency distribution of items according to their difficulty level based on performance of the participants with aphasia is presented in Figure 4. The mean item difficulty was .68 (with a standard deviation of .17). Item difficulty was evenly distributed from .4 to .9, with only two items having a mean score of less than .4 (items #8.3 and 8.4). The lowest item difficulty (i.e., the easiest item) was #1.4 with a mean of .93.

[Insert Figure 4 about here.]

Discussion

Psychometric properties of a new auditory comprehension test in Russian were established based on the data collected from 103 control participants without aphasia and 75 participants with aphasia. Sensitivity and specificity were strong. The test differentiated well between participants with and without aphasia even when age and educational level were taken into account. There was minimal overlap in the overall scores between the two groups. The overall score was a better discriminator for separating participants with and without aphasia than any individual subtest score[2]. An overall score of 95% would provide an appropriate cut-off score to discriminate the MCTAC scores of those with and without aphasia, with a minimal overlap of 5% of participants. As with the traditional RTT (McNeil & Prescott, 1978), etiology of lesion,

[2] For distinguishing between individuals with and without aphasia it is important to take into account not only the absolute difference between groups, but also the variance; both of these factors are reflected in the magnitude of an F-test. The largest value of an F-test was obtained for the subtest 8and for the test overall. Taking into account higher test-retest reliability of the test overall (r=.976) compared to subtest #8 (r=.577), the overall score is better index for differentiating participants with and without aphasia.

time post-onset, age, and aphasia subtype (anterior-posterior) were not related to performance on the MCTAC.

Overall and across subtests the test demonstrated high internal consistency (at or above .7). There was 100% agreement between examiners in scoring of the participants' responses. Test-retest reliability was high overall and across all subtests (except subtest #4).

Performance was variable among participants with aphasia. Item analysis indicated that the test addresses a wide range of comprehension difficulty levels. Overall MCTAC scores were correlated with scores on an additional measure of comprehension ability (the comprehension score on the Russian modified short form of the BAT (Ivanova & Hallowell, in press). Interestingly, MCTAC test scores had a significant linear trend in relationship to subjective ratings of severity, which were based on expressive as well as receptive performance.

The MCTAC has the potential for practical clinical and research applications. Simple administration and scoring procedures allow the test to be administered reliably without extensive training. The test can be administered and scored in a short time – 30 minutes or less. Lack of a correlation between age or educational level and test scores supports the potential for use among participants with varying ages and educational backgrounds. This, along with the aspect of inherently "culture-free" test items attributed to the stimuli for the RTT, may bode well for administration of the test to a culturally heterogeneous population of Russian-speaking adults with aphasia.

In sum, the MCTAC's brevity of administration, ease of scoring, sensitivity, specificity, inter- and intra-rater reliability, internal consistency, validity, and lack of bias according to age and education support the clinical strength of this test for determining the severity of auditory linguistic comprehension deficits in Russian-speaking adults with aphasia. To provide further evidence for the construct validity of the test, it should be administered to individuals with brain injury but without language impairment (e.g., persons with stroke having no language deficits). Ideally, these individuals should perform differently than persons with aphasia. This would support the claim that differences in performance between participants with and without aphasia are due to the language impairment itself and not to other consequences of brain injury, such as exhaustion and memory problems (Allen & Yen, 2002). The test's sensitivity to detecting change following treatment should be explored as well.

Additionally, in the future studies a reading version of the same test in English could be investigated. Once the psychometric properties of the reading version of the test are established, auditory comprehension of persons with aphasia may be compared to reading comprehension abilities.

The current study makes an important contribution to the development of standardized norm-referenced tests in Russian. It is important to acknowledge limitations in applications of the test. The MCTAC addresses only auditory comprehension abilities. It does not include stimuli that vary widely in terms of grammatical form and lexical content, which constrains its usefulness in exploring specific semantic and syntactic deficits. Although the relatively culture-free aspect of the stimuli is beneficial in some ways, there is a trade-off in the test's ecological validity in that references to shape, color, size, and relative location of items may not strongly reflect real-world language use. Additional limitations of the MCTAC are that it does not address expressive language skills and is not suited for determining type of aphasia. In the future, tests addressing other domains of linguistic processing and communication abilities in Russian should be developed and investigated as well.

Acknowledgements

This work was supported in part by grant number DC00153-01A1 from the National Institute on Deafness and Other Communication Disorders, an Ohio University Ph.D. Fellowship in the School of Hearing, Speech and Language Sciences, and College of Health and Human Services Student Research and Scholarly Activity Award. Dr. Karen Evans-Romaine provided excellent assistance in certifying Russian translations for the informed consent process. The authors thank Victor Shklovsky and the staff of the Moscow Federal Center of Speech Pathology and Neurorehabilitation for their continuous support of the project, especially Marina Emeliyanova, for assistance with patient recruitment and data collection. The authors also thank Dr. Malcolm McNeil for helpful support during the development of the original MCTAC and Pro-Ed, Inc. for permission to incorporate modified verbal stimuli from the RTT.

References

Allen, M.J., & Yen, W.M. (2002). *Introduction to measurement theory.* Prospect Heights, Ill.: Waveland Press.

Arvedson, J.C., McNeil, M.R., & West, T.L. (1985). Prediction of Revised Token Test overall, subtest and linguistic unit scores by two shortened versions. *Clinical Aphasiology, 15*, 57-63.

Chang, D.F. (1995). Ophthalmologic examination. In Vaughan, D., Asbury, T., & Riordan-Eva, P. (Eds.). *General ophthalmology* (pp. 2-50). Norwalk, VA: Appleton & Lange.

Cvetkova, L.S., Axytina, T.V., & Pulaeva, N.M. (1981). *Kolichestvennaya ocenka rechi y bolnux s aphasieu* [Quantitative language assessment in patients with aphasia]. Moscow: Izdatelstvo Moskovskogo Gosydarstvennogo Yniversiteta.

Darley, F.L. (1982). *Aphasia*. Philadelphia: W.B. Saunders.

Fishman, J.A., & Galguera, T. (2003). *Introduction to test construction in social and behavioral sciences.* Oxford: Rowman & Littlefield Publishers.

Goodglass, H. (1993). *Understanding Aphasia*. San Diego: Academic Press.

Hallowell, B. (in press). Strategic design of protocols to evaluate vision in research on aphasia and related disorders. *Aphasiology.*

Hallowell, B. (2008). *Using eye tracking to assess auditory comprehension: Results with language-normal adults and adults with aphasia.* Manuscript in preparation.

Hallowell, B., & Chapey, R. (2008). Introduction to language intervention strategies in adult aphasia. In R. Chapey (Ed.), *Language intervention strategies in* *aphasia and related communication disorders.* 5th edition. Philadelphia: Lippincott Williams & Wilkins, pp. 3-19.

Hallowell, B., Kruse, H., Shklovsky, V.M., Ivanova, M.V., & Emeliyanova, M.A. (2006, November). Validity of eye tracking assessment of auditory comprehension in aphasia. Poster presented at the American Speech-Language-Hearing Association Convention. Miami Beach, FL.

Hallowell, B., Wertz, R.T., & Kruse, H. (2002). Using eye movement responses to index auditory comprehension: An adaptation of the Revised Token Test. *Aphasiology, 16* (4/5/6), 587-594.

Heuer, S. & Hallowell, B. (in press). Visual attention in a multiple-choice task: Influences of image characteristics. *Aphasiology*.

Homskaya, E.D. (2005). *Neuropsichologiya* [Neuropsychology]. Moscow: Izdatelstvo Moskovskogo Gosydarstvennogo Yniversiteta, 4th edition.

Hyvärinen, L., Näsänen R., & Laurinen P. (1980). New visual acuity test for pre-school children. *Acta Ophthalmologica*, *58,* 507-511.

Ivanova, M.V., & Hallowell, B. (in press). Short form of the Bilingual Aphasia Test in Russian: Psychometric data of persons with aphasia. *Aphasiology*.

Ivanova, M.V., Hallowell, B., Kruse, H., Shklovsky, V.M., & Emeliyanova, M.A. (2007, November). Indexing changes in auditory comprehension in aphasia using eye tracking. Poster presented at the American Speech-Language-Hearing Association Convention. Boston, MA.

Kertesz, A. (1982). *Western Aphasia Battery.* Austin, TX: Pro-Ed, Inc.

Luria, A.R. (1976). *Osnovu neuropsichologii* [Fundamentals of neuropsychology]. Moscow: Izdatelstvo Moskovskogo Gosydarstvennogo Yniversiteta.

McNeil, M.R., & Prescott, T.E. (1978). *Revised Token Test.* Austin, TX: Pro-Ed, Inc.

Murray, L.L., & Chapey, R. (2001). Assessment of language disorders in adults. In R. Chapey (Ed.), *Language intervention strategies in aphasia and related communication disorders.* 4th edition (pp. 55-126). Philadelphia: Lippincott Williams & Wilkins.

Odekar, A., & Hallowell, B. (2005). Comparison of alternatives to multidimensional scoring in the assessment of language comprehension in aphasia. *American Journal of Speech-Language Pathology*, *14*, 337-345.

Odekar, A., & Hallowell, B. (2006). Exploring inter-rater agreement in scoring of the Revised Token Test. *Journal of Medical Speech-Language Pathology, 14*(3), 123-131.

Paradis, M. (1987). *The assessment of bilingual aphasia.* Hillsdale, NJ: Lawrence Erlbaum.

Paradis, M., & Zeiber, T. (1987). *Bilingual Aphasia Test (Russian version).* Hillsdale, NJ: Lawrence Erlbaum.

Park, G.H., McNeil, M.R., & Tompkins, C.A. (2000). Reliability of the five-item Revised Token Test for individuals with aphasia. *Aphasiology, 14*, 527-535.

Porch, B.E. (1967). *Porch Index of Communicative Ability.* Chicago, Ill: Riverside Publishing Company.

Robey, R.R. (1998). A meta-analysis of clinical outcomes in treatment of aphasia. *Journal of Hearing, Speech and Language Research*, *41*, 172-187.

Spreen, O., & Risser, A.H. (2003). *Assessment of aphasia.* Oxford: Oxford University Press.

Waggoner, T.C. (1994). *Color vision testing made easy.* Gulf breeze: Home Care Vision.

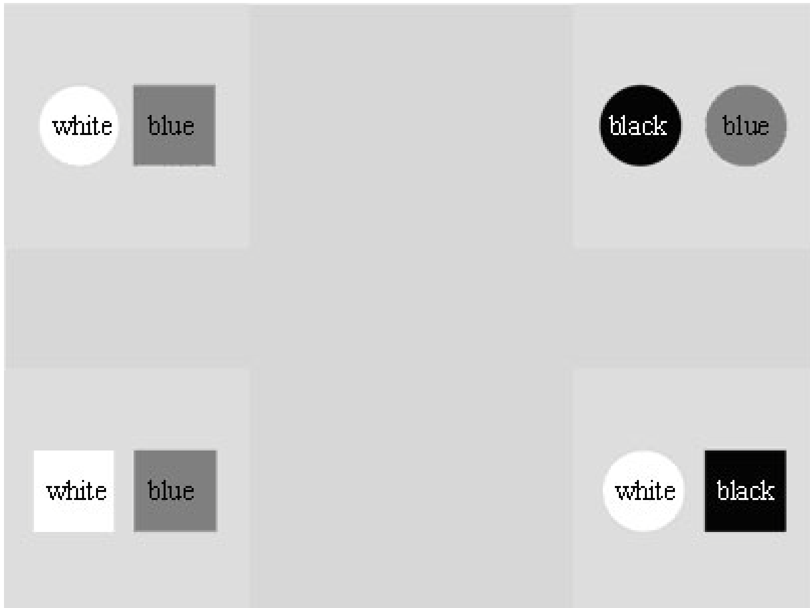

Figure 1. An example of a visual array from the MCTAC. The verbal stimulus for this item is “white square and blue square”. Note: The items are colored; color words are added only for this black-and-white version.

Figure 2. Distribution of overall MCTAC scores for participants with aphasia.

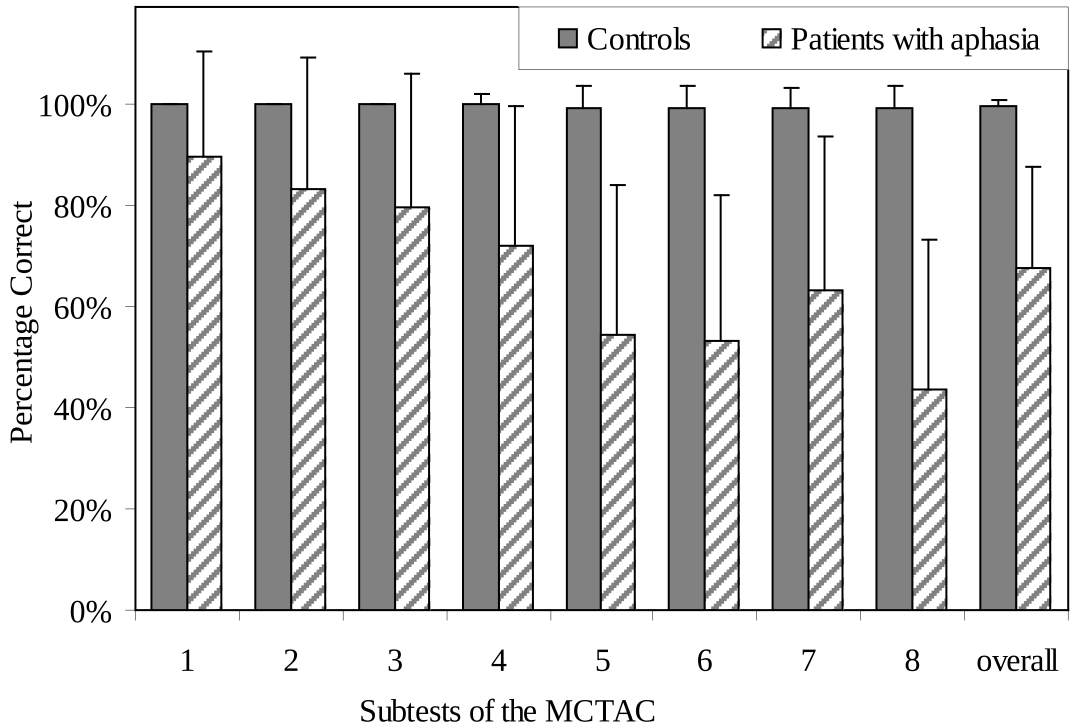

Figure 3. Mean percentage correct and standard deviation across subtests and overall for participants with (*N*=75) and without aphasia (*N*=103). Note: All contrasts between participants with and without aphasia are significant.

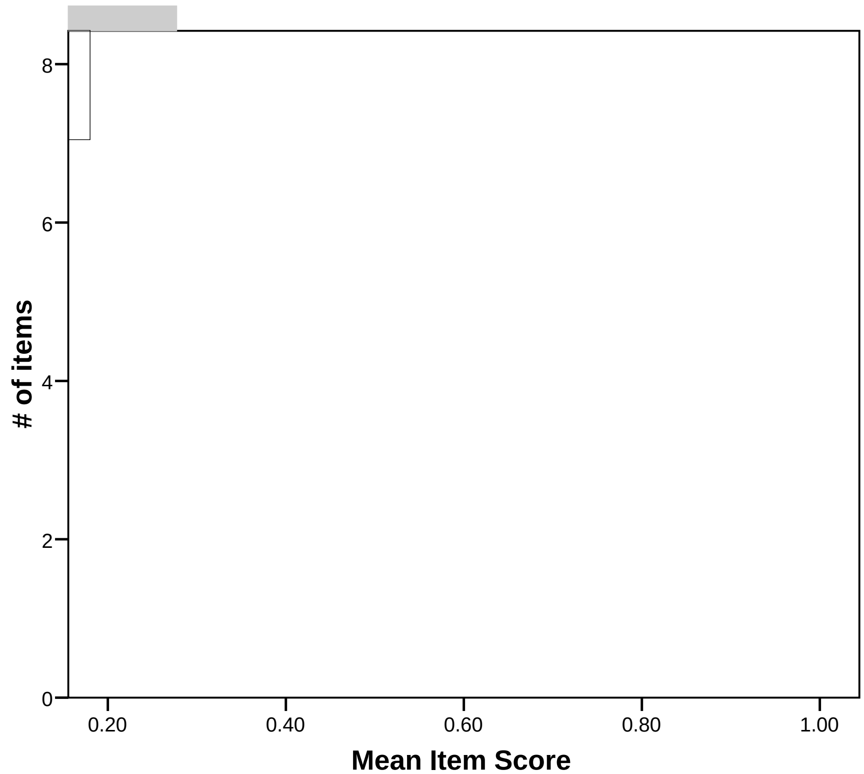

Figure 4. Distribution of items by their mean score.

Table 1

Examples of the Verbal Stimuli from the MCTAC.

Subtest	Verbal Stimuli	
	English	Russian
1	Black circle	Черный круг
2	Big green circle	Большой зеленый круг
3	Green square and black square	Зеленый квадрат и черный квадрат
4	Big green square and little black square	Большой зеленый квадрат и маленький черный квадрат
5	The black circle is above the white square	Черный круг над белым квадратом
6	The big red square is in front of the big white circle	Большой красный квадрат впереди большого белого круга
7	The black circle is to the left of the white square	Черный круг слева от белого квадрата
8	The little green circle is to the left of the big red square	Маленький зеленый круг слева от большого красного квадрата

Note. The verbal stimuli were presented in Russian.

Table 2

Descriptive Statistics across MCTAC Subtests for Participants with Aphasia.

	N	Mean correct %	SD %	Range %
Subtests:				
1	75	89.6	20	20 – 100
2	75	82.9	26	0 – 100
3	75	79.6	26	0 – 100
4	75	72	27	0 – 100
5	75	54.3	30	0 – 100
6	74*	53.1	29	0 – 100
7	73*	63.3	30	0 – 100
8	72*	43.3	30	0 – 100
Overall	75	67.5	20	10 - 100

* Not all participants with aphasia completed subtests 6, 7, and 8; scores corresponding to items not completed were treated as missing values.

Table 3

Internal-consistency Measures (Kuder-Richardson Correlation) and Standard Error of Measurement for MCTAC Based on Patient Data and on Combined Data of the Two Groups.

	Patient Data		Combined Data	
	Kuder-Richardson correlation	Standard Error of Measurement* %	Kuder-Richardson correlation	Standard Error of Measurement* %
Subtests:				
1	.773	9.83	.799	6.41
2	.681	14.82	.746	9.55
3	.670	15.08	.750	9.88
4	.607	17.12	.741	11.42
5	.505	20.80	.766	14.23
6	.537	19.62	.803	13.09
7	.667	17.50	.796	11.97
8	.546	19.98	.838	13.5
Overall	.913	5.94	.959	4.15

* The following formula was used to calculate the Standard Error of Measurement: $SD*(1 - r_{xx})^{1/2}$, where SD is the standard deviation of all the scores in the sample, and r_{xx} is the reliability coefficient for the test.

Table 4

Differences between Mean Subtest Scores for Participants with Aphasia.

	Subtests							
	1	2	3	4	5	6	7	8
Subtests								
1	-							
2	.067*	-						
3	.100*	.034	-					
4	.176*	.109*	.076 *	-				
5	.353*	.287*	.253*	.177*	-			
6	.366*	.301*	.264*	.185*	.012	-		
7	.266*	.203*	.165*	.079	-.090*	-.098*	-	
8	.469*	.403*	.370*	.283*	.117*	.103*	.206*	-

* significant differences between subtest scores using paired-samples t-test and the Holms procedure to control family-wise alpha at .05.

Table 5

Test-retest Reliability of the MCTAC.

	Pearson Correlation
Subtests:	
1	.916**
2	.729*
3	.761**
4	.470
5	.619*
6	.574*
7	.518*
8	.577*
Overall	.976**

*p<.05
**p<.001

Table 6

Test of Differences in Scores between Samples with and without Aphasia with and without Age and Education as Covariates.

	F-value[a]	F-value[b]
Subtests:		
1	26.24*	20.29*
2	43.66*	42.9*
3	62.65*	38.73*
4	106.22*	69.79*
5	226.63*	136.86*
6	250.33*	164.3*
7	141.69*	90.58*
8	353.66*	250.97*
Overall	259.05*	172.91*

[a]Score difference without age and education correction.
[b]Score difference with age and education correction.
*p<.001

Table 7

Group Performance (Percentage Correct) on the Subtests of the BAT.

Subtest	Mean %	SD %	Range %
Auditory Comprehension	82.41	16	40 – 100
Reading	74.32	25	0 – 100
Repetition	75.79	26.00	0 – 100
Naming	68.65	32.20	0 – 100
Metalinguistic Skills	81.39	25.14	0 – 100
Overall	77.60	20.24	18 – 99

Table 8

Correlations between Scores on the MCTAC and Auditory Comprehension Items of the BAT.

	Pearson Correlation
Subtests:	
1	.615*
2	.645*
3	.67*
4	.478*
5	.646*
6	.6*
7	.527*
8	.529*
Overall	.756*

*p<.001

Table 9

Scores on the MCTAC for Different Types of Aphasia and Subjectively Rated Severity of Language Impairment.

	Overall Score		
	N	Mean %	SD %
Type of aphasia			
Anterior	40	66	21.6
Broca's	27	68	21.4
Transcortical motor	13	61.7	22.1
Posterior	35	69.3	18.5
Wernicke's	8	49.6	14.4
Transcortical sensory	24	75.1	15.6
Conduction	3	75	17.5
Severity			
Mild	20	83	10.4
Moderate	31	71.7	14.4
Severe	19	55.1	16.1
Very Severe	5	26.5	10
Overall	75	67.5	20.1

Appendix A
MCTAC percentile scores by subtest and overall for participants without aphasia (N=103)

Percentile	**Subtest*** 4 %	5 %	6 %	7 %	8 %	**Overall %**
1	80.8	80.0	80.0	80.0	80.0	95.1
2	100.0	80.0	80.0	80.0	80.0	97.5
3	100.0	80.0	80.0	80.0	80.0	97.5
4	100.0	80.0	80.0	83.2	80.0	97.5
5	100.0	80.0	80.0	100.0	84.0	97.5
6	100.0	84.8	84.8	100.0	100.0	97.5
7	100.0	100.0	100.0	100.0	100.0	97.5
8	100.0	100.0	100.0	100.0	100.0	97.5
9	100.0	100.0	100.0	100.0	100.0	97.5
10	100.0	100.0	100.0	100.0	100.0	97.5
11	100.0	100.0	100.0	100.0	100.0	97.5
12	100.0	100.0	100.0	100.0	100.0	97.5
13	100.0	100.0	100.0	100.0	100.0	97.5
14	100.0	100.0	100.0	100.0	100.0	97.5
15	100.0	100.0	100.0	100.0	100.0	97.5
16	100.0	100.0	100.0	100.0	100.0	97.5
17	100.0	100.0	100.0	100.0	100.0	97.5
18	100.0	100.0	100.0	100.0	100.0	97.5
19	100.0	100.0	100.0	100.0	100.0	97.5
20	100.0	100.0	100.0	100.0	100.0	97.5
21	100.0	100.0	100.0	100.0	100.0	99.6
22	100.0	100.0	100.0	100.0	100.0	100.0
23 through 100	100.0	100.0	100.0	100.0	100.0	100.0

* Percentile scores are not presented for subtest 1, 2, and 3, as participants without aphasia did not make any errors on them.

Appendix B
MCTAC percentile scores by subtest and overall for participants with aphasia (N=75)

Percentile	**Subtest** 1 %	2 %	3 %	4 %	5 %	6 %	7 %	8 %	**Overall %**
1	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0
2	29.2	9.2	0.0	9.2	0.0	0.0	0.0	0.0	16.9
3	40.0	20.0	3.8	20.0	0.0	0.0	0.0	0.0	26.0
4	40.0	20.0	18.4	20.0	0.0	0.0	0.0	0.0	29.6
5	40.0	20.0	20.0	20.0	13.0	0.0	0.0	0.0	31.6
6	40.0	20.0	20.0	20.0	20.0	7.6	7.6	0.0	33.5
7	40.0	20.0	22.2	22.2	20.0	20.0	20.0	0.0	35.0
8	40.0	20.0	36.8	36.8	20.0	20.0	20.0	0.0	35.0
9	40.0	31.4	40.0	40.0	20.0	20.0	20.0	0.0	35.0
10	40.0	40.0	40.0	40.0	20.0	20.0	20.0	0.0	35.8
11	40.6	40.0	40.0	40.0	20.0	20.0	20.0	0.0	37.6
12	55.2	40.0	40.0	40.0	20.0	20.0	20.0	0.0	39.4
13	60.0	40.0	40.0	40.0	20.0	20.0	20.0	0.0	42.5
14	64.4	44.4	44.4	40.0	20.0	20.0	24.4	0.0	45.0
15	79.0	59.0	59.0	40.0	20.0	20.0	39.0	0.0	45.0
16	80.0	60.0	60.0	40.0	20.0	20.0	40.0	13.6	46.7
17	80.0	60.0	60.0	40.0	20.0	20.0	40.0	20.0	47.5
18	80.0	60.0	60.0	40.0	20.0	20.0	40.0	20.0	47.9
19	80.0	60.0	60.0	40.0	20.0	20.0	40.0	20.0	49.7
20	80.0	60.0	60.0	40.0	20.0	20.0	40.0	20.0	50.0
21	80.0	66.6	60.0	40.0	20.0	20.0	40.0	20.0	50.8
22	81.2	80.0	60.0	40.0	20.0	20.0	40.0	20.0	52.5
23	95.8	80.0	60.0	40.0	20.0	20.0	40.0	20.0	52.5
24	100.0	80.0	63.5	40.0	22.6	20.0	40.0	20.0	53.8
25	100.0	80.0	70.0	40.0	28.8	21.3	40.0	20.0	55.0
26	100.0	80.0	79.7	40.0	39.7	24.9	40.0	20.0	55.0
27	100.0	80.0	80.0	54.2	40.0	35.7	40.0	20.0	56.8
28	100.0	80.0	80.0	60.0	40.0	40.0	40.0	20.0	57.5
29	100.0	80.0	80.0	60.0	40.0	40.0	40.0	20.0	57.9
30	100.0	80.0	80.0	60.0	40.0	40.0	40.0	20.0	59.8
31	100.0	80.0	80.0	60.0	40.0	40.0	40.0	20.0	60.0
32	100.0	80.0	80.0	60.0	40.0	40.0	43.6	27.2	60.6
33	100.0	80.0	80.0	60.0	40.0	40.0	50.0	40.0	61.6
34	100.0	80.0	80.0	60.0	40.0	40.0	50.0	40.0	62.3
35	100.0	80.0	80.0	60.0	40.0	40.0	55.5	40.0	62.5
36	100.0	80.0	80.0	60.0	40.0	40.0	60.0	40.0	62.5
37	100.0	80.2	80.0	60.0	40.0	40.0	60.0	40.0	62.5
38	100.0	94.8	80.0	60.0	40.0	40.0	60.0	40.0	62.5
39	100.0	100.0	80.0	60.0	40.0	40.0	60.0	40.0	62.5
40	100.0	100.0	80.0	60.0	40.0	40.0	60.0	40.0	62.8

41	100.0	100.0	80.0	60.0	40.0	40.0	60.0	40.0	64.0
42	100.0	100.0	80.0	73.2	40.0	40.0	60.0	40.0	64.7
43	100.0	100.0	80.0	80.0	40.0	40.0	60.0	40.0	65.0
44	100.0	100.0	80.0	80.0	40.0	41.2	60.0	40.0	65.3
45	100.0	100.0	80.0	80.0	40.0	48.5	60.0	40.0	67.1
46	100.0	100.0	80.0	80.0	40.0	55.8	60.0	40.0	67.5
47	100.0	100.0	80.0	80.0	46.2	60.0	60.0	40.0	68.0
48	100.0	100.0	80.0	80.0	60.0	60.0	60.0	40.0	69.3
49	100.0	100.0	80.0	80.0	60.0	60.0	60.0	40.0	69.8
50	100.0	100.0	90.0	80.0	60.0	60.0	60.0	40.0	70.9
51	100.0	100.0	100.0	80.0	60.0	60.0	60.0	40.0	72.0
52	100.0	100.0	100.0	80.0	60.0	60.0	60.0	40.0	72.5
53	100.0	100.0	100.0	80.0	60.0	60.0	60.0	40.0	72.5
54	100.0	100.0	100.0	80.0	60.0	60.0	68.4	40.0	72.5
55	100.0	100.0	100.0	80.0	60.0	60.0	80.0	40.0	72.5
56	100.0	100.0	100.0	80.0	60.0	60.0	80.0	40.0	72.5
57	100.0	100.0	100.0	80.0	60.0	60.0	80.0	40.0	72.8
58	100.0	100.0	100.0	80.0	60.0	60.0	80.0	40.0	73.7
59	100.0	100.0	100.0	80.0	60.0	60.0	80.0	40.0	75.0
60	100.0	100.0	100.0	80.0	60.0	60.0	80.0	40.0	75.0
61	100.0	100.0	100.0	80.0	60.0	60.0	80.0	40.0	75.0
62	100.0	100.0	100.0	80.0	63.9	60.0	80.0	40.0	75.7
63	100.0	100.0	100.0	80.0	74.9	60.0	80.0	40.0	77.5
64	100.0	100.0	100.0	80.0	78.6	60.0	80.0	40.0	77.5
65	100.0	100.0	100.0	89.0	80.0	66.8	80.0	49.0	78.4
66	100.0	100.0	100.0	100.0	80.0	75.0	80.0	60.0	79.6
67	100.0	100.0	100.0	100.0	80.0	75.0	80.0	60.0	80.0
68	100.0	100.0	100.0	100.0	80.0	78.2	80.0	60.0	80.0
69	100.0	100.0	100.0	100.0	80.0	80.0	80.0	60.0	80.0
70	100.0	100.0	100.0	100.0	80.0	80.0	80.0	60.0	80.0
71	100.0	100.0	100.0	100.0	80.0	80.0	80.0	60.0	80.0
72	100.0	100.0	100.0	100.0	80.0	80.0	80.0	60.0	80.9
73	100.0	100.0	100.0	100.0	80.0	80.0	85.8	60.0	82.2
74	100.0	100.0	100.0	100.0	80.0	80.0	100.0	60.0	83.8
75	100.0	100.0	100.0	100.0	80.0	80.0	100.0	60.0	84.7
76	100.0	100.0	100.0	100.0	80.0	80.0	100.0	60.0	85.0
77	100.0	100.0	100.0	100.0	80.0	80.0	100.0	60.0	85.0
78	100.0	100.0	100.0	100.0	80.0	80.0	100.0	60.0	85.0
79	100.0	100.0	100.0	100.0	80.0	80.0	100.0	60.0	85.0
80	100.0	100.0	100.0	100.0	80.0	80.0	100.0	68.0	85.0
81	100.0	100.0	100.0	100.0	80.0	80.0	100.0	80.0	85.0
82	100.0	100.0	100.0	100.0	80.0	80.0	100.0	80.0	85.0
83	100.0	100.0	100.0	100.0	80.0	80.0	100.0	80.0	88.0
84	100.0	100.0	100.0	100.0	80.0	80.0	100.0	80.0	90.8
85	100.0	100.0	100.0	100.0	81.0	80.0	100.0	80.0	92.5
86	100.0	100.0	100.0	100.0	95.6	80.0	100.0	80.0	92.5

87	100.0	100.0	100.0	100.0	100.0	80.0	100.0	80.0	92.5
88	100.0	100.0	100.0	100.0	100.0	84.8	100.0	80.0	93.1
89	100.0	100.0	100.0	100.0	100.0	99.4	100.0	80.0	94.8
90	100.0	100.0	100.0	100.0	100.0	100.0	100.0	94.0	95.0
91	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	95.0
92	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	95.0
93	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	95.0
94	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	95.0
95	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	95.9
96	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	97.5
97	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	97.5
98	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	98.9
99	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.3
100	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0