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Development and Standardization of a Test for the Comprehension of Nouns and Verbs in Russian: Data from Individuals with and without Aphasia

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Abstract. There is currently a great need for modern, standardized neuropsychological tests for language assessment in Russian speakers with aphasia. Our group is working on the development of the Russian Aphasia Test (RAT). Within the scope of this work, two subtests for single-word comprehension of nouns and verbs were developed considering contemporary models of language processing and principles of psychometrics. The task for both subtests was spoken word-to-picture matching. The subtests were normed on individuals with aphasia (n = 45) and a control group (n = 30). This resulted in the final set of 30 diagnostic trials for nouns and verbs matched on relevant psychometric properties which are sensitive to language impairments for both fluent and non-fluent types of aphasia. This set of trials will be included in the final version of the RAT.

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Introduction

Aphasia is an acquired neurogenic language disorder that follows focal brain damage most often due to stroke or traumatic brain injury. There are two types of classifications of aphasia: the Russian classification, which is based on the ideas of Luria, and a western one. In the former, aphasia types are divided into anterior and posterior according to the localization of brain damage. Posterior aphasia types are characterized by disturbed speech comprehension and intact fluency of speech. On the contrary, the main disorder in anterior aphasias is usually impaired speech production (Luria, 1969). In the western classification of aphasia, there are fluent and non-fluent types. Individuals with fluent aphasia most frequently have impaired comprehension and fairly intact production of speech, while non-fluent aphasia usually implies poor speech production compared to relatively spared comprehension. Patients are classified into fluent and non-fluent categories in the Western Aphasia Battery — Revised (WAB-R, Kertesz, 1982) and the Boston Diagnostic Aphasia Examination (BDAE, Goodglass, & Kaplan, 1972). The two classifications do not line up identically, but it is usually considered that non-fluent aphasia corresponds to the anterior type in the Russian classification system, and fluent aphasia is similar to posterior aphasia. However, despite widely acknowledged differences between aphasia subtypes, certain symptoms are present in all types of aphasia, varying by level of severity between different aphasia types. Individuals with aphasia often have difficulties in language production and comprehension, including comprehension of single words at the lexical-semantic level (identifying the meaning of a single unit in the lexicon). For a correct diagnosis and effective treatment, it is important to assess each patient's language impairment correctly and to identify mechanisms of impairment.

There is a plethora of standardized language assessment tests in English, but some shortcomings are inherent in most of them. Many involve a small normative sample and/or a lack of data on standardization in the clinical group (Howard, Swinburn, & Porter, 2010), with only a few tests, such as the Comprehensive Aphasia Test (Swinburn, Porter, & Howard, 2004) overcoming these limitations. In general, a lack of psychometric data on the validity and reliability of the tasks casts doubt on the quality of the stimulus material used and the evaluation criteria themselves, which complicates the interpretation of test results.

The most commonly used test for assessment of language disorders in Russian is the Assessment of Speech in Aphasia (Tsvetkova, Akhutina, & Pylaeva, 1981). Despite its numerous advantages, it also has some drawbacks. In general, apart from word length, articulatory complexity and rank frequency of use (which serves as a proxy measure of frequency), no other significant psycholinguistic variables are considered. Furthermore, some of the visual stimuli have become outdated and are often not recognized by the younger population. Such variables as image and name agreement, frequency, age of acquisition, imageability, familiarity and word length were not controlled, as opposed to the current work. Initially, the test was also normed on a limited sample of individuals with aphasia and no healthy controls. With regards to the single word comprehension subtest, its main limitation is the fact that the difficulties of phonologic and semantic processing are tested separately, not simultaneously, making it difficult to determine the patient's prevailing deficit. Single word comprehension is also assessed together with short-term memory as increasing strings of words (up to three) are presented. This, according to authors of the test, should lead to a more sensitive evaluation of the comprehension deficits. However, there is an opposite view that it may obscure the locus of the linguistic deficit. Additionally, it makes it hard to compare obtained results with other standardized test batteries that assess comprehension with single words. Another language assessment test in Russian (Bilingual Aphasia Test, Russian version; Paradis & Zeiber, 1987) is not normed at all and contains unbalanced linguistic stimuli (Ivanova & Hallowell, 2009). Thus, there is a need for modern and standardized neuropsychological tests for language assessment in aphasia in Russian, particularly for the single word comprehension subtest.

Our research group is currently working on the development of the Russian Aphasia Test (RAT). This test considers contemporary models of language processing (Coltheart, Curtis, Atkins, & Haler, 1993) and principles of psychometrics (Blanken, Dittmann, Grimm, Marshall, & de Gruyter, 1993; Fishman & Galguera 2003; Ivanova & Hallowell 2013; Kertesz, 1994), and contains tasks for both production and comprehension language assessment. It permits such assessment at different linguistic levels — phonetic, lexical, semantic, syntactic, and discourse — and the determination of which aspect of language processing is impaired. The part for comprehension assessment includes tasks for auditory discrimination of phonemes, lexical decision making, single word comprehension, comprehension of syntactic constructions and comprehension of oral discourse. For the evaluation of speech production, tasks for repetition, picture confrontation naming, spontaneous discourse elicitation and sentence construction and completion were developed.

At the moment, the most widely used batteries which include single word comprehension tasks are the WAB-R, BDAE, Comprehensive Aphasia Test (CAT, Swinburn et al., 2004) and Psycholinguistic Assessments of Language Processing in Aphasia (PALPA, Kay, Lesser, & Coltheart, 1992). In most of those batteries, the task for single word comprehension assessment is a word-picture matching task. The majority of the tests only assess noun comprehension, and yet comprehension of nouns is not a sufficient condition for intact word-level comprehension in general. It is important to assess both nouns and verbs, as processing of these two grammatical classes may differ (Crepaldi, Berlingeri, Paulesu, & Luzzatti, 2010), and previous case studies have shown that noun and verb comprehension can dissociate in aphasia (Miceli, Silveri, Nocentini, & Caramazza, 1988).

The aims of this study were the development of principles for subtests on single word comprehension, selection of stimuli for these subtests, norming them on healthy individuals and individuals with aphasia, and selection of the best trials for the final battery.

Method

Participants

The materials were normed on a control group of healthy participants without cognitive or neurological disorders (30 individuals) and individuals with different types of aphasia (30 individuals for noun comprehension: 20 non-fluent, 10 fluent; 45 for verb comprehension: 29 non-fluent, 16 fluent). In all participants with aphasia, their language impairments were caused by stroke. All participants gave informed consent before taking part in the study. The mean age of the group of healthy individuals was 44.2, and the group included 13 males. Among the individuals with aphasia, there were 27 men; the mean age was 45.4 and the average time post-onset was 28 months. There were no significant differences in age between participants with and without aphasia. All participating individuals were right-handed native speakers of Russian.

Task

Participants were required to match a spoken word to one of four images in a visual array for the single word comprehension subtests. This task is considered the most appropriate for single word comprehension assessment. There are several reasons for this: it helps to avoid excessive variability of responses, which makes the subtest more standardized; it also specifically evaluates comprehension of a single word (i.e. lexical-semantic comprehension) and not the understanding of the word in a sentential context (as in the case of matching words to their definitions). In addition, the presence of carefully manipulated foil images (distractors) allows for the differentiation of phonemic and semantic difficulties.

Stimulus material

Verbal and visual stimuli were taken from two databases: "Verb and action: stimuli database" (Akinina et al., 2015) and "Noun and object: stimuli database" (Akinina et al., 2014). These databases contain verbal and visual materials along with corresponding psychometric properties that were established based on responses from 100 Russian speakers for each item. One hundred ninety-seven verbs with name agreement (the extent to which different people agree on a name for a picture) higher than 70% and image agreement (the extent to which a subjective image of an object or an action is consistent with a particular picture for different people) higher than 3.5 (out of 5) were selected for the verb comprehension subtest. For the noun comprehension subtest, nouns with name agreement higher than 80% and image agreement higher than 4 were selected. Significant psycholinguistic variables such as frequency, imageability and visual complexity were also considered in the process of selection. For each word, three distractors were selected. First, phonological distractors were chosen. They differed in one or two phonemes from the target word. The hierarchy of selection for the distractors was the following: substitution of one sound for another (the type with the highest priority), such as *razdevatsya* ('to undress') — *razvevatsya* ('to flutter') and *robot* ('robot') — *hobot* ('trunk'); adding phonemes without removal, as in *otryvat'* ('to tear away') — *otkryvat'* ('to open') and *shar* ('ball') — *sharf* ('scarf'); substitution of two phonemes for two in one place, such as *gretsya* ('to warm oneself') — *gnatsya* ('to pursue') and *jula* ('whirligig') — *igla* ('needle'); and substitution of one phoneme for two in one place, such as *dut'* ('to blow') — *gnut'* ('to bend') and *jubka* ('skirt') — *trubka* ('pipe'). Next, semantic distractors were selected. They had to belong either to the same semantic field of the target word, as in *vybivat'* ('to beat' /a carpet/) — *pylesosit'* ('to vacuum'); or *banan* ('banana') — *ananas* ('pineapple') or to occur frequently together with the target , as in *goret'* ('to burn') — *tushit'* ('to extinguish') or *kost'* ('bone') — *budka* ('doghouse'). These two types of semantic distractors were approximately equal in number. In addition, phonological distractors were verified to be not concurrently semantic ones and vice versa. Finally, irrelevant distractors were selected which were unrelated phonologically or semantically to the target word and acted as semantic distractors to the phonological ones; for example, *kovat'* ('to forge') — *zevat'* ('to yawn') — *chikhat'* ('to sneeze'); *skrepka* ('clip') — *skripka* ('violin') — *fleita* ('flute'). This prevented the use of strategic responses by participants. Trials in which a stimulus picture could be named by both the target word and the distractor were excluded. Then, the difference between frequencies of the target word and each of the distractors was calculated. If it was more than 100 and one of the words had a frequency lower than 100, the whole trial was excluded.

Following the described procedure, we conducted 67 trials for the noun comprehension subtest and 66 trials for the verb comprehension subtest.

Visual stimuli were presented in a Power Point presentation, where four drawings were located in the corners of the screen in a quasi-randomized order (Figure 1, 2). The examiner read the target word aloud with the simultaneous presentation of slides, and recorded the selected image on the scoring sheet.

Results

The results of both groups' performance on noun and verb comprehension subtests are presented in Table 1.

The group of individuals without aphasia showed significantly better performance than individuals with aphasia (noun comprehension subtest: $t = -3.48$, $p = .001$, effect size (using Cohen's d) = 0.9; verb comprehension subtest: $t = -5.86$, $p < .001$, $d = 1.39$). The verb comprehension subtest appeared to be more difficult for both groups (individuals with aphasia: $t = -2.3$, $p = .024$, $d = 0.55$; healthy participants: $t = -13.6$, $p < .001$, $d = 3.54$). Individuals with fluent aphasia performed on average better than individuals with non-fluent aphasia in both tasks (noun comprehension subtest: 94.6% for fluent, 90.4% for non-fluent; verb comprehension subtest: 89.8% for fluent, 84.6% for non-fluent). However, these differences were not statistically significant (noun subtest: $t = 0.84$, $p = .411$, $d = 0.32$; verb subtest: $t = 1.39$, $p = .171$, $d = 0.43$).

In addition, a correlation was calculated for the correct answers on each subtest and the scores on the subtests for receptive language in the Assessment of Speech in Aphasia. For the verb subtest, there was a significant positive correlation ($r = .339$, $p = .025$).

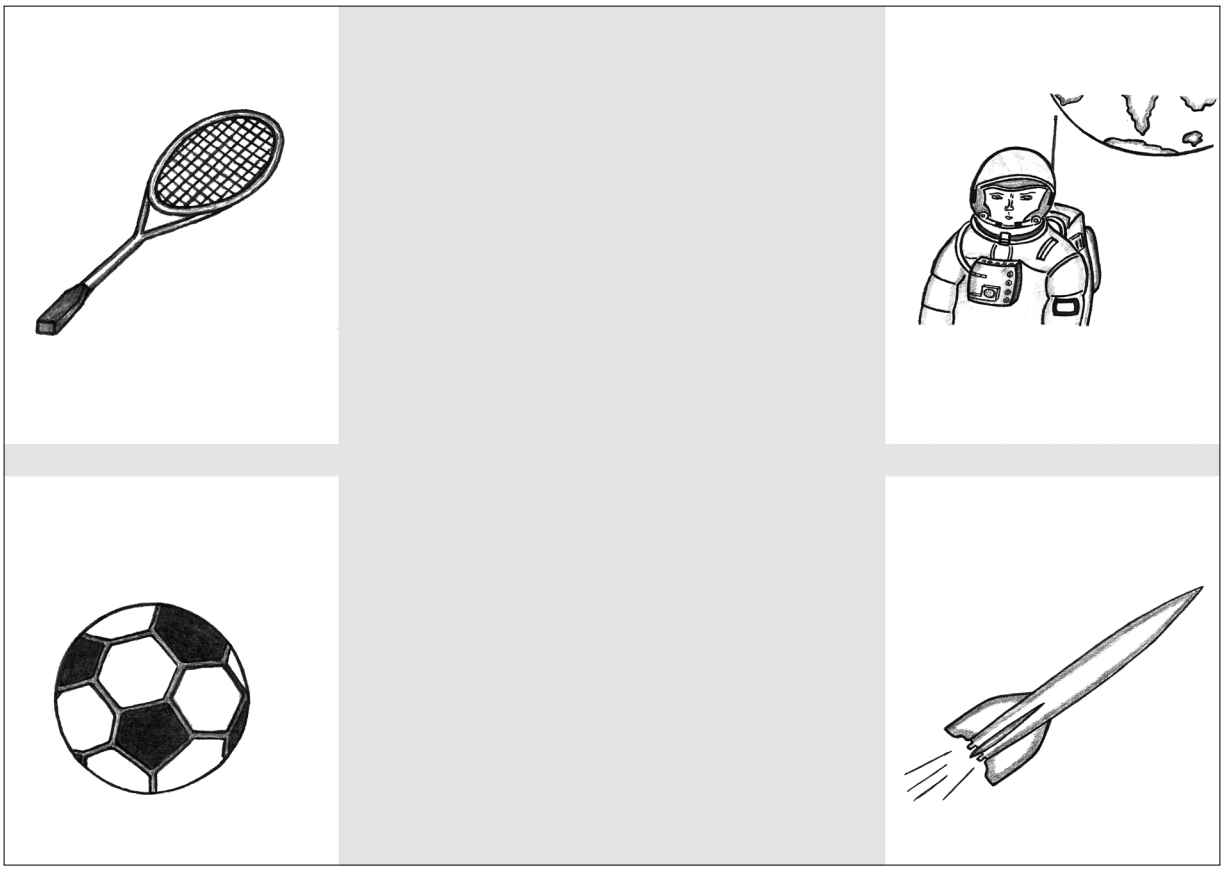

Figure 1. The screen with the visual stimuli as it was seen by participants in the noun comprehension subtest. *Raketa* ('rocket') — *raketka* ('racket') — *kosmonavt* ('cosmonaut') — *myach* ('ball'). Individual object images are retrieved from Akinina et al. (2014) database.

Figure 2. The screen with the visual stimuli as it was seen by participants in the verb comprehension subtest. *Tsvesti* ('to bloom') — *gresti* ('to row') — *sazhat'* ('to plant') — *vycherpyvat'* ('to bail out'). Individual action depictions are retrieved from Akinina et al. (2015) database.

Table 1. Mean and Standard Deviation (in %) for Correct Answers and Errors in Single Word Comprehension Subtests

Type of answer	Nouns		Verbs	
	Healthy individuals *M (SD)*	Individuals with aphasia *M (SD)*	Healthy individuals *M (SD)*	Individuals with aphasia *M (SD)*
Correct answers (%)	100 (0)	92 (13)	99 (0.9)	86 (12)
Phonological errors (%)	0 (0)	2.5 (4)	0.1 (0.4)	2.5 (4)
Semantic errors (%)	0 (0)	5 (7)	0.4 (0.8)	9 (7)
Irrelevant errors (%)	0 (0)	0.75 (3)	0.05 (0.27)	1.8 (3)

Trials in which more than two healthy individuals made an error and those which were answered correctly by all individuals with aphasia were excluded from the further shortened final versions of subtests. The corrected item-total correlation was then calculated; this parameter shows to what extent each trial measures the same concept as the whole subtest. First, trials with values of this parameter less than .1 were excluded, then the analysis was repeated and trials with a corrected item-total correlation less than .2 were left out. As a result, 39 out of 67 trials remained in the noun comprehension subtest and 48 out of 66 trials were kept in the verb comprehension subtest. Next, stimuli were balanced on the following psycholinguistic variables, so that there were no significant differences between target nouns and verbs: name agreement (nouns: 94.43; verbs: 88.85), subjective (nouns: 2.69; verbs: 2.49) and objective complexity (nouns: 336.3; verbs: 228.13), familiarity (nouns: 3.96; verbs: 3.78), age of acquisition (nouns: 1.77; verbs: 1.66), imageability (nouns: 1.12; verbs: 1.17), image agreement (nouns: 4.26; verbs: 4.21), frequency (nouns: 27.38; verbs: 38.81) and length (nouns: 2.07; verbs: 2.53). Thus, a final set of 30 trials in each subtest balanced on all relevant psychometric parameters was created. Interestingly, when the results of performance on these 30 balanced trials were analyzed, the differences in noun and verb comprehension remained for individuals with aphasia ($t = 11.48$. $p < .001$, $d = 2.96$).

Discussion

Significant differences in performance between healthy individuals and participants with aphasia indicate that the subtests reflect single word comprehension difficulties and that they can be used for the assessment of language deficits in individuals with aphasia. This can be reliably stated because stimuli sets were selected from normed databases; that is, all parameters which could influence participants' answers were controlled in advance. This means that errors are made due to language impairment and not to any confounding variables. The fact that healthy participants without cognitive or neurological disorders performed better than the group with aphasia provides evidence of the construct validity of the subtests.

The trials in which individuals with aphasia made errors are sensitive to impairment in noun and verb comprehension and help to reveal semantic and phonological processing difficulties according to the type of errors made. The trials in which healthy individuals made errors, on the contrary, cannot be used for assessment of language disorders. They provoke errors even in healthy participants, and thus additional errors in individuals with aphasia may emerge due to some extraneous factor (such as unfamiliarity with the concept tested) or some aberration in the stimuli material (such as a mismatch between target and foil images) and not to the impairment itself. In most of the cases in this study, errors in the control group occurred because the target image was too close in meaning to the semantic distractor image. Thus, such stimuli were excluded after norming.

The subtest for verb comprehension was more difficult than noun comprehension for both groups. Moreover, this difference remained for participants with aphasia when 30 balanced trials were analyzed. Probably, it can be explained by the fact that a verb is a more complex linguistic unit than a noun. It provides the frame for the whole sentence (Druks, 2002) and it implies more complex structural information, such as the properties and the number of arguments which should be reflected in the syntactic structure of a sentence (Cappa & Perani, 2003). Ours is the first group study in which difficulties in noun and verb comprehension has been directly compared in participants with aphasia. All known previous studies which showed differences in comprehension of nouns and verbs were case studies that demonstrated dissociations in both directions (Miceli et al., 1988).

Thus, two comparable, psycholinguistically balanced subtests for the assessment of noun and verb comprehension were created and normed on participants with and without aphasia. Pilot norming allowed us to reduce the set of trials and exclude invalid trials that cannot be used for diagnostic purposes. In the reduced versions of subtests, standard psycholinguistic parameters of stimuli such as frequency, imageability and length were considered. This is usually the case in widely used standardized batteries such as the BDAE and WAB, which nonetheless ignore other important variables (complexity, familiarity, age of acquisition, image and naming agreement) that were taken into account in our subtests. The subtests were also normed on a group of individuals with aphasia, as opposed to the PALPA. The final set of trials was programmed onto a tablet PC, which makes the test procedure more standardized and facilitates the distribution of the test in the future. It will be further normed and standardized on a larger group of participants (100 individuals with and without aphasia).

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спецвыпуск

Разработка и апробация теста на понимание существительных и глаголов на русском языке: данные нормы и пациентов с афазией

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Аннотация. В настоящий момент существует большая потребность в современном русскоязычном стандартизированном тесте для оценки речевой деятельности при афазии. Нашей группой ведется работа по созданию Русского афазиологического теста (РАТ). В рамках данной работы с учетом современных моделей языковой обработки и принципов психометрики разрабатывались субтесты на понимание отдельных слов: существительных и глаголов. В задании испытуемым необходимо было сопоставить услышанное слово с одним из четырех рисунков. Субтесты были нормированы в группе пациентов с афазией (n = 45) и в контрольной группе (n = 30), что позволило отобрать по 30 итоговых диагностичных проб. В результате работы были созданы психолингвистически обоснованные и нормированные субтесты для оценки понимания существительных и глаголов, которые сопоставимы по психометрическим параметрам и чувствительны к речевым нарушениям при беглой и небеглой формах афазии.

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