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DEVELOPMENT OF LINGUISTIC TESTS FOR DETECTION OF SPEECH/LANGUAGE DISORDERS AND THEIR IMPLEMENTATION IN THE CLINICAL AND RESEARCH PRACTICE

Dissertation Summary

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Olga Dragoy, Doctor of Sciences

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The dissertation was prepared in the National Research University "Higher School of Economics".

Publications

Three publications were selected for the defense. In these publications, authors describe the process of standardization and implementation of the linguistic tests for speech/language assessment. The author of the dissertation is the first and corresponding author of two articles. One of them (Buivolova et al., 2021) was published online in a journal belonging to 1 quartile in the Scopus database. The second article (Buivolova et al., 2020) was published in a journal included in the list of high-level journals prepared by the National Research University Higher School of Economics. In these two papers, the author of the dissertation was the first author responsible for the conceptualization of the study, data collection and analysis, and the writing of the manuscript. For the third article selected for the defense (Vadinova et al., 2020; published in a 1 quartile journal in the Scopus database), the dissertation author is the second author playing a major role in the data collection and curation. Also, the author took part in the discussion of the results and editing of the manuscript.

1. Buivolova, O., Vinter, O., Bastiaanse, R., & Dragoy, O. (2021). The Aphasia Rapid Test: adaptation and standardisation for Russian. *Aphasiology*, *35*(5), 730-744.

2. Buivolova, O., Bastiaanse, R., Dragoy, O., Vinter, O., Pozdniakova, V., Samoukina, A., Shlyakhova, A., & Visch-Brink, E. (2020). Adaptation of the Aphasia Bedside Check for Russian. *The Russian Journal of Cognitive Science*, *7*(3), 45–67.

3. Vadinova, V., Buivolova, O., Dragoy, O., van Witteloostuijn, M., & Bos, L. S. (2020). Implicit-statistical learning in aphasia and its relation to lesion location. *Neuropsychologia*, *147*, 107591.

The results of the present study have also been particularly presented in the following papers:

1. Ivanova M., Dragoy O., Akinina Y., Soloukhina O., Iskra E., Khudyakova M., Stupina E., **Buivolova O.**, Akhutina T. (2019). Standardizing the Russian Aphasia Test: Normative data of healthy controls and stroke patients *Frontiers in Human Neuroscience*, *Conference Abstract: Academy of Aphasia 57th Annual Meeting.*

2. Buivolova O., Vinter O., Bastiaanse R., Dragoy O. (2019). Validation of the

Aphasia Rapid Test in the Russian-speaking post-stroke population. *Stem, Spraak- en Taalpathologie, 24*(Supplement), 72-73.

3. Buivolova O., Dragoy O., Vinter O. (2018) Aphasia Rapid Test: Adaptation for Russian. *Aphasiology, 32*(Sup1: International Aphasia Rehabilitation Conference (IARC) September 2018), 32-33.

4. Ivanova, M., Akinina, Y., Soloukhina, O., Iskra, E., Buivolova, O., Chrabaszcz, A., … Dragoy, O. (2021, May 24). *The Russian Aphasia Test: The first comprehensive, quantitative, standardized, and computerized aphasia language battery in Russian*. https://doi.org/10.31234/osf.io/wajdz

Conference presentations and public demonstrations of the results

The main results and conclusions were presented in 8 conferences in oral and poster presentations:

- Society for Neurobiology of language 2020 Virtual Edition (USA, online, 2020). Poster presentation: Implicit-statistical learning in aphasia and its relation to lesion location
- Science of Aphasia 2019 (Rome, Italy, 2019). Oral presentation: Validation of the Aphasia Rapid Test in the Russian-speaking post-stroke population
- XI International Congress "Neurorehabilitation - 2019" (Moscow, Russia, 2019). Oral presentation: Linguistic instruments for detection of speech/language disorders
- Nordic Aphasia Conference (Turku, Finland, 2019). Poster presentation: Sensitivity of the Aphasia Rapid Test for Russian (ART-Ru) for Detecting Changes in the Patient's Linguistic Status in Acute Stroke
- XI All-Russian Congress of Neurologists. IV Congress of the National Stroke Association (St. Petersburg, Russia, 2019). Poster Presentation: Aphasia Rapid Test: Standardization of the Screening Test to Detect Speech Disorders in Acute Post-Stroke Period
- II Neurobiology of Speech and Language workshop (St. Petersburg, Russia, 2018). Poster Presentation: Aphasia Rapid Test: Adaptation for Russian
- International Aphasia Rehabilitation Conference (Aveiro, Portugal, 2018). Poster Presentation: Aphasia Rapid Test: Adaptation for Russian
- Academy of Aphasia 56th Annual Meeting 2018 (Montreal, Canada, 2018). Poster Presentation: Aphasia Rapid Test: Adaptation for Russian

1. Introduction

The dissertation includes articles on the development and usage of linguistically motivated speech/language assessment tools in clinical and research practice. The process of adaptation and standardization of the two tests is described in two papers included in the dissertation. The third paper is the experimental work devoted to the relationship between the mechanisms of implicit-statistical learning and syntactic processing. This is an example of using the test developed by linguists to identify the underlying language deficit.

Aphasia is a language disorder that follows brain damage (e.g., stroke, trauma, or tumors). The person with aphasia may experience problems with understanding and producing the speech, repetition of the spoken language, reading, or writing. It also negatively affects everyday communication and the quality of life. There are various assessment tools for speech/language disorders: short screening tests, diagnostic language batteries, and tests for communication skills. Unfortunately, there are many speech/language tools available for English, but only a limited number of tests have been developed for other languages (Ivanova & Hallowell, 2013). At the same time, not all existing tools have been standardized, and therefore the reliability of the results remains questionable (Rohde et al., 2018).

Appropriate diagnostics of speech/language disorders allow to develop an optimal rehabilitation program for the patient’s needs. The choice of each specific instrument depends on different factors, for example, the time post-onset. Screening tests are usually used in the acute period (the first days after the onset of the disease). During this period, the aphasia could be very severe, making comprehensive speech assessment not always possible. Moreover, speech therapists and neuropsychologists, who can comprehensively examine a patient's speech/language, are not always available in the hospitals. That is why this is often done by neurologists or other specialists not trained for detailed speech/language assessment. Nevertheless, identifying the presence of speech/language impairments is an important step for further rehabilitation. In addition, studies show that the severity of speech disorders diagnosed in the acute period in combination with information about the lesion location and volume are good predictors for speech recovery (Benghanem et al., 2020).

Screening tests should be easy to use for any staff member of the neurologic department. According to Russian clinical guidelines (Alferova et al., 2017), the National Institutes of Health Stroke Scale (NIHSS; Brott et al., 1989) is used to examine the patient's general condition, including the presence of language impairment. For that, language perception should be scored based on the patient's answers to the clinician's questions. To assess the language production, the clinician asks

the patient to describe what is going on in a picture, to name objects, and to read a short text aloud. Articulation should be scored separately. Unfortunately, the data obtained with such short scales are not detailed enough, which is why they are not very informative for both clinicians and researchers of speech pathologies.

Nowadays, the most widely used instrument in Russian clinics is the scale for speech/language assessment in patients with local brain lesions (Vasserman, Dorofeeva, & Meerson, 1997). This scale allows identifying the aphasia type according to Luria's aphasia classification (Akhutina, 2016; Luria, 1980). This assessment tool includes a great variety of tasks allowing the specialist to examine different aspects of language. However, the number of stimuli for each task is limited, their psycholinguistic properties are not reported, and the scoring criteria are very subjective. Finally, the psychometric characteristics of the scale are not properly described. All these facts do not allow us to consider this scale as a properly standardized assessment tool.

In the first two sections of the thesis, the author describes the process of adaptation and standardization of two screening tests: The Aphasia Rapid Test (ART; Buivolova et al., 2021) in Section 2 and The Aphasia Bedside Check (ABC; Buivolova et al., 2020) in Section 3. The clinicians and researchers can use these tests to verify the presence or absence of speech/language disorders in patients or neurologically healthy participants of linguistic experiments. Both tests were adapted for Russian according to guidelines of the aphasia test development and keeping in mind the psychometric standards (Ivanova & Hallowell, 2013).

Comprehensive language batteries can hardly be applied during the acute period because their administration can take a long time and be effortful for participants. An example of such a tool is the Assessment of Speech in Aphasia (ASA; Tsvetkova, Akhutina, & Pylaeva, 1981) allowing the specialist to identify the aphasia type by Luria's classification. However, the aphasia type itself is not always informative for either the clinician or the researcher. The disorder can manifest itself in different ways even in a group of patients with the same aphasia type. In addition, there are many aphasia classifications (see McNeil & Copland, 2011) based on different principles and models, so they can describe similar syndromes in different ways. This leads to the situation when aphasia types given based on different classifications do not strictly correspond to each other. Despite all the advantages, tools currently available to speech/language therapists and neuropsychologists were developed decades ago, and their standardization has not been described in detail (see papers from Sections 2 and 3 of the thesis).

One of the possible solutions in that situation is to develop a test that would allow us not only to determine aphasia type but to describe underlying language deficit. The Russian Aphasia Test (RAT; Ivanova et al., 2021) is a linguistically motivated assessment tool made for the

assessment of the different linguistic levels (phonological, lexical-semantic, syntactic, and discourse) and different domains (repetition, perception, and production of language). The RAT, designed as an application for a tablet, is widely used for research in people with speech/language impairments (e.g., Soloukhina & Ivanova, 2018; Ulanov et al., 2018; Zyryanov et al., 2019; Dragoy et al., 2020).

Section 4 of the thesis includes a study (Vadinova et al., 2020) aimed to identify the relationships between syntactic processing and the implicit-statistical learning (ISL) mechanisms and their dependence on the lesion location. We hypothesized that 1) as soon as syntactic processing and implicit statistical learning have similar underlying mechanisms, the magnitude of the ISL impairment will correlate with the syntactic deficits; 2) people with frontal lesions will show more severe ISL impairment than people with posterior lesions. The participants performed several tasks included in the RAT, as well as a series of experiments assessing the ability to visual-statistical learning. As a result, we found evidence in favor of the behavioral hypothesis. However, the anatomical hypothesis was not confirmed. This study was included in the dissertation to provide an example of the usage of the linguistic test in neurolinguistic research.

It is known that research on aphasia is based on linguistic theories, and the data obtained from aphasiology studies make it possible to contribute to theoretical linguistics (Garraffa & Fyndanis, 2020). ***The aim*** of the thesis is the rationale for the need for linguistically motivated tests for speech/language pathologies diagnostics in the Russian-speaking population. The studies collected in the current thesis are aimed to show that the usage of linguistic tools in the study of speech pathologies can deepen the understanding of both pathological and the neurotypical functioning of language in the brain. The lack of modern standardized and normed methods that could provide qualitative and quantitative data determines the ***relevance*** of the study.

The ***object of the study*** is speech/language in people who suffered a stroke. The ***subject of the study*** is the assessment of speech/language impairment with standardized methods and usage of the obtained data in neurolinguistic research.

Research ***novelty***

• Nowadays, there are no Russian standardized screening tests for speech/language disorders in the acute period of the disease, developed based on the psycholinguistic parameters.

• The hypothesis about the connection between the lesion location and the mechanisms of implicit-statistical learning was tested for the first time in the Russian-speaking population.

The ***theoretical significance*** of the study

• We provided a rationale for the necessity of using psycholinguistic methods for the development of tests for speech/language disorders diagnostics.

• We identified the advantages and disadvantages of the existing tools and determined the directions for future research.

• The hypothesis of the connection between syntactic processing and implicit-statistical learning was experimentally confirmed.

The ***practical significance*** of the study

• Two screening tests for speech/language disorders have been adapted for Russian. These tests can be recommended as additional tools for the patient's examination during the acute period of the disease.

• The Russian versions of the Aphasia Rapid Test and the Aphasia Bedside Check were tested in the large samples of stroke survivors and neurologically healthy individuals, which confirmed their compliance with psychometric standards.

• The new tools were presented at conferences and workshops for neurologists and speech/language therapists.

The main results of the study and provisions for the defense

1) The Aphasia Rapid Test was validated in two clinical groups and a control group. The results of the study showed that this instrument meets state-of-the-art psychometric standards and makes it possible to distinguish between people with and without speech/language disorders. Unfortunately, ART does not allow differentiating aphasia (language) and articulation (speech) disorders.

2) Another screening test, The Aphasia Bedside Check, was also successfully adapted for Russian. ABC is as simple for performing as ART but provides a larger set of tasks for assessment of speech comprehension production. Although this test does not help to discriminate between aphasia and dysarthria either, an additional set of tasks can help deepen understanding of a particular patient's impairment.

3) Linguistically motivated tests are important not only for clinicians but also for researchers of various aspects of language functioning. Using the results obtained during the performance of some tasks from the Russian Aphasia Test, we provided evidence for the connection between syntactic processing and implicit-statistical learning in aphasia.

2. The Aphasia Rapid Test: adaptation and standardization for Russian

Paper selected for the defense: Buivolova et al. (2021)

In this study, we present a standardized version of the Aphasia Rapid Test (ART) for Russian (Buivolova et al., 2021). ART is a screening test for speech/language disorders in the acute

post-stroke period (up to one month from the onset of the disease). The ART is not meant for identifying aphasia type, but it is allowing the doctors to identify the presence of speech/language disorders at the early stages. Using the results of the screening, the specialist can recommend the patient to consult the speech pathologist or neuropsychologist and to develop the appropriate rehabilitation program.

The ART is a 26-point scale that consists of 6 tasks. They help to examine the patient's abilities to understand speech, to repeat three words and one sentence, and to name three objects in the pictures. The last two tasks include the short examination of articulation and verbal fluency task. The ART performance does not take much time and effort. Any member of medical staff in the neurologic department can assess speech/language with this instrument. This is one of the main advantages of this test because speech therapists or neuropsychologists are not always available in the clinics.

We adapted the original version of the Aphasia Rapid Test (Azuar et al., 2013) to Russian and performed the standardization studies which were aimed to answer the following questions:

- Does the Russian ART follow modern psychometric standards?
- Is it possible to use the Russian ART for speech/language screening in the acute post-stroke period?
- Whether the Russian ART suitable for detecting changes in the linguistic status in the acute stroke period?

To make the Russian adaptation of the test, we took into account the cultural and psychometric features of the items. According to the guidelines for language test development (Ivanova & Hallowell, 2013), the properly standardized instrument should be normed, valid, and reliable. This means, that we should take the following steps:

1) Identify the cut-off scores for the "normal" performance in the group of people without any brain damages and use the same instrument in the big cohort of people with different types of speech/language disorders.
2) Evaluate how well the test measures what it was supposed to measure.
3) Find how well the results of the test correlate with the results of standardized existing measures.
4) Estimate such parameters as internal consistency, inter-rater and test-retest reliability, and so on.

There were three groups of participants in our study. The first clinical group consisted of people with chronic (2 or more months post-onset) speech/language disorders (N = 51, 23 females; mean age = 58.9 years (SD = 10.6, range = 38-81)) following stroke. We considered their

linguistic status as stable, because, at this stage, spontaneous recovery is not probable. People in the acute post-stroke period formed the second clinical group (N = 43, 18 females; mean age = 56 years (SD = 11.3; range = 40-88 years)). Finally, we had a control group consisted of people without brain damages and speech/language disorders. They had normal vision and hearing and did not have any psychiatric or neurological history (N = 66, 42 females; mean age = 45.9 years (SD = 15.8; range = 18-79).

While norming the ART, all participants in the control group performed the test at the ceiling and did not get any penalty score. In the first clinical group of people with chronic speech/language disorders, the mean score on the ART (0 is for absent speech/language disorder, 26 is for the most severe disorder) was 6 points (SD = 4.2; range = 1-15). In the group of people in the acute post-stroke period the mean score on the ART was 7.1 points (SD = 5.6; range = 0-25).

For estimation of concurrent validity, we used the Russian version of the Token Test app (Akinina et al, 2019). We used this test because it is the worldwide "golden standard" of aphasia screening. In the control group the mean score on the Token Test was 32.7 (SD = 1.8, range = 29.5-35) out of 36 points and with the cut-off score of 29. In the group of people with chronic speech/language disorders, the mean score on the Token Test was 19.9 (SD = 8.1, range = 6-30). In the group of people in the acute post-stroke period, only 8 participants could perform the tablet version of the Token Test, because the procedure was difficult for them. The mean score on the Token Test in this group was 24.7 (SD = 10.8; range = 0-34). We performed the correlation analysis and found a significant correlation between the ART and the Token Test scores in the group of people with chronic speech/language disorders (r = -.649, p < .001)[1]. This means that the ART can be used for speech/language screening as well as the Token Test. Also, we estimated the sensitivity (100% of the true positive results), specificity (89% of true negative results) of the Russian ART. Such results can be considered excellent.

To evaluate the test-retest reliability of the Russian ART, we tested 14 participants with chronic aphasia twice (mean time between testing points = 23). There was no significant difference in the results in two points of testing (t(13) = 1.449, p = .171). To evaluate inter-rater reliability, two independent experts scored the results of the participants based on audio recordings of the participants' performance (r = .96, k_w = .778), and the results were also good. The internal consistency of the test was estimated using Cronbach's alpha and was high (α = .766) (Allen & Yen, 2002).

Finally, we performed a study aimed to find whether the Russian ART is suitable for

[1] The correlation coefficient is negative because the scales have opposite directions.

detection of the recovery in the acute stroke period. The results obtained in the two time points were significantly different and showed that participants' speech/language disorder remained stable or improved ($t(15) = 3.280$, $p = .005$).

To sum up, in the paper (Buivolova et al., 2021), we showed that the Russian ART meets modern psychometric standards. We collected normative data in the groups of people with and without speech/language pathologies. Then, we found some evidence for the statement that the Russian ART can be used for speech/language pathologies screening in the acute period. Finally, we used the Russian ART for the estimation of recovery dynamics in the acute post-stroke period. Our results allow us to recommend the Russian ART as an additional linguistic instrument for fast assessment of speech/language disorders despite it does not allow to make a difference between the results of people with speech and with language disorders.

3. Adaptation of the Aphasia Bedside Check for Russian

Paper selected for the defense: Buivolova et al. (2020)

As soon as the Russian ART does not allow us to make a difference between people with speech disorders (e.g., dysarthria) and language disorders (aphasia), we decided to develop one more screening test for the Russian language and to find whether it fills this gap. The new instrument was also an adaptation of the existing screening test named the Aphasia Bedside Check (ABC; Visch-Brink & El Hachioui, 2013; the Russian version: Buivolova et al., 2020). This test is a tool widely used in clinical practice in the Netherlands. This test is also meant for language disorders screening in the acute period of the disease. The ABC is a more detailed instrument than the Russian ART which we described in the previous section. This test consists of three main parts: A – language comprehension; B – language production; C – more complex additional. We made an adaptation for Russian considering psycholinguistic features of the stimuli, such as frequency, age of acquisition, length of the word, imageability, etc. These parameters were taken from the Stimuli Database: Verbs and Nouns Akinina et al., 2015; Akinina et al., 2016).

The final set of tasks in the part A includes the understanding of the words and sentences and answering "yes/no" questions devoted to the assessment of the semantic level. In part B (language production) the participant should name three objects in the pictures, repeat two words, and read two words aloud. In part C the participant is asked to perform additional tasks if the specialist finds it necessary. The tasks of part C are the following: Picture description, 3 semantic "yes/no" questions, more complex words and phrases for repetition and reading aloud

(3 in each task), the completion series of words based on their semantics, verbal fluency task (3 categories), and the task for detection of the articulation problems. Thus, the Aphasia Bedside Check is more detailed than the ART, however, its implementation takes no longer than 10 minutes. This screening test is presented as a booklet that fits the doctor's pocket easily. The adaptation process was described in detail in the paper Buivolova et al., 2020.

To standardize the test, we performed two studies. With the procedure similar to the procedure of the Russian ART standardization studies, we tested the group of people with speech/language disorders following stroke (N = 80, 30 females; mean age = 60 years (SD = 11.5, range = 26-79)) and the group of neurologically healthy individuals (N = 120, 61 females; mean age = 43.16 years (SD = 2.57, range = 10-21)). Following the same principle, as in Chapter 2, the participants performed the tasks of the ABC and the Token Test. As the result, we evaluated the psychometric properties of the test (see Table 1). The results can be defined as good meaning that the test can be used in the acute post-stroke population.

Table 1. Psychometric features of the ABC-Ru

Parameter	**Value**	**95% confidence interval**
Sensitivity	.72	.58 – .83
Specificity	.96	.91 – .99
Positive predictive value	.88	.75 – .96
Negative predictive value	.89	.82 – .93
Likelihood ratio for the positive test	17.35	7.23 – 41.61
Likelihood ratio for the negative test	.30	.19 – .45

The second part of the study aimed to show that the ABC-Ru can be implemented in the population of people with and without speech/language disorders in the acute stroke period. Twenty people (7 females; mean age = 61.3 years, SD = 13.912, range = 32-85). Ten people had aphasia diagnosed by a speech pathologist, 6 people were diagnosed with dysarthria, and 4 people did not have any speech/language disorders. The participants performed the tasks of the ABC-Ru and the Russian ART. A high and significant correlation was found between the results on these two tests (ρ = -.911, p = .000). This means that these two tests can be used for the same purpose.

Then, we compared the results of the groups of people with and without speech/language disorders. The mean score of the participants in the latter group was higher than the cut-off score of 13 points: 13.25 (*SD* = .5, range 13-14). At the same time, the performance of people with speech/language disorders on average performed on ABC-Ru lower that cut-off score: 9.5 (*SD* = 3.633, range 2-14). We used the Wilcoxon signed-rank test and found a significant difference in the performance of these two groups (Z = -3.308, p = .000). At the same time, there was no significant difference between the performance of the groups of people with aphasia and dysarthria.

To sum up, we found that the ABC-Ru follows psychometric standards and can be used in the population of people with speech/language pathologies. However, similarly to the Russian ART, the ABC-Ru cannot be used for making a difference between people with aphasia and people with dysarthria. Despite this, the ABC-Ru is meant for the assessment of the wider range of functions than the Russian ART.

4. Application of the Russian Aphasia Test in the study of implicit-statistical learning in aphasia.

Paper selected for the defense: Vadinova et al. (2020)

For a detailed assessment of language at different linguistic levels (phonological, lexical, syntactic, and at the level of discourse), Ivanova and colleagues (2021) developed the Russian Aphasia Test (RAT). This is unique for the Russian clinical and research practice instrument aimed to examine language in three different modalities: repetition, comprehension, and production, and to describe in detail the core of the patient's language deficit. There are 13 tasks in the test. For details, see Table 2.

Table 2. Tasks of the Russian Aphasia Test

Comprehension	**Production**	**Repetition**
Discrimination of minimal pairs of pseudowords	Object naming	Repetition of pseudowords
Lexical decision	Action naming	Repetition of words
Comprehension of nouns	Sentence production with priming	Repetition of sentences
Comprehension of verbs	Telling a story based on the picture	

Comprehension of sentences		
Comprehension of the text		

The RAT has been developed as the application for the tablet, and this digital version (as well as "the paper-and-pencil" version) was standardized in big cohorts of neurologically healthy individuals and people with aphasia of different types and severity. This tool allows the clinician and the researcher to get qualitative and quantitative results of the examination and to provide the information for clinical routine. As for linguistic studies, the RAT makes the process of participants' selection more objective, because all of them will be assessed with the unified half-automatic instrument. Obtained data can be used in studies on both pathological and neurotypical functioning of language. We used some tasks of the RAT in the study devoted to the connection between implicit-statistical learning and syntactic processing (Vadinova et al., 2020). This study was included in the dissertation to provide an example of usage of the linguistic test in the research practice, and to show that such instruments are very important not only for clinicians but for theoretical linguists as well.

The main purpose of research on implicit statistical learning (ISL) is to study "the human ability to detect and exploit the relations between elements in close temporal or spatial proximity" (Perruchet and Pacton, 2006, p. 237). Neuroimaging studies found that the brain arias active during ISL tasks are also active during syntactic processing tasks (Bapi et al., 2005). Some of the previous research shows that people with lesions in the left frontal lobe demonstrate difficulties with syntactic processing tasks and ISL tasks (e.g., Zimmerer et al., 2014). At the same time, ISL mechanisms in people with lesions in posterior arias (temporoparietal regions) were not studied systematically. The present study answers the following research questions:

1. Whether the ISL mechanisms are more intact in people with posterior lesions than in people with frontal lesions?
2. Is there a connection between the severity of ISL mechanisms impairment and the amplitude of impairment of syntactic processing?

Visual statistical learning task (VSL, van Witteloostuijn et al., 2019) was used to study the relationship between ISL and syntactic processing. The task had two phases. During the introductory phase, the subject was presented with visual stimuli (288 images of 12 types of aliens). The stimuli were organized in a specific way by triples (the participants were not aware of the pattern of stimuli presentation), each triple was presented 6 times. Within each triplet, the

images were presented in a fixed order, while the triples themselves alternated with each other in a pseudorandomized order. Thus, if the second and third elements of the triplet were more predictable than the first element. At this stage, the participant's reaction time (online effect) was measured. With effective learning, it was expected that reaction times would be shorter when participants were presented with more predictable items.

In the second phase, two offline tasks assessing the presence and amplitude of the learning effect. In the first task of the offline phase, the participant had to choose one of two pictures that depicted the "correctly" organized triplet (pictures in the same order as in the online stage). In the second task, the participant should fill in the gaps in the presented image sequences. The materials and research procedure are described in detail in the article (Vadinova et al., 2020).

Additionally, participants performed the tasks from the Russian Aphasia Test allowing the researcher to assess the syntactic (sentence comprehension and production) and lexical (verbs comprehension and production). To estimate the difference in performance at the group level, we used a linear mixed-effects model. To investigate the relations between the effect of implicit-statistical learning and performance on the linguistic tasks, we applied correlational analysis.

Two groups of participants took part in the study. The clinical group included 13 people with chronic aphasia (5 people with damage to the anterior parts of the brain and 8 people with posterior lesions). The control group included 11 neurologically healthy individuals. Only people with aphasia performed the tasks of the Russian Aphasia Test.

To sum up, we found no confirmation for the *anatomical* hypothesis. There was no difference in the performance on ISL tasks between two groups of people with aphasia. At the same time, the results of the control and clinical groups were significantly different both at the first (reaction time, $\Delta z = 0.104$, 95% CI [0.017 ... 0.192], $t = 2.366$, $p = 0.018$) and at the second stage of the study (accuracy, log odds = +3.217, CI 95% = [1.296 ... 8.775], $p = 0.013$). Thus, we found that a) the learning effect is not associated with the lesion location, b) ISL mechanisms are impaired, but not completely absent in people with aphasia.

The results of the *behavioral* data analysis confirmed the presence (albeit rather weak) of the relationship between ISL mechanisms and syntactic processing in the first task of the second stage of the study ($r = 0.156$, CI 98.75% = [0.015 0.290], $p = 0.005$), while no significant correlation with the results of performing lexical tasks was found ($r = 0.034$, CI 98.75% = [-0.107 0.174], $p = 0.542$). In other tasks (the task of the online stage and the second task of the offline stage of the experiment), no significant correlations were found. Thus, we revealed the presence of a weak correlation between the amplitude of syntactic impairments and the accuracy of the ISL task.

The results of the study show that the behavioral linguistic profiles can better explain the results of performance on the experimental tasks than information about the lesion location. This study shows the importance of standardized tests for linguistic research.

5. Conclusions

The articles included in the dissertation are united by the topic of adaptation and development of linguistically motivated tests for language assessment in people with brain damage. We showed that they can be relevant both for clinicians and researchers. The instruments we presented in the articles will allow us to obtain the data that can be used not only for effective diagnosis and prognosis of language function recovery but also for confirming linguistic theories.

In Chapters 2 and 3, the author of the dissertation describes the adaptation process for two screening tests: The Aphasia Rapid Test and The Aphasia Bedside Check. We found that these two tools can be used in clinics for the differentiation of people with and without speech/language disorders. These instruments show the different degrees of detail. While the ART is meant only for quick screening, the ABC test makes the independent assessment of speech/language comprehension and production. The latter test shows the greater variability of stimuli and allows us to use additional part for the more detailed speech/language assessment. Unfortunately, according to our results, both Russian versions of these tests cannot be used to distinguish between people with aphasia and people with articulation disorders. However, this does not contradict the purpose of the screening tests. These instruments are not meant for detailed assessment or establishing the final diagnosis. Nevertheless, they reliably allow us to tell whether the participant has or has not a speech/language disorder, which is very important at the first steps of working with a patient.

Chapter 4 provides an example of how the tablet version of the Russian Aphasia Test can be used in the neurolinguistic study. This instrument is a detailed test battery meant for the assessment of the linguistic deficit in people with aphasia. The people with different lesion locations performed on the experimental tasks and the several tasks of the Russian Aphasia Test examining the preservation of the syntactic and lexical-semantic linguistic levels. In this study, we found no evidence for the relationship between the accuracy in the implicit-statistical learning tasks and the lesion location. At the same time, we found the presence of a weak connection between syntactic processing and implicit statistical learning. To some extent, this became possible due to the existence of a detailed linguistically motivated Russian Aphasia Test.

Thus, the materials included in this dissertation provided a rationale for the usage of the linguistic methodology while developing the tests for speech/language assessment. The results of the carried studies allow us to shed a light on the gaps and to find a new direction in the field of language assessment tools development for Russian. Currently, the author of the dissertation and colleagues

work on the development of other tools filling the gap of linguistic assessment tools and their introduction to the clinicians. The development of new instruments, and their digitalization will be innovative and perspective for future generations of clinicians and researchers. The dissertation is interdisciplinary and can be considered as one of the bridges connecting clinical and theoretical studies of language.

6. References

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