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HIGHER SCHOOL OF ECONOMICS

*As a manuscript*

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**LANGUAGE IMPAIRMENT IN CHILDREN WITH AUTISM SPECTRUM DISORDER:  
LINGUISTIC ASPECTS**

**Dissertation Summary**

for the purpose of obtaining academic degree  
Doctor of Philosophy in Philology and Linguistics

Academic Supervisor:  
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## **Publications**

The publications were selected for the defense. The author of the dissertation is the first and corresponding author of all articles.

1. **Arutiunian, V.**, Lopukhina, A. The effects of phonological neighborhood density in childhood word production and recognition in Russian are opposite to English // *Journal of Child Language*. 2020. Vol. 47. P. 1244–1262 (Q2 Web of Science / Q1 Scopus).
2. **Arutiunian, V.**, Lopukhina, A., Minnigulova, A., Davydova, E., Pereverzeva, D., Sorokin, A., Tyushkevich, S., Mamokhina, U., Danilina, K., Dragoy, O. Expressive and Receptive Language in Russian Primary-School-Aged Children with Autism Spectrum Disorder // *Research in Developmental Disabilities*. 2021. Vol. 117. Article 104042 (Q1 Web of Science / Q1 Scopus).
3. **Arutiunian, V.**, Lopukhina, A., Minnigulova, A., Davydova, E., Pereverzeva, D., Sorokin, A., Tyushkevich, S., Mamokhina, U., Danilina, K., Dragoy, O. Language Abilities of Russian Primary-School-Aged Children with Autism Spectrum Disorder: Evidence from comprehensive assessment // *Journal of Autism and Developmental Disorders*. 2022. Vol. 52. № 2. P. 584–599 (Q1 Web of Science / Q1 Scopus).

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

4. **Arutiunian, V.**, Minnigulova, A., Lopukhina, A., Davydova, E. *Phonologicheskaya discriminacia u detej s rasstrojstvami autisticheskogo spectra: pilotnoe issledovanie na materiale russkogo jazyka* [Phonological discrimination in children with Autism Spectrum Disorder: A pilot study in Russian] // *V kn.: Kognitivnaya nauka v Moskve: novye issledovaniya. Materialu konferencii 19 iyunya 2019* [In the book: Cognitive science in Moscow: new research]. M.: Buki Vedi, 2019. P. 70–75.
5. **Arutiunian, V.**, Minnigulova, A., Lopukhina, A. Nonword repetition is impaired in children with Autism Spectrum Disorder: A pilot study in Russian // *In Abstract Book of the Typical and Atypical Language Development Symposium, 4 September, 2019. Moscow*. P. 10–11.
6. **Arutiunian, V.**, Minnigulova, A., Sorokin, A., Davydova, E., Pereverzeva, D., Tyushkevich, S., Mamokhina, U., Danilina, K., Lopukhina, A. Expressive and Receptive Vocabulary Impairments in Primary-School-Aged Child with Autism Spectrum Disorder: A Pilot Study in Russian // *In Abstract Book of the International Society for Autism Research Annual Meeting Virtual, 3 June, 2020*. P. 186.
7. **Arutiunian, V.**, Lopukhina, A., Minnigulova, A., Shlyakhova, A., Davydova, E., Pereverze-

va, D., Sorokin, A., Tyushkevich, S., Mamokhina, U., Danilina, K., Dragoy, O. Language Profiles of Russian Primary-School-Aged Children with Autism Spectrum Disorder // In Abstract Book of the International Society for Autism Research Annual Meeting Virtual, 3–7 May, 2021. P. 228.

8. Gomozova, M., **Arutiunian, V.**, Lopukhina, A., Dragoy, O. Instrument dlya kompleksnogo obsledovaniya rechevyh navykov KORABLIK i opyt ego primeneniya v gruppe mladshih shkolnikov s RAS [Russian Child Language Assessment Battery (RuCLAB) and its Application in Primary School Children with ASD] // Autism i narusheniya razvitiya [Autism and Developmental Disorders]. Vol. 19, № 4. P. 24–31.
9. Pereverzeva, D., Mamokhina, U., Davydova, E., Lopukhina, A., **Arutiunian, V.**, Khaustov, A.V. Osobennosti ponimaniya rechi u detej s rasstrojstvami autisticheskogo spectra mladshego shkolnogo vozrasta [Receptive Language in Primary-School-Aged Children with Autism Spectrum Disorder] // Klinicheskaya i specialnaya psichologia [Clinical Psychology and Special Education]. Vol. 10, № 4. P. 137–161.

### **Conference presentations and public demonstrations of the results**

The main results and conclusions of the present study have been presented in 2019–2021 in oral and poster presentations at both domestic and international conferences, including:

- Summer School «Infant Studies on Language Development in Europe» (11–15 June 2018, Potsdam, Germany).
- International Conference ABC «Asia-Pacific BabyLab Constellation» (4–5 October 2018, Singapore).
- I Global Speech Forum (26–28 April 2019, Moscow, Russia).
- Cognitive Science in Moscow: new research (19 June 2019, Moscow, Russia).
- Typical and Atypical Language Development Symposium (4 September 2019, Moscow, Russia).
- International Society for Autism Research Annual Meeting Virtual (3 June, 2020, Seattle, United States of America).
- I International Congress on Cognitive Studies, Artificial Intelligence, and Neuroinformatics (10–16 October 2020, Moscow, Russia).
- Society for Research in Child Development Biennial Meeting (07–09 April 2021, Minneapolis, United States of America).
- International Society for Autism Research Annual Meeting Virtual (03–07 May, 2021, Boston, United States of America).
- MEGUK 2021 Conference (06–07 September, 2021, Cambridge, United Kingdom).

## 1. Introduction

The papers included in this dissertation addressed the linguistic aspects of language impairment in children with Autism Spectrum Disorder (ASD). On the one hand, the present study investigates the language abilities of Russian primary-school-aged (7-11-year-old) children with ASD at different linguistic levels (phonology, vocabulary, morphosyntax, and discourse); on the other hand, it focuses on the phonological mechanisms which play a significant role in word production and recognition in pre-school typically developing (TD) children and can be impaired in children with ASD. The published articles show how linguistic approaches can contribute to such complex problem as language development in ASD.

ASD is a highly heterogeneous group of neurodevelopmental disorders associated with impairment in social interaction and restricted / repetitive behavior [American Psychiatric Association, 2013; Григоренко, 2019]. Although language impairment is not a core symptom of ASD, about 75% of children have comorbid language impairments at different linguistic levels [Kjelgaard, Tager-Flusberg, 2001]. The behavioral studies of language functioning in TD children and children with autism is one of the most important areas in contemporary experimental linguistics because of the several theoretical and applied reasons. First, according to the epidemiological evidence, there is a dramatic increase of this disorder in the last 20 years [Cardinal et al., 2021]; second, some atypical patterns of language development in children with ASD may shed a light on psycholinguistic aspects of language acquisition in TD children. Finally, investigations of phonological mechanisms involved in the word production and recognition at the early stage of child development (pre-school age) can highlight some aspects of language development and help to explore the atypical trajectory of developmental state of these mechanisms in ASD.

The previous studies have addressed some aspects of language impairment in Russian children with ASD: e.g., grammar and lexicon [Манелис и др., 2005; Романова, Ахутина, 2011; Романова, 2012]; discourse [Павлов, 2017, 2018a, 2018b, 2018c]; phonology [Lyakso et al., 2021; Ляксо и др., 2020]; finally, some general characteristics of language abilities in autism were explored in [Фёдорова, 2020].

However, although some aspects of language functioning were studied in Russian children with ASD, until now there is a lack of systematic analysis of language impairment in ASD at different linguistic levels, using standardized language assessment tools. Moreover, the previous studies, investigating language in ASD, included a small number of participants. Finally, nothing is known about how phonological mechanisms (i.e., *phonological neighborhood density*) involved in word production and recognition are functioning in Russian-speaking pre-school children. This knowledge is needed for understanding the trajectory of language development in school-aged children with ASD.

The *central goal* of the study was to show that a) language assessment at different linguistic levels with the standardized tool, taking into account psycholinguistic parameters of the Russian language, can significantly contribute to the understanding of language behavior in autism and explore some new mechanisms of language deficit in ASD; b) such linguistic approach can be useful for speech and language therapists because it highlights the specific deficit in a child; c) phonological neighborhood density of a word is a language-specific and play a different role in word production and recognition even at the early stage of language acquisition. In general, this corresponds to interdisciplinary ‘nature’ of contemporary psycholinguistics.

The *object* of the research is a language behavior of Russian children with ASD. The *subject* of the study is impairment at different linguistic levels in children with ASD and phonological mechanisms involved in word production and recognition at early stages of language development in TD children.

The research *novelty*:

- The language abilities of a large group of Russian children with ASD were described at different linguistic levels with standardized language assessment tool which takes into account the relevant for Russian psycholinguistic properties.
- Expressive and receptive domains were compared at the levels of vocabulary, morpho-syntax, and discourse in the same group of children with ASD; also, the role of non-verbal IQ in difference between expressive and receptive domains was shown.
- Phonological neighborhood density influenced word production and recognition in young children. This may be used for the further studies on language development in ASD.

The *theoretical significance* of the study:

- We showed the essential positive effect of applying a linguistically based approach to exploring language impairment in children with ASD.
- We described language impairment at different linguistic levels in children with ASD, showed the role of non-language factors in language functioning, and highlighted the subgroups of children with ASD according to their language abilities.
- We revealed experimentally the patterns in expressive and receptive language domains at different linguistic levels in children with ASD and demonstrated the role of non-verbal IQ in these patterns.
- The study showed that phonological neighborhood density of a word influenced word production and recognition in Russian pre-school children, and these patterns are language-specific.

The *practical significance* of the study:

- The results of the study showed that the language abilities of children with ASD may

depend on linguistic level, so that the child may have normal vocabulary, but impaired morphosyntactic processing. This means that the formal language assessment needs to include the assessment of all linguistic levels, from phonology to discourse. As a result, language testing could help speech-language therapists to choose the best therapy.

- The results of the study demonstrated that although language impairment is not a core symptom of ASD, the formal language assessment should become part of the general psychological assessment of children with ASD besides the tests which accounted for the severity of autistic traits or non-verbal IQ. In Russian clinical practice, language therapy for children with autism is mostly dependent on the general communication skills of a child, the severity of autistic symptoms and the child's intellectual level: children with severe autistic traits and problems in social communication usually receive more language therapy although they can have normal language abilities. At the same time, children with good communication skills and normal non-verbal IQ may not get language therapy although some of them can have a deficit in linguistic processing. In other words, language abilities of children with ASD are not always related to general cognitive profile and have to be assessed separately.
- The series of lectures "The stages of brain development in typically developing children and children with Autism Spectrum Disorder" implemented into the educational program "Practicum in Psycholinguistics" (Bachelor program, HSE School of Linguistics).

The *main results* of the study and *provisions* for the defense:

- The language assessment tools which take into account the relevant for specific language psycholinguistic properties contribute significantly to exploration of language profiles of children with ASD.
- Non-verbal IQ differently account for the patterns of production and comprehension at different linguistic levels in children with ASD.
- Word production and recognition in TD children depend on the phonological neighborhood density of a word. This has to be taken into account in speech therapy of children with ASD which predominantly based on the vocabulary development.

## **2. Language abilities of Russian children with ASD**

### Article selected for the defense:

*Arutiunian V. et al.* Language Abilities of Russian Primary-School-Aged Children with Autism Spectrum Disorder: Evidence from Comprehensive Assessment // *Journal of Autism and Developmental Disorders*. 2022. Vol. 52. № 2. P. 584–599.

### **2.1. Introduction**

Although language impairment in ASD is a comorbid disorder, most of the children with this disorder has impairments at all linguistic levels in both production and comprehension [Bishop et al., 2004; Nevill et al., 2019]. At the phonological level, children with ASD have difficulties in phonological awareness and phonological short-term memory [Habib et al., 2019; Loucas et al., 2010; Wang et al., 2017; Wolk et al., 2016]. Although children with ASD have impairment at the vocabulary, this is the less affected linguistic level [Arunachalam, Luster, 2018; Kjelgaard, Tager-Flusberg, 2001]. Morphosyntax and discourse is also significantly affected in these children in both expressive and receptive domains [Coderre et al., 2018; Eigsti et al., 2007; Kuijper et al., 2017; Wittke et al., 2017].

Some studies have investigated which non-language factors influenced the language abilities of children with ASD. Specifically, it was shown that non-verbal IQ [Kjelgaard, Tager-Flusberg, 2001], early vocalization, and joint attention [Nevill et al., 2019] contributed language functioning in autism.

Summarizing, previous studies have demonstrated a high variability of language in children with ASD. The goal of the present study was to describe the language profiles in 7–11-year-old (primary-school-aged) Russian children with ASD in both expressive and receptive language domains and to understand which non-language factors (age, non-verbal IQ, and the severity of autistic symptoms) accounted language abilities of these children. The novelties of the studies were following: 1) we investigated only primary-school-aged children whereas most of the studies included children from a broader age range (e.g., 4–14-year-old); 2) our group of children with ASD included participants varying in non-verbal IQ, so we did not pre-select children with autism in order to get a full picture of language abilities in this population; 3) we aimed to explore language profiles in children with ASD at all linguistic levels using not parental reports but measuring language abilities directly, i.e., in formal testing; 4) this is the first study that systematically described the language abilities of Russian children with ASD.

### **2.2. Method**

A total of 107 native Russian-speaking children participated in the study: 82 children with ASD

(65 boys, 17 girls, age range 7.01–11.10 years,  $M_{\text{age}} = 9.11$ ,  $SD = 1.5$ ) and 25 age-matched TD children as a control group (14 boys, 11 girls, age range 7.09–10.11 years,  $M_{\text{age}} = 9.1$ ,  $SD = 1.0$ ).

All children with ASD had a clinical diagnosis within the autistic spectrum, according to ICD-10, and 67 out of 82 also were assessed by a licensed psychiatrist with Autism Diagnosis Observation Schedule—Second Edition, ADOS-2. Additionally, to confirm the validity of the diagnosis, parents of both ASD and TD groups of children were asked to fill in the Russian version of the Autism Spectrum Quotient: Children’s Version, AQ. The results from the AQ questionnaire were in agreement with the clinical diagnosis. Non-verbal IQ was also measured in both groups.

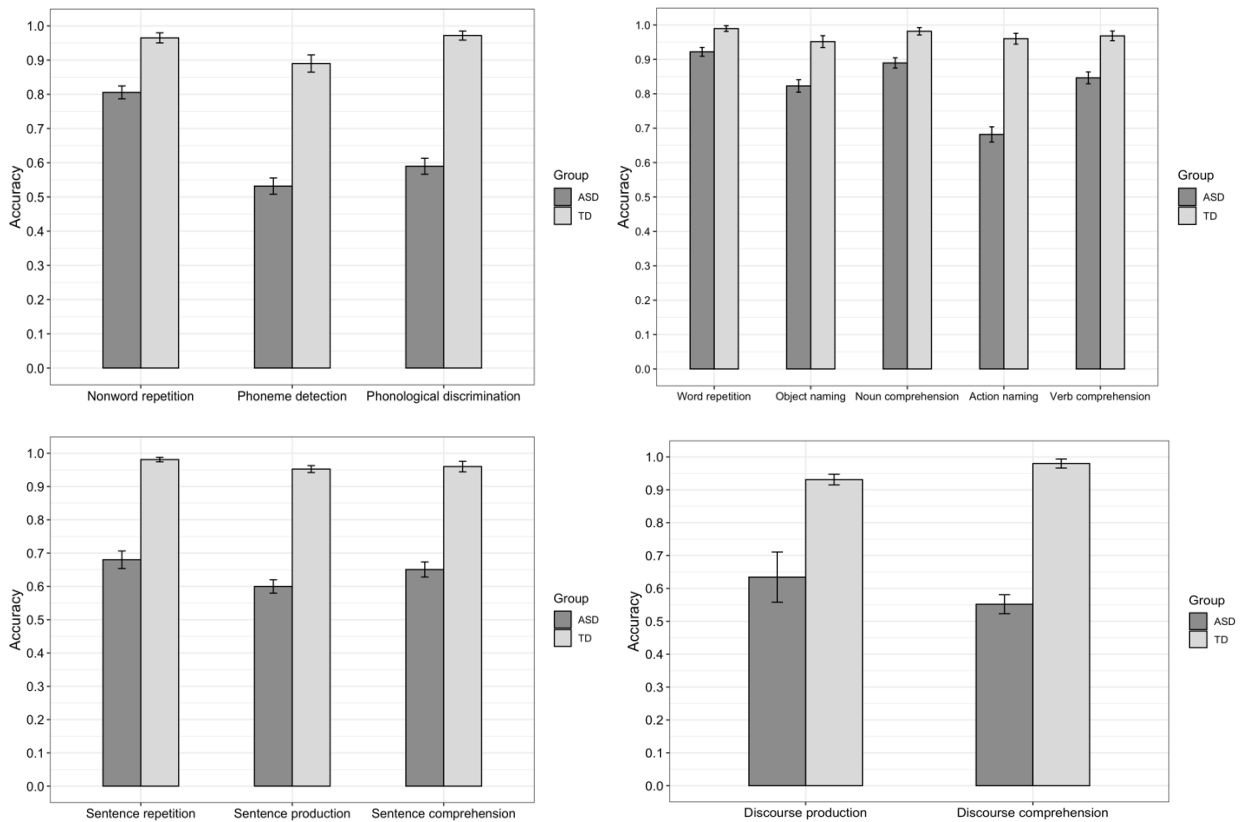
Language abilities were measured with the Russian Child Language Assessment Battery, *Word repetition* test and *Phoneme detection* test from [Dorofeeva et al., 2020]. Thus, in general each child was screened with 13 tests, assessing phonology, vocabulary, morphosyntax, and discourse in expressive and receptive domains.

### **2.3. Results**

The first step of analysis was to provide between-group comparison in each language test. The results showed that children with ASD had statistically significantly lower scores in each test, excluding Word repetition (see Figure 1). In general, this corresponded to studies demonstrating that lexical level is less affected linguistic level in children with ASD [Kjelgaard, Tager-Flusberg, 2001].

The second step of analysis was to reveal how different psycholinguistic parameters of stimulus items influenced the accuracy in each test. In phonological tests, the length of items did not account for accuracy in any groups of children. In lexical tests, we found the effect of word class: nouns and verbs were produced and recognized with comparable accuracy in TD group but children with ASD struggled more with verbs than with nouns in both production and comprehension.





**Figure 1.** The comparison of ASD and TD groups in each language test

In morphosyntax, the psycholinguistic parameters also influenced accuracy: e.g., in *Sentence repetition* test the items were balanced in such parameters as word frequency (high vs. low) and word length (short vs. long). In TD children neither frequency nor length predicted accuracy. By contrast, in the ASD group we found the significant effects of frequency and length on accuracy, so that children with ASD repeated short sentences and sentences with high-frequency words better than long sentences and sentences consisting of low-frequency words. *Sentence comprehension* test consisted of items with canonical (SVO) and non-canonical (OSV) word order. The results demonstrated there was no effect of word order on accuracy in the TD group. However, in the ASD group there was the significant influence of word order on accuracy, indicating that children with autism comprehended sentences with canonical SVO word order more accurately than sentences with noncanonical OVS word order.

At the level of discourse, in *Discourse comprehension* test there was an effect of question type (explicit vs. implicit) in accuracy in ASD group: children with ASD struggled more with implicit questions.

At the next step of analysis we aimed to reveal the relationships between non-language factors (age, AQ scores that reflected the severity of autistic traits, and non-verbal IQ) and language abilities in children with ASD. The results showed that children's non-verbal IQ predicted accura-

cy in 9 out of 11 language tests (in the other two tests the IQ effect was significant only before a Bonferroni correction), indicating that the lower non-verbal IQ was associated with lower language abilities. Interestingly, that children's age and AQ scores were not related to language abilities in any test.

The final step of the analysis aimed to subgroup children with ASD according to their language abilities on each language test. For each language test across linguistic levels, we divided children into those who had scores within the normal range (normal language group), those who scored between 1 and 1.27 standard deviations below the mean (borderline group), and those whose scores were more than 1.27 standard deviations below the mean (impaired group). The results showed that first, there were subgroups of autistic children with normal language abilities in any test we used. Second, the number of children within the normal range depended on the linguistic level, so that according to morphosyntax and discourse tests the groups with normal performance consisted of fewer children in comparison to phonological and lexical tests. Finally, the subgroups of children with ASD differed in non-verbal IQ in most of the tests, i.e. normal subgroups had overall higher IQ than the impaired subgroups. Note, however, but there were some children with normal language abilities and low non-verbal IQ (40) as well as children with impaired language skills and high non-verbal IQ (115).

#### **2.4. Conclusion**

In general, this study showed a high variability in language skills of children with ASD and also proposed some exploration of this variability. For the first time, language abilities of Russian children with ASD were described with standardized language assessment tool. The practical significance of the study is that it highlighted that the language skills of children with ASD may differ depending on a linguistic level, e.g. a child may have normal vocabulary, but impaired morpho-syntactic processing. This means that formal language assessment needs to include the assessment of all linguistic levels, from phonology to discourse. Moreover, the study demonstrated that children with normal non-verbal IQ and non-severe autistic traits may have severe language impairments, who may need special intervention by a speech-language therapist.

### **3. Expressive and receptive language in Russian children with ASD**

Article selected for the defense:

*Arutiunian V. et al.* Expressive and Receptive Language in Russian Primary-School-Aged Children with Autism Spectrum Disorder // *Research in Developmental Disabilities*. 2021. Vol. 117. Article 104042.

#### **3.1. Introduction**

The previous studies in language functioning in autism disagree on the difference in the degree of impairment between expressive and receptive language domains. Most of the studies have shown that receptive language is more impaired in comparison to expressive language [Charman et al., 2003; Kover et al., 2013]. In Kover et al. (2013) study, 49 boys with ASD (Mage = 7.6) were assessed in receptive vocabulary relative to expressive vocabulary. The authors showed that receptive vocabulary was significantly more impaired in these children. The same pattern was revealed in [Charman et al., 2003] with another language assessment tool. All these studies resulted the idea that the expressive-better-than-receptive pattern in language is the unique hallmark of ASD.

However, other studies have revealed the opposite pattern, i.e. more impaired expressive than receptive language. For example, in Weismer et al. (2010) study with 257 children with ASD it was shown a more severe expressive than receptive language delay. In [Luyster et al., 2008] the same pattern was observed: receptive language was stronger than expressive, as measured by the VABS.

Importantly, some studies did not demonstrate the difference between expressive and receptive domains in children with ASD [Kjelgaard, Tager-Flusberg, 2001; Kwok et al., 2015].

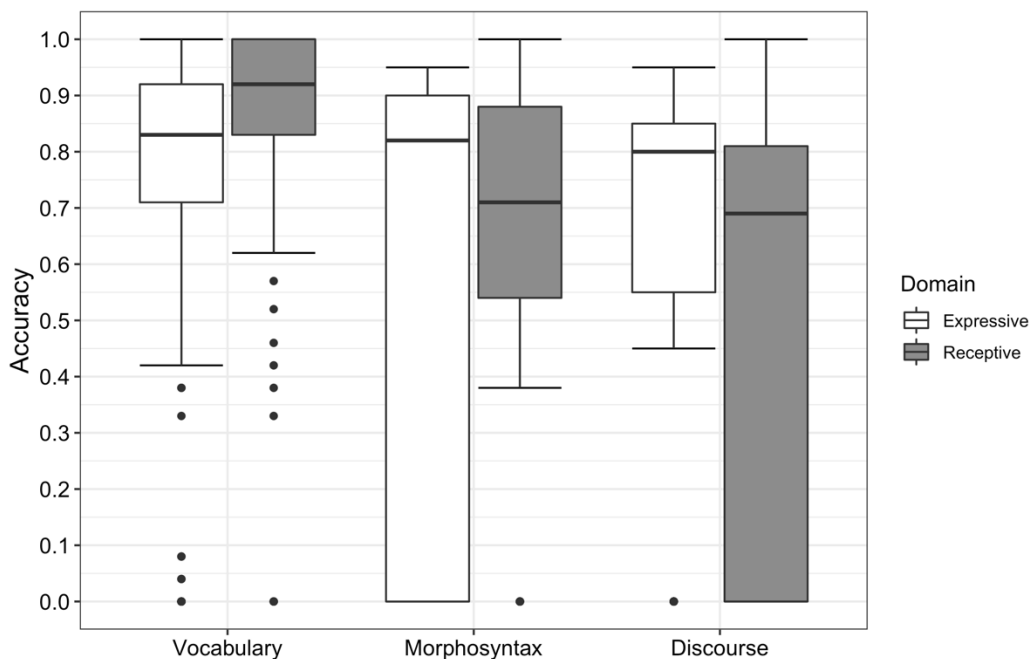
The aim of the present study was to directly compare expressive and receptive language abilities in a representative group of Russian primary-school-aged children with ASD. The novelties of the study are the following: first of all, our ASD group consisted of only primary-school-aged children whereas most other studies that compared expressive and receptive language domains focused on toddlers and preschoolers. This can influence the expressive / receptive patterns in language because the change with age [Bornstein, Hendricks, 2012]. Second, we assessed language abilities using formal testing, and did not rely on parental reports as many previous studies did. Third, we separately compared expressive and receptive vocabulary, morphosyntax, and discourse abilities. To the best of our knowledge, this is the first study which has aimed to directly investigate expressive and receptive language in children with ASD at three different linguistic levels. Fourth, we investigated the possible role of children's non-verbal IQ in the difference between expressive and receptive language domains.

### 3.2. Method

The study included 82 children with ASD (65 boys, 17 girls, age range 7.01–11.10 years,  $M_{age} = 9.11$ ,  $SD = 1.5$ ); this was the same children as in the previous study. Thus, the diagnosis and testing procedure see 2.2. Method.

### 3.3. Results

The first step of analysis was to compare expressive and receptive language at the level of vocabulary (word production vs. comprehension), morphosyntax (sentence production vs. comprehension), and discourse (discourse production vs. comprehension) in children with ASD. The results showed that there was a significant difference at vocabulary (word production was more impaired than word comprehension); no difference was found at morphosyntax level; and there was also a significant difference between domains in discourse (comprehension was more impaired, Figure 2).



**Figure 2.** Expressive and receptive domains at different linguistic levels in ASD

Therefore, a discrepancy between expressive and receptive language domains in primary-school-aged children with autism was found at the levels of vocabulary and discourse but the patterns were not similar: word comprehension was less impaired than production but discourse comprehension was more impaired than production.

The second step of the analysis was to clarify whether the non-verbal IQ of children with ASD accounted for the difference between their expressive and receptive language domains. We

divided our participants into two groups: ASD children without intellectual disability (ASD without ID,  $N = 33$ , non-verbal IQ  $\geq 80$ ) and ASD children with intellectual disability (ASD with ID,  $N = 33$ , non-verbal IQ  $< 80$ ). A sample  $t$ -test showed that there was no difference between the groups of children in age,  $t(63.9) = 0.88$ ,  $p = 0.37$ . Then we compared expressive and receptive language at the levels of vocabulary, morphosyntax, and discourse in two groups of children with ASD separately.

The results showed that at the level of vocabulary in both groups of children word comprehension exceeded word production, indicating that non-verbal IQ did not influence the expressive-receptive pattern. At the level of morphosyntax, there was a difference in patterns between two groups of children: we showed that ASD children with ID comprehended sentences more accurately than they produced them. At the same time, we found that ASD children without ID did not show any difference between sentence production and comprehension. Thus, non-verbal IQ accounted for the expressive-receptive pattern at the morphosyntactic level. Finally, at the discourse level, we also showed a between-difference: ASD children with ID produced a story more accurately than they comprehended a story. By contrast, ASD children without ID did not show any difference between story production and comprehension. This means that non-verbal IQ influenced the expressive-receptive pattern at the level of discourse.

### **3.4. Conclusion**

The expressive-better-than-receptive pattern in language has been considered by some authors as the unique hallmark of ASD which differentiates these children from children with other developmental disabilities. However, several studies, including our own, demonstrate that this is not a universal characteristic of ASD. Moreover, we have revealed that expressive and receptive language patterns differ depending on the linguistic level and children's non-verbal IQ. We suppose this has to be taken into account in clinical practice.

## **4. The influence of phonological neighborhood density on word production and recognition in 4-to-6-year-old children**

Article selected for the defense:

*Arutiunian V., Lopukhina A.* The effects of phonological neighborhood density in childhood word production and recognition in Russian are opposite to English // *Journal of Child Language*. Vol. 47. P. 1244–1262.

### **4.1. Introduction**

Phonological neighborhood density (PND) is one of the significant properties of a word that influences its production and recognition. PND refers to the number of words that can be formed from a given word by substituting, adding or deleting one phoneme. Words with many similar sounding neighbors, such as *mash* (e.g., *smash, ash, cash, mush, mat*), have a dense neighborhood, whereas words with few or no neighbors, such as *fudge* (*judge, fun*), have a sparse neighborhood. Cross-linguistic studies have shown that PND influenced differently word production and recognition depending on a language [Harley & Brown, 1998; Luce & Pisoni, 1998; Vitevitch, 2002; Vitevitch & Luce, 1998, 1999; Vitevitch & Sommers, 2003]. Studies with English- and French-speaking children and adults showed that words with dense neighborhoods were produced faster than words with sparse neighborhoods; at the same time, words with dense neighborhoods were recognized slower than words with sparse neighborhoods [Luce & Pisoni, 1998; Vitevitch, 2002]. The reverse pattern was shown for Spanish-speaking adults: words with dense neighborhoods were produced slower than words with sparse neighborhoods, whereas a dense neighborhood facilitated word recognition [Sadat et al., 2014; Vitevitch, Rodríguez, 2004; Vitevitch, Stamer, 2006]. These cross-linguistic differences in production and recognition were explained by the morphological properties of the languages: words with rich inflectional system have multiple phonological neighbors that are morphologically derived from the word. This can influence on the patterns in production and recognition.

The aim of the present study was to determine how PND influences word production and recognition in 4-to-6-year-old Russian children in comparison to Russian adults. The novelties of the study are following. First, it compares word production and recognition in the same groups of participants: the experimental group, consisting of 4-to-6-year-old Russian children, and the control group of Russian adults. Secondly, our study compares young children and adults using the exact same experimental design and materials. Finally, this is the first study that investigates the facilitatory and inhibitory effects of PND on word production and recognition in young children who speak a highly inflected language.

## 4.2. Method

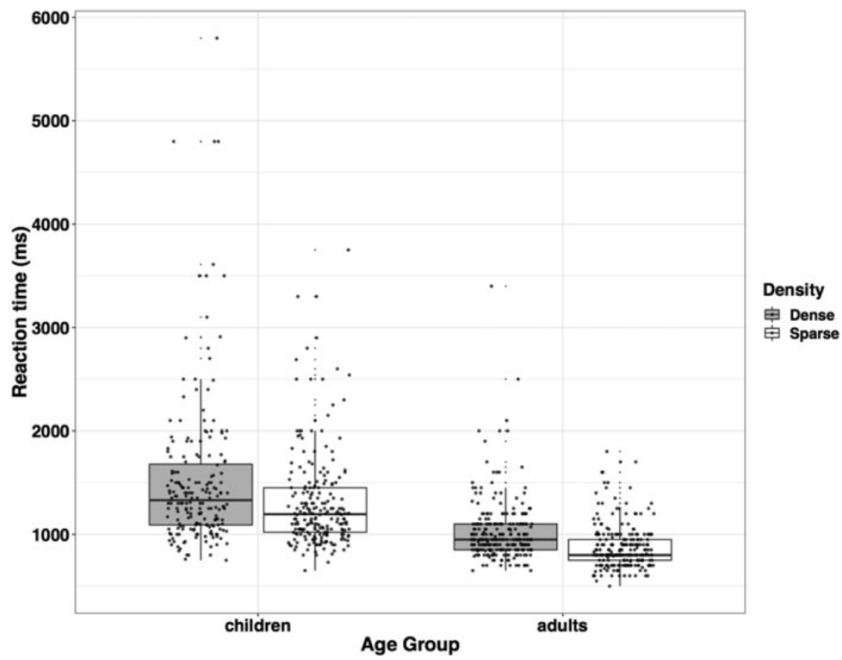
A total of 25 children (10 boys, 15 girls, aged 4 – 6,  $M_{\text{age}} = 4.09$ ;  $SD = 0.8$ ) and 20 adults (13 males, 7 females, aged 19 – 36,  $M_{\text{age}} = 25.02$ ;  $SD = 4.6$ ) participated in the study.

In a word production experiment, we used classical picture-naming task. The stimulus items included 30 pictures, half of them corresponded to words with dense neighborhoods and the other half to words with sparse neighborhoods. All stimulus words were selected from the *Verbs and Nouns Database* and *StimulStat Project* and were acquired before the age 4; the groups of words (high vs. low PND) did not differ in frequency, length, and the age of acquisition. In this task, we recorded reaction time (RT) and of answers in picture naming.

In a word recognition experiment, we used a visual world eye-tracking paradigm with a classical ‘look and listen’ task. As in production experiment, we have selected 30 pictures, half of which corresponded to words with dense neighborhoods and the other half to words with sparse neighborhoods. The groups of words (high vs. low PND) did not differ in frequency, length, and the age of acquisition. The portable SMI RED eye-tracker was used in the study. Each trial started with the presentation of three pictures (one of them corresponded to stimulus word and other two were distractors) for 2000 ms, and the participants were familiarizing themselves with the pictures during this time. Then the stimulus word was played, and the participant has to look at the named picture as fast as possible. We registered the reaction time from the beginning of the stimulus word to the fixation on the picture.

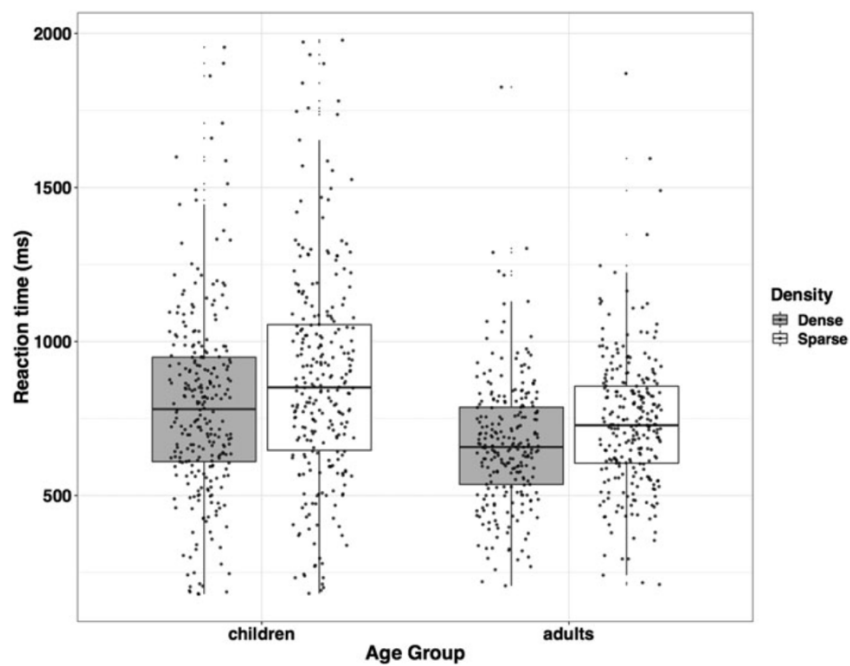
## 4.3. Results

In a word production experiment, in children, there was no significant difference in RT between pictures that corresponded to words with dense versus sparse phonological neighborhoods (Figure 3). At the same time, there was a significant difference in RT between these conditions in adults. We found that the PND effect in word production in Russian-speaking adults is the same as in Spanish-speaking adults: words with dense neighborhoods are produced slower than words with sparse neighborhoods; this pattern is the opposite to word production in English.



**Figure 3.** Mean RT's as a function of PND type and age (ms)

In a word recognition experiment, the results demonstrated that both children and adults recognized pictures corresponding to words with sparse neighborhoods slower than pictures corresponding to words with dense neighborhoods (Figure 4). Therefore, there is a reverse PND effect in word recognition in comparison to word production for Russian adults. Importantly, the pattern in both children and adults was the same as in Spanish-speaking adults and the opposite to English.



**Figure 4.** Mean RT's as a function of PND type and age (ms)



#### **4.4. Conclusion**

The results of the study support the hypothesis that morphological complexity of a language influence the patterns of PND in word production and recognition in children and adults. We found no effect in 4-to-6-year-old Russian children in word production and a large PND effect in word recognition, which means that the PND recognition effect starts to develop in early childhood, and the PND production effect is formed later. Presumably, it is related to vocabulary growth and morphological development in highly inflected languages such as Russian. Indeed, morphology plays a significant role in Russian word production and recognition, and it has been reported that morphological awareness increases when children acquire reading skills [Anglin, 1993; Kornilov et al., 2012].

## 5. Conclusions

The papers included in this dissertation were focused, on the one hand, on language impairment in Russian primary-school-aged children with ASD at different linguistic levels (phonology, vocabulary, morphosyntax, and discourse) and on the expressive and receptive patterns of language functioning in these children. On the other hand, the study investigated phonological mechanisms involved in word production and recognition in pre-school TD children which can be significantly associated with language impairment in ASD.

Chapter 2 described the comprehensive language assessment of children with ASD at different linguistic levels. The study revealed psycholinguistic variables for each language test which significantly influenced accuracy in children with ASD as well as highlighted non-language factors contributing to language functioning in these children. The present work described, for the first time, the language profiles of a representative group of Russian primary-school-aged children with ASD.

In Chapter 3, we investigated the difference between expressive and receptive language domains at the levels of vocabulary, morphosyntax, and discourse in children with ASD. The results showed that expressive and receptive patterns can be different depending on linguistic level. Moreover, non-verbal IQ partly accounted for expressive and receptive patterns in these children.

Chapter 4 presented the psycholinguistic experiment using picture-naming and eye-tracking with visual world paradigm in Russian pre-school TD children and Russian adults. The results showed that phonological neighborhood density differently influenced word production and recognition in young children which further can be used to study children with ASD.

To summarize, the results of the present dissertation described new aspects of language functioning at different linguistic levels in children with ASD as well as highlighted the mechanisms of word production and recognition in TD children and adults.

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