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Language development in rural and urban Russian-speaking children with and without developmental language disorder

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Abstract

Using a newly developed Assessment of the Development of Russian Language (ORRIA), we investigated differences in language development between rural vs. urban Russian-speaking children ($n = 100$ with a mean age of 6.75) subdivided into groups with and without developmental language disorders. Using classical test theory and item response theory approaches, we found that while ORRIA displayed overall satisfactory psychometric properties, several of its items showed differential item functioning favoring rural children, and several others favoring urban children. After the removal of these items, rural children significantly underperformed on ORRIA compared to urban children. The urbanization factor did not significantly interact with language group. We discuss the latter finding in the context of the multiple additive risk factors for language development and emphasize the need for future studies of the mechanisms that underlie these influences and the implications of these findings for our understanding of the etiological architecture of children's language development.

Keywords

Language development; Developmental language disorder; Specific language impairment; Assessment; Differential item functioning; Socio-economic status; Rural

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <http://dx.doi.org/10.1016/j.lindif.2015.07.001>.

1. Introduction

Language development is an efficient and rapid process that, in terms of key milestones, occurs in a relatively uniform fashion for the majority of children. Yet, there exists a substantial variation in children's language development in both typical and atypical developmental contexts (e.g., in the context of developmental language disorders, DLD¹). In the past two decades, the field's understanding of the importance of both the quantity and quality of linguistic input and, in general, of environmental and social and socio-economic contexts for children's language development has replaced the early debate between those who suggested that variation in language input parameters and developmental contexts is irrelevant for language development beyond the presence of “normal” input and those who opposed this idea (Snow, 2014). Gaining a better understanding of both typical and atypical language development thus requires examining it in understudied settings and populations that naturally vary with respect to these factors, such as children reared in rural vs. urban environments and children with DLD.

Characteristics of children's linguistic input and their levels of language development are linked to family socio-economic status (SES) and poverty, as well as their correlates, e.g., parental education and income, access to resources, and quality of child care (Hirsh-Pasek et al., 2015; Hoff, 2003; Roulstone, Law, Rush, & Peters, 2011; Vernon-Feagans & Bratsch-Hines, 2013; Zambrana, Ystrom, & Pons, 2012). For example, the amount of “parentese” speech in one-to-one contexts predicted children's concurrent speech and future lexical development at 24 months (Ramírez-Esparza, García-Sierra, & Kuhl, 2014). Huttenlocher, Vasilyeva, Cymerman, and Levine (2002) also found that 47–59-month-olds' syntactic abilities were linked to the characteristics of paternal and teachers' linguistic input, suggesting that these effects extend beyond lexical knowledge. More recently, Demir, Rowe, Heller, Goldin-Meadow, and Levine (2015) showed that SES predicted both children's language and such input parameter as parental decontextualized talk at 30 months, which in turn predicted children's language across multiple domains in kindergarten. However, most of the research on the effects of SES-related characteristics on children's language development and the characteristics of their linguistic environments has been conducted with typically developing (TD) children in disadvantaged urban communities, while both typical and atypical language development in rural settings have received very little attention.

Rural settings are characterized by geographic isolation, low SES, poverty, and limited access to resources and services (e.g., Brossart et al., 2013). These factors likely exert their effects on children's cognitive and language development via multiple distal and proximal mediational pathways that range from metabolic and neuroendocrine imbalances to lack of medical/educational services to cognitive understimulation related to low-quality parenting practices. For example, limited dietary availability of certain nutrients during pregnancy has been associated with children's poorer language development in rural communities in

¹Although the term most commonly used in the literature to refer to a developmental (rather than acquired) disorder of language development in the absence of obvious explanatory factors is specific language impairment (SLI), we will use the DLD label when referring to this condition with an understanding that it is similar to the categories of expressive and mixed expressive–receptive language disorders in the DSM-IV-TR (American Psychiatric Association, 2001) and the category of language disorder in the DSM-V (American Psychiatric Association, 2013).

Bangladesh (Skröder et al., in press). Limited access to medical resources has been associated with delayed diagnosis of hearing problems in rural Appalachian children in Kentucky, characterized by an increased prevalence of congenital hearing loss (Bush et al., 2014). Delayed identification of congenital hearing problems has, in turn, been associated with poorer language development (Yoshinaga-Itano, Sedey, Coulter, & Mehler, 1998; Kasai, Fukushima, Omori, Sugaya, & Ojima, 2012; for a review, see Pimperton & Kennedy, 2012). Atypical maternal work schedules in African-American families living in rural households were associated with children's lower expressive language outcomes, mediated by maternal engagement and negative work-family spillover (Odom, Vernon-Feagans, & Crouter, 2013). Finally, household disorganization and instability in low-income rural families have been linked to children's poorer expressive and receptive language outcomes (Vernon-Feagans et al., 2012).

The nature of the effects of rural settings on children's language development remains unclear, both in terms of its mechanism(s) and its implications for atypical language development, especially in the light of the recent reports of unusually high rates of delayed language development among the most disadvantaged groups of young children (Law, McBean, & Rush, 2011; Letts, Edwards, Sinka, Schaefer, & Gibbons, 2013), considerably lower SES levels among children diagnosed with DLD (Elbro, Dalby, & Maarbjerg, 2011), and reports of SES-related delays in language development being detectable at as early as 18 months of age (Fernald, Marchman, & Weisleder, 2013).

Children with DLD present an important window into the nature of the variation in children's language development. DLD is a highly familial and heritable neurodevelopmental disorder (Stromswold, 1998; Tomblin, 1989), and it is now widely accepted that it has prominent genetic and neurobiological components. Little is known about the precise characteristics of these components and the mechanisms of their action, despite several intriguing molecular genetic (e.g., Eicher et al., 2013; Nudel et al., 2014) and neuroimaging (e.g., Soriano-Mas et al., 2009; Whalley et al., 2011) findings published in recent years. Perhaps surprisingly, environmental influences on language development in children with DLD have rarely been investigated. Yet, studies that employ multiple populations for the purpose of describing and partitioning inter-individual variation in language development are critical for advancing our understanding of the etiology of DLD and the complex interactions between different sources of variation in typical language development.

The study had two goals. First, given the dearth of research on child language development in Russian (both typical and atypical) and the current absence of published standardized instruments for the assessment of Russian language development (Lebedeva, 2014; Rakhlin et al., 2013) available to clinicians, educators, and researchers, we first aimed at using the sample data to obtain preliminary psychometric data on a new assessment of Russian language development (ORRIA). Correspondingly, we conducted a set of psychometric analyses aimed at 1) providing evidence for the reliability of the indicators of Russian language development obtained using the ORRIA assessment, and 2) evaluating ORRIA's items for the presence of content bias (also called differential item functioning or

DIF), which could locally favor urban children and therefore distort the pattern of results of group comparisons.

The second goal of the study was to examine the roles of urbanization (rural vs. urban children), language group (TD children vs. children with DLD), and the interaction between these factors in children's language development. We expected children with DLD to significantly underperform compared to TD children, and rural children to underperform relative to urban children.² We explicitly examined the interaction between these two factors, envisioning three possible outcome scenarios. Under the multiplicative risk factors scenario, we expected to find a significant interaction between urbanization and language status, manifesting in a disproportionately large decrease in language performance in TD vs. DLD children in the rural setting compared to urban setting. Alternatively, under the additive risk factors scenario, we expected children from rural settings to show overall lower language development levels compared to urban children, and both groups of children with DLD to show similar decreases in language performance compared to their rural and rural TD peers, with no interactions between urbanization and language group. Finally, under the overlapping restricted variability scenario, we speculated that if the amount of “free” variation in children's language performance is limited (and in the case of clinically significant language problems is already accounted for by as yet unspecified DLD-specific factors), we would also see a significant interaction between language group and urbanization, resulting in a smaller TD vs. DLD performance gap in the rural setting compared to urban setting.

2. Materials and methods

2.1. Participants

A total of one hundred children in the age range from 4.17 to 8.75 years ($M = 6.75$, $SD = .27$; 56 boys and 44 girls) participated in the study. Participants were sampled from two different locales (rural and urban; see below), for a total of four groups ($n = 25$ each), following a 2 (rural vs. urban) $\times 2$ (TD vs. DLD) design.

2.1.1. Urban typically developing children and children with developmental disorders of language—TD children ($n = 25$) in the urban group were recruited through local kindergartens and primary schools in a large metropolis located in the Central Federal District of the Russian Federation. All children were nominated by teachers as having no apparent problems with speech, language, and literacy.

Urban children with DLD ($n = 25$) were recruited from speech- and language services groups at the metropolis's centers for psychological, medical, and social services. Although speech

²Recent studies also suggest that there is a significant discrepancy between rural and urban poverty in the so-called “transition countries” in general and Russia in particular (Macours & Swinnen, 2008), with an almost two-fold increase in poverty rates among rural areas compared to urban areas. In its current wording, the current hypothesis that urban children will outperform rural children relies on the assumption of significant differences between the urban and rural settings in Russia on a variety of environmental variables favoring the urban settings with respect to the resources and stimulation they provide. We would like to recognize that this places emphasis on the between-group comparisons rather than the examination of, for example, factors specific to urban poverty. Note, however, that in Russia poverty is largely a rural phenomenon (Gerry, Nivorozhkin, & Rigg, 2008), and, thus, it is specifically urban vs. rural comparisons that are likely to be sensitive with respect to detecting environmental influences on child language development.

sound disorder (SSD), SLI, and DLD are not used as diagnostic categories in Russia, a set of diagnostic labels similar to these is used to identify children with special needs in the areas of speech and language. These labels include Delayed Speech Development (DSD; задержка речевого развития or ЗРР), General Underdevelopment of Speech and Language (GUSL; общенееоразвитие речи or ОНР), Phonetic–Phonemic Underdevelopment (PU; фонемико-фонематическое недоразвитие or ФФН), and [Developmental] Alalia (DA, алалия). Children were classified as DLD if their medical records indicated the presence of any of these diagnoses based on the results of a clinical evaluation by a psychological–medical–educational committee.

2.1.2. Rural typically developing children and children with developmental disorders of language—TD children (n=25) in the rural group were recruited through local kindergartens and primary schools in two villages located in the North-Western Federal District of the Russian Federation and were nominated by their teachers as having no apparent speech, language, and literacy problems. The majority of these children (n = 21) were additionally classified as TD using the Russian narrative task, a standardized elicited speech and language assessment protocol described in detail elsewhere (Rakhlin et al., 2013). Briefly, the protocol relies on the analysis of speech samples elicited using wordless storybooks according to a coding scheme that produces several expressive language measures (i.e., phonetic/prosodic development, wellformedness, number of complex structures, mean length of utterance, number of semantic/pragmatic errors, and lexical richness) in the domains of articulatory phonology, lexical, grammatical, and semantic/pragmatic language development. A child was considered TD if she demonstrated age- and narrative length-adjusted Z scores above –1 relative to the mean of the larger sample described elsewhere on all six measures (Rakhlin et al., 2013).

Children with DLD in the rural group were previously identified as DLD using the narrative task described above for the purpose of an epidemiological study of genetic bases of DLD (Rakhlin et al., 2013). They were classified as DLD if they showed low (i.e., a Z score of below –1) performance on at least two out of six expressive language measures. Note that, unlike for urban children, instead of using formal diagnostic information obtained through medical or educational records, we had to rely on our own formal classification approach because diagnostic (as well as treatment) services for children with special needs in Russia are limited in general (Pervova, 1998) and virtually absent in most rural settings.

The two locales we sampled from roughly represent the two ends of the SES continuum in Russia and differ on a number of SES-related indices, summarized in Table 1. The differences are most marked with respect to average monthly income (\$1126 vs. \$649) and official unemployment rates (1.8% vs. 7%). Taken together, the indices presented in Table 1 demonstrate a significant SES advantage of the urban compared to the rural locale.

Although nonverbal intelligence scores were unavailable for most children in the sample, no children were diagnosed with intellectual disability. Children identified as DLD satisfied a set of exclusionary criteria typically applied to such samples, including the absence of frank sensory or neurological impairment, known genomic disorders, or the diagnosis of Autism Spectrum Disorder (ASD; based on the analysis of medical records). The children in the four

groups (urban TD, urban DLD, rural TD, and rural DLD) were individually matched to each other on age and sex as closely as possible (both p 's > .05; see Supplemental Information for descriptive statistics).

2.1.3. Assessment of the Development of Russian Language—All children were administered the Assessment of the Development of Russian Language (ORRIA; Babyonyshev et al., unpublished assessment; Kornilov, Rakhlin, & Grigorenko, 2012), a standardized Russian language development test comparable to the Clinical Evaluation of Language Fundamentals (Semel, Wiig, & Secord, 1995), and the Test of Language Development (Newcomer & Hammill, 1982). ORRIA consists of 7 subtests aimed at assessing language development in the areas of morphology, syntax, semantics, and lexicon, both in comprehension and production in children aged 3 to 9 years, as well as phonological awareness in children aged 5 to 9.

We administered five ORRIA subtests to the participants in this study: 1) Receptive Vocabulary is a standard three-choice picture-pointing task that consists of 31 items that tap into children's basic as well as more advanced vocabulary across different parts of speech and semantic categories; 2) Expressive Vocabulary is a picture naming task that evaluates children's lexical knowledge in the domain of production using 22 pictures with responses rated using a partial credit scale; 3) Linguistic Operators is a picture-pointing task that consists of 28 items aimed at the evaluation of children's semantic knowledge of temporal and logical operators in comprehension of complex sentences; 4) Sentence Structure is a 24-item three-choice picture-pointing task designed to assess children's grammatical knowledge in comprehension of different simple and complex sentence structures (e.g., relative clauses, passives, conjoint clauses using “but”); 5) Word Structure is a sentence completion task that was designed to assess children's morphosyntactic competence in production and includes 24 items that target inflectional morphology related to pronouns, nouns, and their modifiers, and verbs, as well as derivational morphology. The items as well as scoring rubrics for ORRIA subtests were designed to reduce the effects of (minimal in modern standard Russian) dialectal variation on children's performance.

All children were administered ORRIA by test administrators blind to child's language status and scored offline. The study protocol was approved by the Yale Institutional Review Board and the proper authorities in Russia, depending on the data collection site; informed consent was obtained from parents, and oral assent from children at the time of data collection.

3. Results

3.1. Psychometric properties of ORRIA subtests and differential item functioning

To evaluate the psychometric properties of ORRIA, we conducted several analyses within the classical test theory (CTT) as well as item response theory (IRT) approaches. First, we calculated reliability coefficients for ORRIA subtests using Cronbach's α coefficient of internal consistency, with all subtests demonstrating satisfactory levels of reliability: $\alpha = .81$ for Receptive Vocabulary, $\alpha = .85$ for Expressive Vocabulary, $\alpha = .92$ for Linguistic Operators, $\alpha = .80$ for Sentence Structure, and $\alpha = .76$ for Word Structure.

Second, ORRIA scores were analyzed using a set of unidimensional Rasch IRT measurement models as implemented in FACETS (Linacre, 2009), aimed at revealing the differential item functioning (DIF) of items that differentiate urban and rural children while controlling for overall language development differences, and arriving at a “pure” set of items for further analyses. Responses were analyzed for all ORRIA items simultaneously (using a combination of rating scales for dichotomous and partial credit items); person and item parameters were estimated iteratively using the joint maximum likelihood algorithm. The fit of the unidimensional model was good, with 47.26% of variation in ORRIA performance patterns explained by Rasch measures, and the reliability of the composite ORRIA index was high (so-called person separation reliability index = .94). Separation (strata parameter) was estimated at 5.47, indicating that the composite ORRIA model is capable of statistically distinguishing between at least five different levels (i.e., from very low to very high) of performance.

DIF analysis was based on the evaluation of the invariance of item difficulty parameters in rural vs. urban children within the same model, and utilized the omnibus test for the presence of DIF items as well as the t criterion to test each item $\times$ urbanization interaction parameter separately. The computation of DIF interactions is a two-staged process; at the first step, the measures for all model elements and the structure of the rating scale are estimated (calibrated) and fixed; at the second step, the expected values for observations are subtracted from observed values, and residuals corresponding to each interaction term are integrated and transformed into a DIF (item bias) estimate. The DIF parameters are then evaluated for statistical significance using the t -statistic, and their overall impact is evaluated by the omnibus test for the presence of DIF items and % of variance attributable to DIF items that favor one group of children over another given fixed language ability estimates.

The overall test for the presence of DIF items (under the null hypothesis that all bias terms = 0, indicating no DIF) was significant, $\chi^2(256)=442.2$, $p < .01$, and urbanization-related DIF items accounted for approximately 3.18% of the variance in children's performance. Using univariate DIF tests, we found that out of 132 ORRIA items, 22 items displayed significant ($p < .05$) differential item functioning (2 in Receptive Vocabulary, 8 in Expressive Vocabulary, 6 in Linguistic Operators, 3 in Sentence Structure, and 3 in Word Structure; see Fig. 1).

Out of 22 items, twelve favored rural children with six items from the Linguistic Operators, five items from the Expressive Vocabulary, and one item from the Word Structure subtests. Our informal analysis of the content of item wordings and accompanying drawings suggested that they represented objects and actions that might indeed be more familiar to rural children (e.g., a hammer or an old lady knitting). Although it is more difficult to explain why rural children would perform better than expected on several Linguistic Operators items, it is likely that the DIF items in this subtest reflect the differential familiarity of rural children with farm (e.g., cow) and wild (e.g., fox) animals, that may have reduced the burden of processing complex sentences with multiple operators (e.g., “Before you point to the first small animal, point to the dog next to the fox and the large cow”).

The ten items that favored urban children included three items from the Expressive Vocabulary, three items from the Receptive Vocabulary, three items from the Sentence Structure, and one item from the Word Structure subtests. Item content analyses revealed that the majority of these items included lexical items that could be less familiar to children reared in a rural environment (e.g., a ruler, a juggler); for other items, the likely culprit was in the drawings (e.g., in the Word Structure item, the child is asked to complete the sentence “This building is tall, and this one is even... (taller)” while looking at a picture of two multi-story urban buildings).

We removed 22 DIF items from the dataset and repeated the analyses to confirm that modifications did not adversely affect subtest internal consistency or decrease ORRIA's measurement properties overall, and to examine DIF with respect to language group. These analyses revealed that the decrease in internal consistency was minimal for all subtests, with the final reliabilities estimated at $\alpha = .80$ for Receptive Vocabulary ($k = 20$), $\alpha = .78$ for Expressive Vocabulary ($k = 15$), $\alpha = .90$ for Linguistic Operators ($k = 22$), $\alpha = .77$ for Sentence Structure ($k=21$), and $\alpha = .73$ for Word Structure ($k=21$). The Rasch measurements accounted for 45.46% of variance in children's performance, with person reliability estimated at .93 and strata separation index at 5.28. Further analyses found no evidence of significant DIF related to urbanization, $\chi^2(212) = 170.4$, $p = .98$, language group status, $\chi^2(212)=139.3$, $p=1.00$, or the interaction between the two factors, $\chi^2(424) = 394.7$, $p = .84$.

Thus, preliminarily, ORRIA has satisfactory psychometric properties when applied to our mixed sample of Russian-speaking children aged 4 to 9. We also showed that language development assessment is susceptible to DIF that can nevertheless be remediated by removing items that show significant DIF, albeit not blindly. Next, we asked whether rural and urban children with and without DLD differ in their average levels of language development as measured by this “pure” set of ORRIA items.

3.2. Language development in rural and urban children with and without DLD

Developmental and clinical populations are frequently characterized by the presence of a large amount of variation and outliers, especially pronounced when data are collected from multiple populations. Thus, to investigate the associations between children's language development and rural vs. urban settings and language status variables, we used a linear regression approach with robust parameter estimators as implemented in the *lmrob* function in the *R* package *robustbase* v. 0.92–2 (Rousseeuw et al., 2014). Robust methods are a class of iterative regression parameter estimation methods that minimize the effects of influential data points (e.g., outliers and high-leverage observations) compared to traditional generalized linear model approaches with maximum likelihood (e.g., OLS) estimators. We used robust regression with the SMDM estimator and parameter settings recommended by Koller and Stahel (2011).

We ran six separate regressions using *Z*-transformed language development scores for the ORRIA composite (ability estimate from the Rasch model that included the full set of “pure” ORRIA items) and its five subtests (models fitted separately) as dependent variables. Mean-centered age and dummy-coded sex (i.e., girl = 0, boy = 1) variables were entered in the models first to adjust for demographic variables. Urbanization and language group were

also dummy-coded (i.e. urban=0, rural=1; TD=0, DLD=1) and entered in the next step, producing the baseline model. We then entered the urbanization $\times$ language group interaction term in the model, and compared the fit of the baseline and the interaction models using the robust Wald test (corrected for multiple testing using the Bonferroni procedure). The same approach was used to examine the effects of the set interactions between sex $\times$ urbanization $\times$ language group. Fig. 2 shows mean performance of each group of children on the ORRIA composite and its subtests; parameter estimates for the linear models are presented in the online supplementary data.

Demographics accounted for 17.3% of variance in children's performance on ORRIA overall (Sex Est. = .39, SE = .20, p = .0558; Age Est. = .35, SE = .09, p = .0003). Urbanization and language group together accounted for additional 13.2% of variance, significantly improving model fit (Wald(2) = 17.96, p = .0007): rural children (Est. = -.45, SE = .18, p = .0135) significantly underperformed compared to urban children, and children with DLD underperformed (Est = -.61, SE = .18, p = .0010) compared to TD children. The addition of urbanization $\times$ language group interaction did not improve model fit, Wald(1) = .47, p = 1.00; Est. = -.24, SE = .35, p = .4927, and neither did the addition of sex $\times$ urbanization $\times$ language group interaction term, Wald(3) = 9.01, p = .1746.

Demographics accounted for 13% of variance in children's performance on Receptive Vocabulary (Sex Est. = .37, SE = .19, p = .0550; Age Est. = .28, SE = .09, p = .0020). Urbanization and language group accounted for an additional 14% of variance, Wald(2) = 21.57, df = 2, p = .0001. Again, rural children (Est. = -.66, SE = .17, p = .0002) significantly underperformed compared to urban children, and children with DLD underperformed (Est = -.42, SE = .17, p = .0144) compared to TD children. The addition of urbanization $\times$ language group interaction did not improve model fit, Wald(1) = .00, df = 1, p = 1.00; Est. = -.0002, SE = .33, p = .9994, and neither did the addition of sex $\times$ urbanization $\times$ language group interactions, Wald = 4.61, df = 3, p = 1.00. A similar pattern of results was obtained for Expressive Vocabulary with demographics accounting for 19.4% of the variance (Sex Est. = .40, SE = .18, p = .0274; Age Est. = .34, SE = .08, p = .00008). An additional 9.6%, Wald(2) = 14.87, p = .0036, were explained by urbanization (Est = -.43, SE = .16, p = .0089) and language group (Est = -.45, SE = .16, p = .0067) variables, with the same direction of effects. The addition of the urbanization $\times$ language group interaction term did not improve model fit, Wald(1) = 1.68, p = 1.00; Est. = -.42, SE = .32, p = .1983, and neither did the addition of sex $\times$ urbanization $\times$ language group interactions, Wald(3) = 6.93, p = .4452.

For Linguistic Operators, demographics explained 8.3% of variance in performance (Sex Est. = .39, SE = .19, p = .0450; Age Est. = .19, SE = .09, p = .0314). Neither urbanization (Est. = .01, SE = .19, p = .9553) nor language group (Est. = -.18, SE = .19, p = .3417) were significantly related to children's performance, and the addition of these variables in the model did not improve its fit (Wald(2) = .92, p = 1.00). Urbanization $\times$ language group $\times$ sex interactions also did not improve model fit, Wald (3) statistic = 5.92, df = 3, p = .6924; for urbanization $\times$ language group interaction, Est. = .45, SE = .57, p = .4256. A similar pattern of results was observed for Word Structure, with demographic variables explaining 11.1% of the variance (Sex Est. = .13, SE = .18, p = .4738; Age Est. = .31, SE = .09, p = .0006).

Again, neither urbanization (Est. = $-.09$, $SE = .18$, $p = .6273$) nor language group (Est. = $-.18$, $SE = .19$, $p = .3314$) was significantly related to children's performance, and the addition of these variables to the model did not improve its fit, Wald(2) = 1.17, df = 2, $p = 1.00$. As was the case for Linguistic Operators, we did not obtain evidence for significant urbanization $\times$ language group, Wald(1) = .00, df = 1, $p = 1.00$; Est. = .01, $SE = .37$, $p = .9788$, or urbanization $\times$ language group $\times$ sex interactions, Wald(3) = 6.04, $p = .6576$.

We found a slightly different pattern of results for the second grammatical ORRIA subtest, Sentence Structure. Demographics accounted for 10% of variance (Sex Est. = .02, $SE = .20$, $p = .9162$; Age Est. = .32, $SE = .09$, $p = .0008$). Urbanization and language group accounted for an additional 5.9% of variance, significantly improving the model fit, Wald(2) = 9.84, $p = .0439$: rural children (Est. = $-.45$, $SE = .19$, $p = .0228$) significantly underperformed compared to urban children, and children with DLD underperformed (Est. = $-.41$, $SE = .19$, $p = .0342$) compared to TD children. The addition of urbanization $\times$ language group interaction did not improve model fit; Wald(1) = .37, $p = 1.00$; (Est. = $-.23$, $SE = .38$, $p = .5464$). However, model fit significantly improved with the addition of interactions of study variables with children's sex, Wald(3) statistic = 15.06, $p = .0106$, likely driven by a significant interaction of sex $\times$ urbanization (Est. = 1.59, $SE = .51$, $p = .0025$) and a trend for the interaction between sex $\times$ language group (Est. = .88, $SE = .51$, $p = .0889$), accounting for an additional 10% of variance. The size and direction of the regression coefficient estimate for the interaction between sex and urbanization and sex and language group indicated that both urbanization and language status had a larger effect on girls' performance than on boys' performance. Visual examination of boys' and girls' performance on this subtest (see Supplemental Information) also suggests that this effect might be driven by 1) typically developing urban girls' overall high (compared to other groups of children) scores on the subtest; and/or 2) the presence of language group and urbanization effects in the sample of girls but not boys for this particular subtest.

Thus, we found that even in the absence of individual DIF items, children from a rural locale underperformed compared to urban children on three out of five ORRIA subtests and its composite. The differences were most pronounced for subtests that tapped into lexical development (Receptive and Expressive Vocabulary), and approached in magnitude the differences between the performance of TD children and children with DLD. Interestingly, we did not find statistically significant interactions between language group and urbanization, suggesting that the effects of these two factors are additive rather than multiplicative, i.e., the performance gap between TD and DLD children was similar in the rural vs. urban sample. We also found a sex-specific pattern of group differences with respect to children's performance on Sentence Structure: while urban and rural boys with and without DLD showed similar levels of sentence comprehension, girls showed an uneven profile of performance resembling that found for other ORRIA subtests for the combined sample of boys and girls (with significant effects of both urbanization and language group).

4. Discussion

The study reported here had two aims. First, we obtained preliminary psychometric evidence for the satisfactory reliability, as well as evidence for the construct validity of the new

Assessment of the Development of Russian Language (ORRIA). We showed that five ORRIA subtests that tap into children's lexical and grammatical development in the domains of comprehension and production had high internal consistency in our sample. We also found that some ORRIA items showed DIF likely attributable to the differential exposure of rural vs. urban children to certain lexical items and visual objects. The elimination of this limited set of DIF items resulted in a “pure” set of items that did not show evidence of bias with respect to the factors of urbanization and language group. Given the sample size of this study, these results should be treated as preliminary, warranting further psychometric investigation of ORRIA's item and subtest content, as well as the overall assessment structure. To the best of our knowledge, the data reported in this manuscript are the first psychometric data on a language development assessment in Russian.

Second, we examined the contributions of urbanization and language group, as well as their interaction, to children's language development as measured by this new assessment. Expectedly, children with DLD showed lower levels of performance on three out of five ORRIA subtests used in this study, Receptive Vocabulary, Expressive Vocabulary, and Sentence Structure, as well as the composite ORRIA score. These results align well with reports of smaller vocabularies and impaired sentence comprehension performance of children with DLD compared to that of their TD peers (e.g., Brackenbury & Pye, 2005; Montgomery & Evans, 2009).

We also found a significant effect of urbanization on children's language performance on the same ORRIA subtests, as well as ORRIA's composite score. Effect size estimates obtained in this study were moderate to large and in fact similar for language group and urbanization variables. However, we did not find significant language group $\times$ urbanization interactions for any of the ORRIA subtests: children with DLD underperformed (compared to TD children) to a similar extent in the rural vs. the urban setting. Rural TD children showed language development levels in-between those of urban children with and without DLD or, as was the case for Receptive Vocabulary, actually showed levels of performance nearly identical to those of urban children identified as DLD (see Fig. 2). Correspondingly, rural children with DLD were the poorest performers on lexical and sentence comprehension subtests, as well as the composite ORRIA score. According to this pattern of results, the influence of risk factors behind the clinically significant variation in children's language and behind the depressed language performance in rural compared to urban children is additive rather than multiplicative in nature (thereby suggesting relative independence of pathways and mechanisms through which these risk factors operate). These results corroborate recent reports of significant effects of low SES on children's language development (e.g., Fernald et al., 2013; Hirsh-Pasek et al., 2015; Law et al., 2011; Letts et al., 2013) and offer a potential explanation for the increased prevalence of language difficulties among low SES populations.

It is intriguing that similar levels of performance were observed for children who were identified as having clinically significant developmental language difficulties (i.e., urban children with DLD) and those who were nominated by their teachers as having no apparent developmental language-related problems (i.e., rural TD children). Whether such phenotypic similarity is mirrored at the level of the neurobiological systems that support language

development and functioning or at the level of prospective language and literacy outcomes is currently unknown, but intriguing given 1) the speculated risk factors' additivity referred to above; 2) the reported significant associations between SES and early brain and cognitive development (e.g., reviewed in Hackman & Farah, 2009); and 3) the methodological problems with identifying children with DLD in rural vs. urban settings.

For Sentence Structure, the effect seemed to be sex-specific — i.e., this subtest differentiated between urban vs. rural and TD vs. DLD girls but not boys (with girls also showing higher performance overall and boys showing a flat performance profile). Interestingly, urban TD girls were the best performers on this subtest, with the lowest scores seen for rural DLD girls. The first finding maps onto reports of higher early language development levels among girls compared to boys, in particular in the domain of comprehension (Eriksson et al., 2012; Zambrana et al., 2012), which could manifest in our data for the “least disadvantaged” group of TD girls reared in cognitively stimulating urban settings. The second finding is more difficult to explain in the context of reports of increased prevalence of DLD among boys compared to girls (Shriberg, Tomblin, & McSweeney, 1999; Tomblin et al., 1997). However, it is possible that it reflects the sex specificity of the etiological mechanisms underlying the manifestation of DLD, as has, for example, been suggested for other communication and learning disorders (e.g., Evans, Flowers, Napoliello, & Eden, 2014; Suresh et al., 2006).

Our study focused on the comparisons of (a) typical language development in children that live in rural vs. urban settings, and this variable was used as a proxy for a potentially large set of mechanisms and factors that affect early development. To the extent that living in a rural locale indeed has a negative effect on language development, we can speculate that this effect is at least partially realized through SES-related factors such as parental education and income, parenting practices, quality of early child care (e.g., NICHD Early Child Care Research Network, 2006), and the characteristics of the child's communicative environment (e.g., parental linguistic behavior and quality of early parent–child communication; Hirsh-Pasek et al., 2015). Future studies can focus on these mechanisms by investigating individual-level SES predictors of language development in typical as well as atypical language groups, and by investigating the moderating role of rural vs. urban settings on the patterns of relationship between language and SES, as well as investigating the mediating role of linguistic input. This would enhance our understanding of the role of environment in language development through the lens of urban poverty (currently understudied in transition countries) and individual differences in SES.

Note that in our study, rural and urban children with DLD were identified using different methods. As pointed out by an anonymous reviewer, the urban DLD group included children whose diagnoses suggest a combination of expressive and receptive language difficulties, while rural children with DLD were classified as such based on expressive measures solely. We would like to note the potential differences in subtypes are unlikely to have affected the results as: a) evidence for identifiable DLD subtypes is mixed at best (e.g., Lancaster, 2015) and would in this case favor the rural group that was identified using expressive measures, b) children with DLD in the rural group come from a population where affected individuals also present with substantial receptive language development and processing deficits (e.g.,

Kornilov, Magnuson, Rakhlin, Landi, & Grigorenko, 2015; Rakhlin, Kornilov, & Grigorenko, 2014). Further studies might benefit from a unified phenotyping approach (e.g., by using DIF-free normed ORRIA scores to identify DLD after the norming is complete).

Overall, our study demonstrated that Russian-speaking rural children significantly underperformed (compared to urban children) on measures of lexical, grammatical, and the composite measure of general language development, and that the corresponding depression of language scores had an additive (negative) effect on the performance of rural children with DLD. Future studies should directly examine variables proximal to the potential mechanisms behind the effects of urbanization on children's language development at the individual level and in a set of communities characterized by varying levels of urbanization. Such studies are critical for advancing our understanding of the etiology of typical and atypical variation in language development and their inter-relationships.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Fig. 1.

Item characteristics for five ORRIA subtests. Average Score — group average performance on each item with the scale ranging from 0 to 1 for dichotomous items (all subtests but Expressive Vocabulary) and 0 to 2 for partial credit items (Expressive Vocabulary). Item difficulty — IRT (Rasch) estimates of item difficulty in logit units. T-to-overall ratio — measure of item bias (differential item functioning) in the context of rural vs. urban children's performance comparisons with values above and below ± 1.96 indicating significant DIF.

Fig. 2.

Mean performance of four groups of children on the ORRIA composite and its five subtests (with standard errors). DLD — Developmental Language Disorder, TD — typically developing. ORRIA scores were calculated using the IRT (Rasch) approach and converted into standard Z scores using the combined sample's ($n = 100$) M and SD after the DIF items were excluded.

Table 1

Socio-economic characteristics of the two study locales.

	Rural	Urban
Total population (individuals)	20,161	11,382,000
Number of libraries	22	440
Number of museums	1	61
Number of educational institutions for children with disabilities	1	80
Average unemployment rate (%)	7	1.8
Average monthly income (USD per person)	649	1126
% Individuals with income below minimal living wage	14	10
% Households with Internet access ^a	44.9	71.9
Average annual amount of consumed meat products (kg/year) ^a	77	87
Number of medical doctors	33	89,700
Number of other medical personnel	196	114,700
Number of municipal educational units	19	3933
Number objects of industrial objects that are significant pollutants	19	27,127
Environmental safety expenses (total USD)	13,418	20,844,482

Note. For the rural population, statistics were taken for the administrative district (“raion”). For the urban populations, statistics were taken for the metropolis. Statistics were obtained using publicly available databases (e.g., the Federal State Statistics Service, <http://www.gks.ru>) for year 2010 or the closest year when 2010 information was not available.

^aFor the rural population, the data were only available for the larger administrative division (“oblast”).