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Acquisition of nominal morphophonological alternations in Russian

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Abstract

Morphophonological alternations can make target-like production of grammatical morphemes challenging due to changes in form depending on the phonological environment. This article explores the acquisition of morphophonological alternations involving the interacting patterns of vowel deletion and stress shift in Russian-speaking children (aged 4;0–7;11) using a 'wug' test with real and nonce words. Depending on the phonological context, participants were expected to either delete vowels (e.g. *ko'mok*$_{Nom,sg}$ – *kom'ka*$_{Gen,sg}$) or preserve them (e.g. *pʲi´lot*$_{Nom,sg}$ – *pʲi´lota*$_{Gen,sg}$). The results showed that children's sensitivity to morphophonological patterns increases with age: 4-year-olds tended to preserve underlying vowels and stress across conditions, whereas older children demonstrated growing accuracy, at least with real words. Stressed vowels were more appropriately alternated and preserved across conditions, suggesting suprasegmental effects on the acquisition of segmental alternation patterns in Russian.

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Introduction

From their first day of exposure to a linguistic environment, infants start extracting and storing in memory the general patterns they hear. As with any type of learning, this process follows a natural path reflected in children's developmental milestones: from simpler and more systematic regularities (e.g. native/non-native phonemes, intonation patterns, first words) to more complex and abstract (e.g. grammatical morphemes and syntactic patterns). One of the puzzling questions is whether even the most complex patterns can be generalised. If so, at what age do children become sensitive to these regularities and show adult-like behaviour? If not, what are the cognitive limitations for this 'pattern extraction ability', i.e. which patterns are generalisable to new words and which are lexicalised?

The problem that we address in this article is how children learn the complex morphophonology of Russian. In particular, we study morphophonological processes of case formation involving interactions between vowel deletion and stress. Some of these mophophonological processes are both rare and complex. We show that once these patterns are applied in familiar words, they take much longer to be generalised to nonce words, and are often lexically restricted even for adults.

Acquisition of morphophonology

Morphophonological alternations are changes in sounds that take place at morphological boundaries. For example, English 3rd person singular is realised as [s] when it appears after a voiceless consonant (e.g. *She si**t***[s̲]), as [z̲] after a voiced consonant (e.g. *She no**d***[z]), and as [əz] following a sibilant (e.g. *She dre**ss***[ə̲z̲]). Morphophonological alternations can also be observed in lexical stems, as in the case with Dutch final devoicing $[\text{bɛ}\underline{\text{t}}]_{\text{Nom,sg}}$ – $[\text{bɛ}\underline{\text{d}}\text{ə}]_{\text{Nom,pl}}$ 'bed'.

Learning morphophonological alternations thus requires knowledge about both the phonology and morphology of a language, which may explain why mastering these patterns often occurs *after* some of these grammatical morphemes start appearing in spontaneous speech. For example, it has been shown that English-speaking children start producing syllabic allomorphs which add an unstressed syllable to the stem (e.g. *dress*[ə̲z̲]), later than allomorphs which add only a consonant (e.g. *cat*[s̲], *dog*[z̲]) (Berko, 1958; Brown, 1973). Similarly, young Spanish-speaking children often overgeneralise allomorphs consisting of a segment, producing them in place of syllabic allomorphs (e.g. *papel<u>es</u>* 'papers' and *camion<u>es</u>* 'trucks' are produced as **papel<u>s</u>* and **camion<u>s</u>*) (Kernan & Blount, 1966).

Several recent studies have reported similar findings based on experimental data from English, Dutch and German (Kager, van der Feest, Fikkert, Kerkhoff & Zamuner, 2007; Kerkhoff, 2003, 2007; Mealings, Cox, & Demuth, 2013; Tomas, Demuth, & Petocz, 2017;

Tomas, Demuth, Smith-Lock, & Petocz, 2015; van de Vijver & Baer-Henney, 2011, 2012, 2013; Zamuner & Johnson, 2011; Zamuner, Kerkhoff, & Fikkert, 2011), demonstrating the protracted acquisition of certain allomorphs of a morpheme. The main reason for this protracted acquisition of some allomorphs is believed to be their much *lower frequency* in child-directed speech (Brown, 1973; Jolly & Plunkett, 2008; Tomas et al., 2015, 2017).

It has also been shown that children's ability to *generalise* morphophonological patterns to new/nonce words does not fully develop until around the age of 5 or 6 (Kerkhoff, 2007; Tomas et al., 2017; Zamuner et al., 2011). This is the case even for phonologically regular patterns such as final devoicing in Dutch (e.g. [bɛt̲]$_{\text{Nom,sg}}$ – [bɛd̲ə]$_{\text{Nom,pl}}$ 'bed') or the use of syllabic [əz] in English. Importantly, these studies have explored the acquisition of *highly predictable* (i.e. systematic and regular) morphophonological patterns. However, little is known about how and when more complex morphophonological alternations, like those found in Russian, are learned.

Morphophonological alternations and their acquisition in Russian

Due to the complex case system of Russian, children at the age of 2;6 still often add incorrect inflections to noun stems, using inflections from other declension classes, omitting obligatory prepositions and violating morphophonological constraints. These children are typically able, however, to choose the appropriate case for a given syntactic function (e.g. children are unlikely to mark Instrumental with Accusative case ending), suggesting early sensitivity to some aspects of case information. Even at the age of 3;0–3;6 knowledge about declension paradigms is still rudimentary, with adult-like consistency in the correct use of most case markers reached only around 6–7 years, around the time children start attending school (Ceytlin, 2000, p. 98).

Although the acquisition of the Russian case system has long been a focus of research (Ceytlin, 2000, 2006; Gagarina & Voeikova, 2009; Gvozdev, 1949; Ionova, 2007; Lepskaya, 1997; Ufimtseva, 1979, 1981; Voeikova, 2015), these works mainly explored how children acquire the semantic and syntactic functions of different case markers. However, little is known about how children learn to use these grammatical morphemes when stem sounds alternate, which is often the case in Russian.

The patterns of morphological alternation are complex due to the joint effects of suprasegmental and segmental alternations. The former are associated with the position of stress, which can shift within the word paradigm (e.g. *'do̲m*$_{Nom,sg}$ – *'do̲ma*$_{Gen,sg}$ – *do'ma̲*$_{Nom,pl}$ 'house') and across related words (e.g. *'do̲m – do'mašnʲij* 'home'– 'homely/domestic') (Švedova, 1980). Segmental alternations include changes such as vowel–ø alternations (e.g. *lo̲b*$_{Nom,sg}$ – *lba*$_{Gen,sg}$ 'forehead') and the historic palatalisation of consonants (e.g. *drug*$_{Nom,sg}$ – *druz̲ʲ'ja*$_{Nom,pl}$ 'friend'), both of which result from diachronic processes. These alternations are mostly fossilised, being largely restricted to existing stems. However, they can occasionally be found in new words, where they occur with productive derivational morphology. For example, in the word *ka'to̲k*$_{Nom,sg}$ – *ka'tka*$_{Gen,sg}$ 'skating rink', *kat-* is a root, meaning 'skating', and the yer-containing morpheme *-ok* is a productive suffix meaning 'a place where the action takes place'. However, the majority of these vowel–ø alternations are lexicalised and are therefore difficult to predict, unless they occur in these high-frequency productive morphemes.

Stress patterns in Russian

Russian is a language with variable stress, i.e. it can fall on any syllable. Importantly, the position of stress is also not fixed throughout the word paradigm, so that the various case forms may have different stressed syllables, as in (1). However, in most Russian nouns the stress remains on the same syllable across all case forms, as in (2) (Švedova, 1980).

(1) *'tom*$_{Nom,sg}$ – *'toma*$_{Gen,sg}$ – *to'ma*$_{Nom,pl}$ – *to'mov*$_{Gen,pl}$ 'volume/book'.
(2) *'spor*$_{Nom,sg}$ – *'spora*$_{Gen,sg}$ – *'sporɨ*$_{Nom,pl}$ – *'sporov*$_{Gen,pl}$ 'argument/bet'.

In the Russian linguistic tradition, the system of stress patterns across case forms and their associated inflections are known as 'accentologic types' (Redkin, 1971; Shapiro, 1986; Švedova, 1980). Thus, the dominant accentologic type in nouns is characterised by stress that is fixed on the same syllable across all case forms, as in (2). The frequency of this accentologic type throughout the lexicon is likely to result from the unmarked nature of these inflected forms, i.e. they all have the same prosodic structure, which ensures greater formal resemblance. However, although the dominant pattern for Russian nouns is to have fixed stress, children also need to learn which words have systematically shifting stress as well as the case and number combinations where stress can move and where it can move to.

Stress effects on phoneme neutralisation: Synchronic vowel alternations

Most Russian vowels exhibit systematic phonological reduction (i.e. neutralisation of their contrastive features) in unstressed position (Barnes, 2007; Hamilton, 1980). For example, the vowel [o] in *'dom*$_{Nom,sg}$ 'house' contains a full vowel when stressed. However, when the stress shifts to the inflectional suffix, as in *do'mam*$_{Dat,pl}$, the stem vowel is reduced to [ə] ([də'mam]). The unstressed vowel /a/ also neutralises to [ə], as in the pair [taz]$_{Nom,sg}$ – [tə'zam]$_{Dat,pl}$ 'tub'.[1] Importantly, [ə] does not exist as a phoneme in Russian, only as neutralised form of /o/ or /a/, hence the problem identifying the underlying phoneme in an unstressed position. Similarly, the phonemes /e/ and /i/, when unstressed, are reduced to a single allophone [ɪ], as in [mʲex]$_{Nom,sg}$ – [mʲɪ'xa]$_{Nom,pl}$ 'fur' and [pʲir]$_{Nom,sg}$ – [pʲɪ'rɨ]$_{Nom,pl}$ 'feast'. In this study we investigated children's sensitivity about both these types of vowel reduction: /a/ and /o/ to [ə]; and /e/ and /i/ to [ɪ].

Diachronic vowel alternations: Russian 'yers'

Russian also shows historical vowel–ø alternations occurring in stem vowels that have originated from so-called yers. These yers used to be two extra short vowels which later underwent a transformation: depending on their phonotactic position, they were either elided or merged with the mid-vowels [e] and [o] (Gorshkova & Khaburgaev, 1981). In contemporary Russian this process is reflected in systematic morphophonological alternations, known as so-called 'fugitive' vowels, as in ['rot]$_{Nom,sg}$ – [r'ta]$_{Gen,sg}$ 'mouth'. Here [o] is replaced with ø when a stressed inflection is added to the stem, thus creating a phonologically weak/unstressed context (Becker & Gouskova, 2012; Gouskova, 2012; Gouskova & Becker, 2013; Gorshkova & Khaburgaev, 1981).

Importantly, these alternations are restricted *only* to vowels which originated from yers. Thus, mid-vowels /e/ or /o/ that have never been yers do not alternate with ø. For example, in a pair $[\text{p}^{\text{j}}\text{en}^{\text{j}}]_{Nom,sg}$ – $[\text{pn}^{\text{j}}\text{i}]_{Nom,pl}$ 'stump' the stem contains a former yer, whereas the pair $[\text{t}^{\text{j}}\text{en}^{\text{j}}]_{Nom,sg}$ – $[\text{'t}^{\text{j}}\text{en}^{\text{j}}\text{i}]_{Nom,pl}$ 'shadow' historically contained a full mid-vowel /e/ – hence no alternation. Since these vowels may appear in similar phonological contexts, this poses a problem for Russian-speaking children, who need to learn when to alternate the stem vowel with ø as in (3), and when to preserve it as in (4).

(3) Typical alternating CVCVC stems (Nominative – Genitive, singular) – yer vowel underlined:
bu'g<u>o</u>r – bu'gra 'hill'
'pʲepʲ<u>e</u>l – 'pʲepla 'ash'
'vʲetʲ<u>e</u>r – 'vʲetra 'wind'

(4) Words with similar phonotactics (Nominative – Genitive, singular) containing non-alternating mid-vowels:
'mus<u>o</u>r – 'mus<u>o</u>ra 'rubbish'
'fakʲ<u>e</u>l – 'fakʲ<u>e</u>la 'torch'
'dʲevʲ<u>e</u>rʲ – 'dʲevʲ<u>e</u>rʲa 'brother-in-law'

Although vowel–ø alternations are mostly restricted to a closed class of words, some studies have demonstrated the awareness of adult speakers to these patterns, generalising 'yer alternations' to nonce words in some contexts (Becker & Gouskova, 2012; Gouskova, 2012; Gouskova & Becker, 2013). The following observations have been made: (1) participants were more likely to delete yer-resembling mid-vowels /e/ and /o/ than high or low vowels (which could not have originated from yers); (2) deletions were more acceptable in disyllables than in monosyllables, reflecting frequencies in the lexicon; and (3) deletions were unlikely to violate the *Sonority Sequencing Principle* (SSP): phonemes preceding the nucleus must progressively increase in sonority (Selkirk, 1984), while the /e/–ø alternation in a nonce word $[\text{kəs'n}^{\text{j}}\text{et}]_{Nom,sg}$ would result in $*[\text{kəs'nta}]_{Gen,sg}$, with a more sonorous /n/ followed by a less sonorous /t/. This process would then appear to be similar to what has been observed in experiments with English irregular past tense, where participants managed to generalise these patterns to nonce verbs (Albright & Hayes, 2003; Pinker & Prince, 1988; Rumelhart & McClelland, 1986). Thus, it appears that native speakers can rely on 'systematic exceptions' (i.e. unproductive and irregular patterns) as a system of rules with limited scope, and generalise them to nonce words with similar phonotactics. However, although adults appear to be sensitive to such 'irregular' patterns, it is unclear at what age young children show a similar awareness.

Importantly, although yer–ø alternations are *diachronic* changes, *new real* words can also follow this 'fugitive' vowel alternation pattern (i.e. have stem vowels alternate with ø) – but only if the target vowel occurs in a *productive morpheme* containing a former yer. These include the nominal suffixes *-ok* and *-e͡ts*, which systematically alternate with ø, as illustrated in (5a) and (5b). A similar pattern is found in words that are *etymologically* bimorphemic, but now represent a single morpheme, as in (5c)–(5e) (Vasmer, 1986).

(5) Real words with vowel–ø alternations in the Nominative/Genitive, singular:
a. *prɨ'zʲ-ok – prɨ'zʲ-k-a* 'hop'
b. *sa'mʲ-e͡ts – sa'm-t͡s-a* 'male'
c. *'pʲere͡ts – 'pʲert͡s-a* 'bell pepper'
d. *'tanʲe͡ts – 'tant͡s-a* 'dance'
e. *'rɨnok – 'rɨnk-a* 'marketplace'

Thus, vowel alternation patterns that were attested diachronically can be extended to new real words when suffixes like *-ok* or *-e͡ts* are added to the stem. We explore the distribution of these forms below to better understand the potential learnability implications.

Distribution of the alternation patterns in the Russian lexicon

In order to estimate how often the target alternation patterns are present in the lexicon, we searched Zaliznjak's Grammatical Dictionary, which contains 93,392 Russian words (Zaliznjak, 1977), using several phonotactic and prosodic constraints for filtering. We focused on disyllabic stems, since these are much more likely to contain former yers (Gouskova & Becker, 2013). In addition, we selected only disyllabic noun stems with /e/ and /o/ mid-vowels (i.e. CVCeC and CVCoC structures) – as other vowels could not have originated from yers. Finally, to further explore SSP constraints (Gouskova & Becker, 2013) we compared stems with CV+Sonorant+e/o+Obstruent structure to those with CV+Obstruent+e/o+Sonorant.

As shown in Table 1, items with sonorant–obstruent sequences are much more likely to have an alternating vowel, as in $m^{j}e'lok_{Nom,sg}$ – $m^{j}e'lka_{Gen,sg}$ 'chalk'. Specifically, 83 out of 168 words with sonorant–obstruent structure contained a historic yer. In contrast, among 180 obstruent–sonorant words only 29 had a historic yer.

To further characterise phonological contexts in which alternations were more likely to occur, we focused on CV+Sonorant+e/o+Obstruent stems. Importantly, out of 83 alternating stems, 82 had either *-ok* or *-e͡ts* endings. The only exception was the disyllabic root $lo'mot^{j}_{Nom,sg}$ – $lo'mt^{j}a_{Gen,sg}$ (archaic term for 'slice'), which, despite ending in *-otʲ*, also requires vowel deletion in the Genitive case. Thus, both *-ok* and *-e͡ts* endings, which also represent productive high-frequency nominal suffixes, seem to consistently contain historic yers. In fact, in 85 words with non-alternating mid-vowels none ended in *-e͡ts* and only 3 very low-frequency nouns ended in *-ok*, as in $'morok_{Nom,sg}$ – $'moroka_{Gen,sg}$ (archaic term for 'darkness').

Overall these observations support the idea that real words ending in *-e͡ts* and *-ok* nearly always follow a vowel–ø alternation pattern. In contrast, other real disyllabic words with CV+Sonorant+e/o+Obstruent structure are unlikely ever to alternate. These trends in the lexicon, therefore, suggest that native speakers are much more likely to generalise the alternation to nonce words if they ended in *-e͡ts* or *-ok* compared to any other e/o+Obstruent combination.

Present study

The main aim of the present article was to explore how Russian-speaking children learn nominal declensions and how this is affected by the position of stress and alternation of

Table 1. Frequency counts for the target CVCVC stems and the proportions of alternating cases in the Grammatical Dictionary (Zaliznjak, 1977).

Consonant sequence	Vowel type	Total cases	Alternating stems: total (proportion in %)
Obstruent–Sonorant	CVObs+o+Son	88	12 (14)
	CVObs+e+Son	92	17 (18)
Sonorant–Obstruent	CVSon+o+Obs	102	50 (49)
	CVSon+o+k*	52	49 (94)
	CVSon+e+Obs	66	33 (50)
	CVSon+e+t͡s*	33	33 (100)

*Highlighted in grey are two stems, which represent subsets of the respective CVSon+**o**+Obs or CVSon+**e**+Obs structures.

vowels. It also investigated how these suprasegmental and segmental factors interact, i.e. whether stress position, for example, helps learners determine vowel type.

Thus, the study explored the effects of three main factors of interest: type of target vowel, position of stress and word type (i.e. real or not). In particular, we wanted to determine whether the position of stress and phonological environment of the target vowel affected the ability of children to decline nonce words. To this end, we ran an elicited production 'wug'-type experiment (Berko, 1958) using real and nonce words, and examined how these were produced by children of different ages. We then compared their performance to that of adults. By studying the behaviour across age groups, we hoped to ascertain the age at which children start showing sensitivity to Russian morphophonological processes, and when they begin to reach adult-like competence.

Objectives and predictions

The main objective of this study was to investigate the ability of children to generalise morphophonological patterns. In addition, we wanted to determine at what age children start showing sensitivity to the various segmental and suprasegmental processes, and how this sensitivity develops with age. Finally, we were interested in observing whether the various types of morphophonological alternations are mastered independently, and if so, in which order they are acquired.

Based on previous findings (Gouskova & Becker, 2013) and general trends in the lexicon, we made the following predictions. First, since there are few productive morphemes containing former yers in Russian, we expected that participants would find generalising the vowel deletion pattern problematic. This was particularly expected of the younger children, whose vocabulary is small. In contrast, we predicted that stress preservation would be likely followed with greater accuracy across age groups, since it is a much more frequent pattern found in Russian nouns, and the one which helps preserve the stem's phonotactic structure throughout the case paradigm.

Second, based on evidence from Russian (Ceytlin, 2000), Dutch (Zamuner et al., 2011) and German (van de Vijver & Baer-Henney, 2013), we predicted that children would start demonstrating consistent sensitivity to morphophonological alternations around the age of 5 or older. In addition, their progress in following the various morphophonological patterns was likely to be more apparent in real words due to their expanding vocabulary, reaching adult-like competence in the older children.

Third, we expected the various types of patterns – segmental (i.e. vowel alternations) and suprasegmental (i.e. stress patterns) – to be mastered independently from one another, with the segmental changes acquired later, since these create multiple surface forms of the same stem. However, segmental and suprasegmental alternations might have a joint effect on the performance, making some contexts systematically more challenging to generalise. For example, in cases when stress does not fall on an initial syllable, participants were less likely to follow the vowel deletion pattern, probably since the target vowel is neutralised to [ə] or [ɪ] and thus requires additional processing time.

Method

Experimental design

Our selection of target words was based on three criteria: vowel type, stress position and type of word (real or not). Below we consider how each of these factors is represented in the final set.

Vowel type. Based on the frequency distribution of former yers in the lexicon, we restricted the list of stimuli to CV+Sonorant+e/o+Obstruent structures. These were one of two classes: (1) words ending in *-ok*/*-e͡ts*, which were likely to be interpreted as former yers, and thus alternate with *-øk/-ø͡ts*, as in *bu'lo̲k*$_{Nom,sg}$ – *bu'lka*$_{Gen,sg}$; and (2) words ending in other obstruents, which were likely to be interpreted as containing non-yer mid-vowels [e]/[o], and thus be preserved, as in *da'lo̲p*$_{Nom,sg}$ – *da'lo̲pa*$_{Gen,sg}$. The experiment included equal numbers of items for each condition.

Stress position. Stress position as a factor focused on establishing whether participants tend to follow the dominant stress pattern of Russian, preserving the stress position of the Nominative singular form, as in *da'lo̲p*$_{Nom,sg}$ – *da'lo̲pa*$_{Gen,sg}$, or whether they would shift stress to another syllable. Recall that Russian vowels in unstressed syllables are neutralised; thus, we also investigated whether participants' ability to identify alternating and non-alternating conditions varied depending on whether the target vowel was stressed or not.

Unlike in English, Russian disyllabic nouns tend to carry stress on the final syllable. Thus, only nonce words could be perfectly balanced for stress position: 16 out of the 32 nonce words used and 11 out of the 32 real words carried stress on the first syllable. However, the initial position of stress was not in itself our variable of interest, since we aimed to explore whether the participants could consistently *preserve* the stress throughout the case paradigm. In this respect all the real-word items were consistent, requiring the same stress position across the case forms. Therefore, for each condition we expected to observe a *stress preservation* strategy, which would reflect a general tendency in the lexicon to preserve the stress position of the Nominative form. Note that, in order to preserve the prosodic structure for words with second syllable stress in the yer condition, stress needs to be placed on the inflection, as in *bu'l*$\underline{o}$*k*$_{Nom,sg}$ – *bu'lk*$\underline{a}$$_{Gen,sg}$. All real words belonged to the dominant accentologic (stress-preserving) type, as in *'r*$\underline{ɨ}$*nok*$_{Nom,sg}$ – *'r*$\underline{ɨ}$*nka*$_{Gen,sg}$ 'marketplace', *ko'm*$\underline{o}$*k*$_{Nom,sg}$ – *ko'mk*$\underline{a}$$_{Gen,sg}$ 'ball'.

Word type: real vs nonce words. Using both real and nonce words with the same phonotactic structure allowed us to establish (1) children's sensitivity to morphophonological alternations in the lexicon (words); and (2) children's ability to generalise these alternation patterns to nonce words. Nonce words were created by changing vowels in the initial (non-target) syllable or by changing one or more consonants in a real word, occasionally accompanied by a shift in stress. For example, *'tanʲe͡ts* 'dance' served as a prototype for the nonce word *'banʲe͡ts; ku'rok* 'hammer in firearms' for *'zurok*. Due to the limited number of real words with the required structure, four items differed in 2 phonemes, as in the pair *'vɨrok – 'rɨnok* 'marketplace'. All items were legal CVCVC nonce word structures, as verified independently by two native speakers of Russian. Both real and nonce words had an equal number of items for each alternation type.

Stimuli

The stimuli consisted of 64 test items (plus 6 practice items): 32 real words and 32 nonce words selected based on the type of vowel (alternating/non-alternating) and the position of stress (1st/2nd syllable). The order of presentation was pseudorandomised. The full list of items is given in Appendix B.

Participants

The participants were 62 Russian-speaking children and 20 adults recruited in Novosibirsk (Russian Federation). The children were analysed in three age groups: 4-year-olds, 5–6-year-olds and 7-year-olds (see Table 2 for additional participant information).

Procedure

The experiment involved an elicited production task similar to the 'wug' test with real and nonce words. Participants were tested individually by the same experimenter – a Russian native speaker (ET). The sessions were audio-recorded using a digital voice recorder Olympus VN-5500PC.

During the experiment, the participant was seated in front of a computer screen and received the following instructions: 'I'll show you some pictures of both familiar creatures and objects, and also some funny monsters you have never seen before. I'll tell you what they are called, and then ask you to use these words in a game. To make sure you understand the rules, we'll practise for a bit first!' (See Appendix A for the Russian version of this introductory statement). Then, 6 practice items – 4 real and 2 nonce words – were introduced, and 64 test items followed.

Table 2. Age and gender distributions in four groups of participants.

Group	No. participants	Age range (*mean; SD*)	Gender
Group1	21	4;0–4;11 (*4;6; 0;4*)	10 boys, 11 girls
Group2	21	5;0–6;9 (*5;8; 0;7*)	5 boys, 16 girls
Group3	20	7;0–7;11 (*7;6; 0;3*)	10 boys, 10 girls
Group4 (Adults)	20	21–76 (*41.2; 16.2*)	10 males, 10 females

Table 3. Nominative–Genitive pairs with real-word examples.

Vowel	First syllable stress			Second syllable stress		
	Nom, sg	*Gen, sg*	*Example*	*Nom, sg*	*Gen, sg*	*Example*
YER	'CVCet͡s	'CVCt͡s-a	*ranʲet͡s – rant͡sa* 'backpack'	CV'Cet͡s	CVC't͡s-a	*borʲet͡s – bort͡sa* 'wrestler'
	'CVCok	'CVCk-a	*rɨnok – rɨnka* 'marketplace'	CV'Cok	CVC'k-a	*surok – surka* 'marmot'
Non-YER	'CVCVC	'CVCVC-a	*gorod – goroda* 'town'	CV'CVC	CV'CVC-a	*pʲilot – pʲilota* 'pilot'

The protocol for both practice and test items was the same. The participant first saw a picture of a single object/creature introduced by the experimenter: '*Here is a* $X_{Nom,sg}$'. The next slide showed two identical items together and the experimenter asked the participant to finish the sentence '*Here are two* $X_{Gen,sg}$'. In Russian, the target word here requires Genitive singular, which often carries the meaning of 'composition', i.e. *two items* '*of this type*' as in English *several of these men*. Examples are provided in Table 3.

Typically, participants needed only a single attempt to produce the target Genitive singular form. However, in the few cases where participants failed to give a response, requested a repetition of the prompt, or changed the stem (e.g. substituted [tʲiˈlʲet͡s] for the target [tʲiˈlʲet]), the experimenter introduced the item again. Up to three attempts were allowed for each item; in all cases only the last response was used for the analysis. The recordings were then downloaded onto a computer for coding and analysis.

Coding

The data were transcribed from the audio-recordings using perceptual cues. If there was any doubt regarding the presence/absence of the stem vowel, spectrograms and waveforms were consulted using Praat (Boersma & Weenink, 2014). Each target item was originally classified by the following three binary parameters: (1) real/nonce word; (2) yer/non-yer type of vowel (i.e. alternating/non-alternating stem); (3) stress on the 1st /2nd syllable. For example, the word [ˈrɨnok]$_{Nom,sg}$ 'marketplace' was described as (1) real; (2) yer type; (3) 1st syllable stress. During coding, the target Genitive singular productions were labelled as 'correct' or 'incorrect' depending on whether they followed the morphophonological patterns expected for their class. Thus, a correct production simultaneously satisfied two criteria: it followed the expected vowel deletion/preservation pattern, and preserved the position of stress. For instance, the production [ˈrɨnka]$_{Gen,sg}$ was 'correct' since it demonstrated vowel deletion, as expected for the yer vowel, and preserved the position of stress. In contrast, both *[rɨnˈka]$_{Gen,sg}$ and *[ˈrɨnoka]$_{Gen,sg}$ were coded as incorrect: in the first case the stress was misplaced, while the second violated the alternation pattern. Note, however, that the labels 'correct'/'incorrect' were used conventionally, i.e. to indicate whether the productions followed the morphophonological patterns observed in real words with the same phonotactics (see Table 1 for frequency counts in the lexicon).

To ensure consistency in transcriber judgements, a reliability check was performed on 15% of the data. These included equal proportions of responses for each age group, which were examined by another transcriber, also a linguist and native speaker of Russian. This second transcriber was instructed to transcribe each production following the same protocol, i.e. include only the last response for each item and use perceptual cues to code. The two transcripts were then compared, reaching 98% consistency between coders with respect to the (1) vowel presence/deletion and (2) stress position. In cases of mismatch in the judgements (e.g. the first researcher transcribed the production as [ˈrɨnoka] and the second as [ˈrɨnka]), the item was re-examined by the first transcriber in Praat, making the final decision based on this last examination.

Due to the potential for final devoicing in Russian (Kulikov, 2012 *inter alia*; though see also Dmitrieva, Jongman, & Sereno, 2010), 4% of the items ending in *-ok* had alternative interpretations of the stem. For example, the nonce word *bu'lo<u>k</u>* was occasionally analysed as *bu'log*. In this case, the item was reassigned to a different class, and labelled as correct or incorrect depending on whether it followed the alternation and stress patterns associated with this class. For example, as *bu'log* ends in a *-g*, the vowel is expected to be preserved. Thus, the 'correct' production is *bu'loga*, whereas **bu'lga* would be counted as incorrect.

Analysis

The analysed dataset included the productions of 64 test items by each of the 82 participants. Out of the total 5248 trials, 36 items were excluded because participants failed to produce valid forms, either skipping items or producing a non-target type of stem. For example, the target CVCVC stem of the real-word item *'kolos* 'ear in botany' occasionally substituted with the diminutive form *kolo's<u>ok</u>* 'small, cute ear'.

The final set of items consisted of 5212 forms, including 3935 child and 1277 adult productions. Due to the number of factors and interactions, as well as differences in the overall adult and child performance, the data could not be fitted with a single model. Specifically, the near 100% accuracy of adults with real words (ceiling effects) made their productions hard to compare with the child data. Analysing children and adults together was therefore only possible if the number of significant interactions was sacrificed or a large proportion of data excluded from the analysis (e.g. real words for adults), thus oversimplifying the model. Therefore, the final decision was made to analyse the child and adult datasets separately.

We used an additional grouping variable for the child data, based on the participants' age. This factor had three levels: 4-year-olds, 5–6-year-olds and 7-year-olds. Analysing 5- and 6-year-olds within one group was justified by preliminary findings from 45 children (16 four-year-olds, 15 five-year-olds, 5 six-year-olds, 9 seven-year-olds). Our original assumption was that 6-year-olds would be closer to 7-year-olds in their performance and thus would show adult-like behaviour at least in their production of real words. However, after multiple versions of the binary logistic regression model were applied to the data, using age as a continuous predictor and as a grouping factor, based on these preliminary data the age predictor had the best explanatory power when used as a grouping factor with those three levels. The analysis of the full dataset confirmed this preliminary result. The greater difference between the ages of 6 and 7 years compared to 5 and 6 years may be due to the onset of formal education in Russia at the age of 7, when children begin to read, developing a higher metalinguistic awareness of morphophonological paradigms along with an increase in vocabulary size.

Results

Two similar binary logistic regression models were applied separately to the child and adult data, using Minitab 17 Statistical Software (URL: www.minitab.com). The same three main factors of interest – *Vowel* type (yer/non-yer), *Stress* position (1st/2nd syllable), *Word* type (real/nonce word) – and their interactions were used as predictors of the correct responses. The children's model also included *Group* as an independent factor and its interactions with the other three predictors, so as to investigate age-specific differences. Unlike the other factors, *Group* included not two, but three levels: 4-year-olds, 5–6-year-olds and 7-year-olds. Overall, children showed greater variability in their responses than the baseline adult population, as indicated by the difference in the R^2 values between the models: 57.6% for the adult data, and 19.2% for the child data. Table 4 summarises the output of the analysis with all significant predictors highlighted in grey.

Importantly, the two models were made as similar as possible even if it meant keeping an interaction that was non-significant for one of the models, e.g. *Vowel*Word* interaction for children. The outputs for the child and adult datasets are given in separate subsections below.

Child data. The analysis revealed significant main effects of *Vowel* type ($\chi^2 = 139.9$, $p < .001$) and *Stress* ($\chi^2 = 69.2$, $p < .001$), and also a *Vowel*Stress* interaction ($\chi^2 = 125.1$, $p < .001$). As suggested by the *Vowel* type coefficient, other factors fixed, children were roughly 2 times more accurate in producing targets in the non-yer condition (e.g. *'molot*$_{Nom,sg}$ – *'molota*$_{Gen,sg}$ 'hammer') compared to the yer condition. The position of *Stress* also had a robust effect on correct production, both as an independent factor, and in interaction with *Vowel*. Thus, with all other terms kept constant, children were 1.5 times more accurate in vowel alternation or preservation when it was stressed. However, children were also significantly more successful when declining words in the non-yer condition, with a coefficient of –1.7. In other words, the appearance of non-yer vowels in their non-reduced forms (e.g. *s^{j}i'rop*$_{Nom,sg}$ – *s^{j}i'ropa*$_{Gen,sg}$ 'syrup') helps identify these vowels as candidates for preservation.

Table 4. Summary of the binary logistic regression models applied to adult and child data, with the asterisks (*) indicating statistically significant values.

	Factors: levels	Adults			Children		
		χ^2	*p* value	Coef.	χ^2	*p* value	Coef.
Main factors	*Vowel*: yer vs non-yer	0	.99	0.01	139.9	* < .001	2.1
	Stress: 1st vs 2nd syllable	0.2	.65	0.6	69.2	* < .001	1.4
	Word: real vs nonce	150.5	* < .001	–6.2	9.7	* .002	–0.5
	Group: 4 years vs 5–6 years vs 7 years	–			31.5	* < .001	0.5; 1.2
Interactions	*Vowel*Stress*	39.3	* < .001	–3.2	125.1	* < .001	–1.7
	*Stress*Word*	1.4	.24	1.2	2.5	.11	–0.3
	*Vowel*Word*	27.2	* < .001	4.2	0.6	.44	0.1
	*Group*Vowel*	–			19.6	* < .001	–0.7; –0.7
	*Group*Word*	–			18.9	* < .001	–0.1; –0.8
	*Group*Stress*	–			2.9	.23	0.3; 0.2
Model	Hosmer–Lemeshow goodness-of-fit test; R^2	$\chi^2 = 0.8$, $p = .98$; $R^2 =$ 57.6%			$\chi^2 = 6.9$, $p = .33$; $R^2 = 19.2\%$		

Another significant predictor of children's performance, as predicted, was *Group*. Overall, we observed that the children's accuracy increased with age at a more or less steady pace (positive coefficients of 0.5 and 1.2 between the levels). In addition, the *Group* Vowel* interaction suggests that older children alternate vowels with ø more often, thus applying a less conservative strategy when declining both real and nonce words.

Finally, *Word* type – both on its own and when interacting with *Group* – was also significant. With all other terms kept constant, children were 2 times more accurate when declining real rather than nonce words. However, this pattern was also affected by the age of the participants. Specifically, 4-year-olds did not show any difference between real and nonce words, and even high-frequency items used in everyday speech often violated the expected patterns. For example, the word *ˈpalʲe͡ts*$_{Nom,sg}$ 'finger, toe' containing a yer vowel was incorrectly paired with **ˈpalʲe̲͡tsa*$_{Gen,sg}$ instead of *ˈpalʲ͡tsa*$_{Gen,sg}$. Since younger children showed a preference for a conservative strategy, preserving stem integrity regardless of its phonotactics, the differences between the age groups are particularly apparent within the yer condition. Figure 1, which gives the summary of the entire dataset, illustrates this pattern. Here the levels for *Stress* include *stress1* and *stress2* for words with first- and second-syllable stress, respectively. Target *Vowels* are either alternating *yers*, or *non-yers* which need to be preserved. *Words* are either *real* or *nonce words*.

On the second panel (i.e. *stress1, yer* condition, as in *ˈrɨnok* 'marketplace') we observe that 4-year-olds decline both real and nonce words with an equally poor accuracy of about 25%. The older children were significantly more accurate declining real words, reaching an average of about 70% of the correct responses in 5–6-year-olds and 90% in 7-year-olds. However, the proportions of correctly declined nonce words in the same condition remain at a relatively low level. This suggests high lexicalisation of the alternation patterns in Russian. In addition, the significant differences in the curves for the

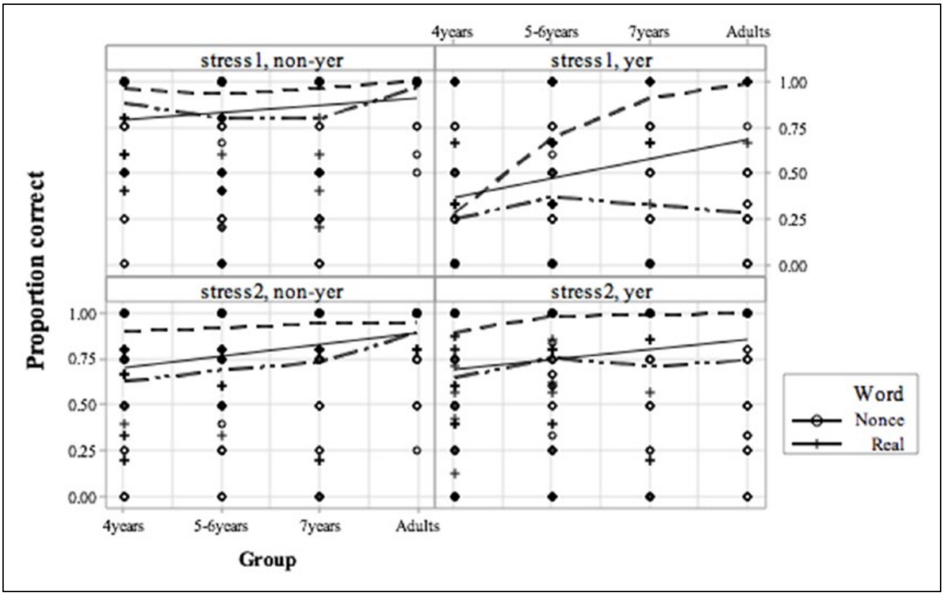

Figure 1. The proportion of the correct responses in groups as a function of three binary categories (stress position, type of target vowel and word type), with the dashed lines representing lowess .5 degree smoothing for each condition. Pluses and circles show the spread of individual data points, and the solid line – linear regression fit.

items with stressed vs unstressed vowels underline the important role of stress in determining vowel types. Specifically, as shown in Figure 2, stressed vowels are more consistently preserved or alternated, particularly in nonce words.

Adult data. Overall, adults showed much less within-group variability, particularly in the way they treated real words, which they declined with almost 100% accuracy. Therefore, the greatest effect on the proportion of correct responses had *Word* as a predictor – i.e. whether the item was a real or a nonce word. This observation is supported in Table 4, which shows that nonce words were, as expected, declined 6 times less accurately than the real words. The only incorrectly declined real noun was the word *valʲet* 'knave', which was often paired with **valʲta* instead of *valʲeta*. However, this is a frequent overgeneralisation in adult spontaneous speech as well.

Adult success in producing the Genitive forms for the nonce words was also significantly affected by two interactions. The first was a *Word*Vowel* interaction. The coefficient indicated that nonce words in the yer condition (e.g. *'banʲe̲t͡s*$_{Nom,sg}$ –*'bant͡sa*$_{Gen,sg}$) were over 4 times less accurate than those belonging to the non-alternating class (e.g. *'koro̲s*$_{Nom,sg}$ – *'koro̲sa*$_{Gen,sg}$). The second was a *Vowel*Stress* interaction, which significantly affected adult productions in the same manner as that observed in children. Specifically, correctly preserving/deleting stressed vowels (e.g. *da'lo̲p*$_{Nom,sg}$ – *da'lo̲pa*$_{Gen,sg}$

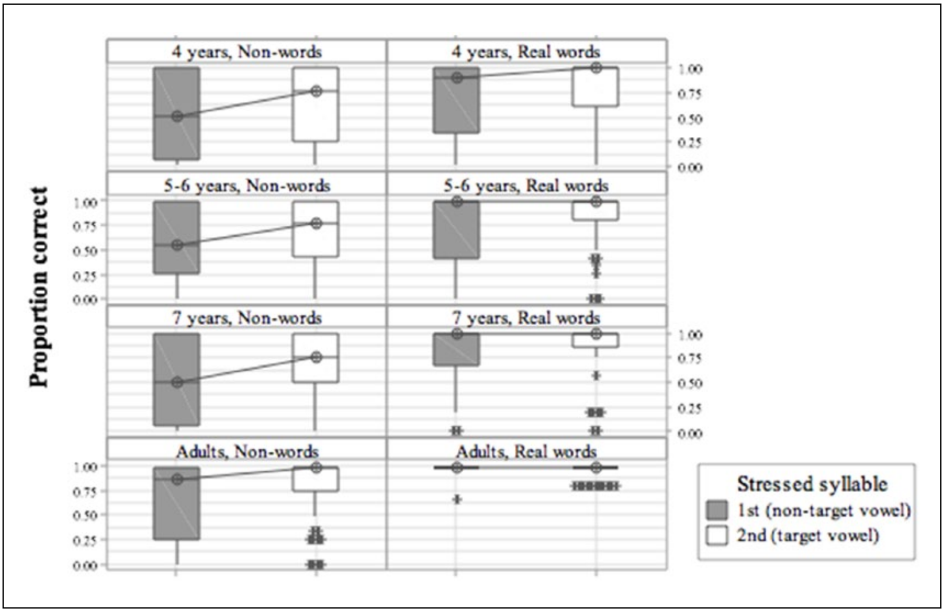

Figure 2. Proportions of productions as a function of stress position across age groups. Boxes represent interquartile ranges, whiskers – end points of the data; asterisks – the outliers. The lines between the boxes show the distances between the median values across the conditions.

or *gu'lok*$_{Nom,sg}$ – *gu'lka*$_{Gen,sg}$) was about 3 times easier than for unstressed vowels, i.e. when these were reduced to [ə]/[ɪ] (e.g. *'gol*[ə]*p*$_{Nom,sg}$ – *'gol*[ə]*pa*$_{Gen,sg}$ or *'zur*[ə]*k*$_{Nom,sg}$ – *'zurka*$_{Gen,sg}$). The nature of this effect is discussed in the next section.

Discussion

This study investigated Russian-speaking children's and adults' knowledge of morphophonological alternations in case marking with real and nonce words. As expected, children showed greater variability in their responses than adults (see the R^2 values in Table 4), as shown in Figure 1. This variability, observed even in 7-year-olds, is probably rooted in the complexity of the Russian morphological system. In other words, due to the great number of morphophonological and morphological patterns the number of real-word exemplars available in the input children hear does not provide sufficient information to reliably identify the morphophonological alternations in order to generalise these processes to novel forms (cf. Pierrehumbert, 2006). This is confirmed by the statistics summarised in Table 4, demonstrating a number of significant interactions which suggest why generalisation of the morphophonological patterns is problematic.

However, despite this variability, there are several patterns observed in the participants' responses, indicating development in learning morphophonological alternations.

The results show that both segmental and suprasegmental patterns influence production. Specifically, *Vowel* type (i.e. yer/non-yer condition) has a strong correlation with the proportion of correct responses.

As predicted, all participants were generally more successful with non-alternating stems. This is likely to result from (1) much higher overall frequency of this type of stem in the lexicon; and (2) fewer formal representations (i.e. allomorphs) of the same morphemes throughout the case paradigm. Since even the adults showed variability in the strategies applied when declining nonce words in the yer condition, this suggests that the vowel alternation pattern is lexicalised. However, when the target vowel is stressed, native speakers were more consistent at following the expected preservation or deletion pattern. In other words, stressed vowels were much easier to attribute to an appropriate yer or non-yer class, as illustrated in Figure 1: when the target vowel was stressed (*stress2* condition) the overall accuracy in deleting yer-type vowels for both real and nonce words was higher even at the age of 4, while productions in the *stress1* condition were much less accurate. This confirms our prediction that stress position might affect the learner's ability to posit the correct type of vowel alternation.

As discussed in the Introduction, we also wanted to investigate the reverse effect, i.e. whether the process of vowel deletion influences the speaker's ability to preserve stress. Specifically, when the target vowels in the yer condition (i.e. in words ending in *-ok* and -*e͡ts*) are stressed, the stress needs to shift to the following vowel – now the inflection – as in *ko'mok*$_{Nom,sg}$ – *kom'ka*$_{Gen,sg}$ 'ball'. The results demonstrated that there was not a single error that violated this pattern, i.e. there were no productions such as **'komka*$_{Gen,sg}$ in the entire dataset. This suggests that stress has an effect on the ability to correctly alternate/ preserve vowels, whereas vowel type does not seem to contribute to ascertaining the position of stress.

In addition, stress significantly contributed to successful performance in children and adults as an independent factor, reflecting speakers' familiarity with the various accentologic types that govern Russian nominal declensions. Although the dominant accentologic type requires the preservation of stress on the same syllable throughout the declension paradigm, as in *po'rog*$_{Nom,sg}$ – *po'roga*$_{Gen,sg}$ – *po'rog*^{j}*i*$_{Nom,pl}$ 'threshold', there are several other frequent accentologic patterns, involving stress shifts when the form changes from the Nominative singular. For example, *p*^{j}*i'rog*$_{Nom,sg}$ – *p*^{j}*iro'ga*$_{Gen,sg}$ – *p*^{j}*iro'g*^{j}*i*$_{Nom,pl}$ 'pie' or *'korob*$_{Nom,sg}$ – *'koroba*$_{Gen,sg}$ – *koro'ba*$_{Nom,pl.}$ 'box, chest'. It is apparent from these examples that stress either remains on the same syllable, or moves to the inflection, and that there is no obvious phonotactic rule for determining the accentologic type of a word prior to seeing its declension paradigm. Participants tended to follow the dominant stress pattern, thus preserving its position when producing a Genitive singular form (see Figure 2), which suggests that the higher frequency of the pattern in the lexicon and the greater phonological resemblance between the two output forms (i.e. Nominative–Genitive) result in a higher proportion of correct responses.

However, despite the overall high proportion of stress preservations, the existence of other accentologic types is likely to account for the most common 'stress errors' – the shifts of stress to the inflection. For example, when the stress fell on the first syllable, as in *'zurok*, participants often moved it towards the end, thus producing **zu'rka*$_{Gen,sg}$ instead of the target *'zurka*$_{Gen,sg}$ (see Figure 2). Interestingly, depending on age, participants differed in the types of stress errors they made. Specifically, 4-year-olds very rarely misplaced stress, and when they did, they only shifted it to the inflection. The same trend was observed in the majority of 5–6-year-olds (96% of the cases). However, for the older children and adults, the variability in the types of stress errors increased. Thus, only 88% of the stress misplacements in 7-year-olds and 73% in adults were shifts to the inflection. In other cases, these older participants placed it on the first syllable instead. For example, the nonce word *da'lop* was occasionally paired with **'dalopa*$_{Gen,sg}$ instead of the target *da'lopa*$_{Gen,sg}$ This pattern goes counter to what is predicted by Russian accentologic patterns, but could probably be explained by sensitivity to other morphophonological processes. For example, some Russian nouns exhibit these shifts during derivation, as in *ku'sok* 'slice, bite' – *za'kuska* 'snack', and also when they are preceded by prepositions and thus form a single prosodic word, as in *dom* 'house' – *'iz domu* 'out of the house'. We therefore conclude that, as predicted, Russian-speaking adults and children generally followed the expected stress preservation pattern. The misplacements of stress were due to participants' increasing knowledge about other accentologic patterns in Russian as well as stress shifts during derivation.

As predicted on the basis of evidence from Russian (Ceytlin, 2000, 2006) and Dutch (Zamuner et al., 2011), at the age of 4 children do not yet show systematic sensitivity to nominal morphophonological patterns. The process of morphophonological development is likely to be additionally influenced by children's vocabulary size (van de Vijver & Baer-Henney, 2014). Thus, in Figures 1 and 2 we observe that only at the age of 5 did the children in this study start treating real and nonce words differently, suggesting that children below that age do not yet have enough experience in using these forms to make generalisations about the morphophonological patterns.

Finally, our data demonstrate high within-group variability. The variability among adults suggests that, due to the complexity of the morphophonological system and the interacting nature of some of its patterns, participants *applied different strategies* when declining nonce words. This raises questions about other factors that may influence participants' behaviour. Specifically, it has been shown that factors such as statistical learning abilities, which are believed to be an essential language-learning mechanism (Saffran, 2003 *inter alia*), can also be a stable individual capacity like IQ and thus could be estimated using standardised psychometric tools (Siegelman, Bogaerts, & Frost, 2017; Siegelman & Frost, 2015). If this is the case, the use of different strategies by adults and older children could be attributed to variability in their individual statistical learning abilities, a potential area for future research.

Conclusion

The present study investigated whether Russian-speaking children and adults can generalise interacting segmental and suprasegmental patterns when declining nonce words and real nouns. Our results demonstrated that participants found it problematic to generalise morphophonological patterns for vowel deletion to nonce words. In addition, our findings suggest that the interactions between segmental and suprasegmental effects have a significant effect on children's language acquisition and grammatical development. This becomes particularly apparent when looking at languages with rich morphophonological alternations, such as Russian. Therefore, it seems important to include morphophonology as an additional aspect of language competence when building models of child language development. These observations are also supported by evidence from atypical populations. For example, children with Specific Language Impairment (SLI) often find it difficult to generalise morphophonological patterns, as observed in English- (Tomas et al., 2015, 2017), French- (Royle & Stine, 2013) and Dutch-speaking children (Kerkhoff, 2007). Interestingly, similar effects have also been observed in Dutch and German speakers with aphasia (Grijzenhout & Penke, 2005), suggesting possible general vulnerability of morphophonological patterns in atypical populations. Future research is needed to better understand how allomorphy and other morphophonological alternations influence the acquisition of grammatical morphemes across languages.

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Note

1. Here we follow the approach introduced by Barnes (2004, 2006, 2007), who demonstrated that traditional second-degree of vowel reduction in Russian vowels (Avanesov, 1972; Bondarko, 1977; Trubetskoi, 1969) is gradient.

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Appendix A

The initial introduction of the task in Russian: «Я покажу тебе картинки, на которых нарисованы знакомые тебе предметы и животные, а также забавные монстры, которых ты никогда раньше не видел(а). Я буду тебе говорить, что изображено на картинке, а твоя задача будет использовать это слово в игре. Но сначала мы немножко потренируемся, чтобы тебе стали понятны правила!»

Appendix B

Word	Alternation	Former yer vowel			
		e vowel		*o* vowel	
		Stress: 1st syllable	Stress: 2nd syllable	Stress: 1st syllable	Stress: 2nd syllable
Real	+	*ˈranʲet͡s* ‘backpack’ *ˈpʲerʲet͡s* ‘bell pepper’ *ˈpalʲet͡s* ‘finger’	*veˈnet͡s* ‘crown’ *saˈmʲet͡s* ‘male’ *boˈrʲet͡s* ‘wrestler’ *goˈnʲet͡s* ‘messenger’ *maˈlʲet͡s* ‘lad’	*ˈrɨnok* ‘marketplace’	*koˈmok* ‘ball’ *ɕeˈnok* ‘puppy’ *t͡ɕuˈlok* ‘stocking’ *hoˈrʲok* ‘ferret’ *suˈrok* ‘marmot’ *vʲeˈnok* ‘garland’ *mʲeˈlok* ‘chalk’
	–	*ˈt͡ɕerʲep* ‘skull’ *ˈbʲerʲeg* ‘shore’	*ʐɨˈljet* ‘vest’ *bʲiˈlʲet* ‘ticket’ *maˈnʲeʐ* ‘playpen’ *ruˈlʲet* ‘roll’ *vaˈlʲet* ‘knight’	*ˈmolot* ‘hammer’ *ˈvolos* ‘hair’ *ˈkolos* ‘[plant] ear’ *ˈgorod* ‘city’ *ˈkorob* ‘chest’	*pʲiˈlot* ‘pilot’ *poˈrog* ‘threshold’ *sʲiˈrop* ‘syrup’ *koˈmod* ‘cabinet’
Nonce	+	*ˈpolʲet͡s* *ˈbanʲet͡s* *ˈkʲenʲet͡s* *ˈgʲemʲet͡s*	*paˈnʲet͡s* *taˈlʲet͡s* *kaˈrʲet͡s* *gʲiˈlʲet͡s*	*ˈfʲirok* *ˈdɨnok* *ˈzurok* *ˈvɨrok*	*puˈrok* *buˈlok* *kʲiʲˈlok* *guˈlok*
	–	*ˈtʲerʲep* *ˈpʲerʲek* *ˈʂerʲep* *ˈdʲerʲek*	*tʲiˈlʲet* *bʲiˈnʲet* *puˈrʲet* *baˈrʲet*	*ˈdolot* *ˈkoros* *ˈgolop* *ˈtorop*	*pʲiˈrot* *tʲiˈrop* *daˈlop* *dʲiˈrop*