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ACQUISITION OF WORD-FINAL DEVOICING BY AMERICAN LEARNERS OF RUSSIAN

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This study investigated the acquisition of the phonological rule of word-final devoicing by American learners of Russian and examined the effects of articulatory features, such as place of articulation, manner of articulation and palatalization, on the degree of voicing preserved in final obstruents. Twenty-six American learners of Russian participated in a word-learning task to memorize 24 target words and subsequently performed a picture-naming task. In order to control for previous lexical knowledge, frequency effects and phonetic environment, we used pseudowords that were matched to pictures of real objects, which were assigned a new meaning related to space travel. Minimal pairs were excluded to avoid task effects. The results suggested that learners did not fully acquire the rule of word-final devoicing in Russian despite the fact that voiceless consonants are unmarked and occur in English word-finally. Manner of articulation had a significant effect on the degree of voicing. Stops retained more voicing than fricatives.

INTRODUCTION

The phonological rule of word-final devoicing states that voiced obstruents (i.e., stops and fricatives) become voiceless in word-final position. Learners whose native language preserves voicing contrasts word-finally, e.g. English, must learn to discard the feature [+voice] in that position for a neutralizing language such as Russian. The Markedness Differential Hypothesis, proposed by Eckman (1977), suggests that areas of a target language that are different from the native language and more marked cross-linguistically are difficult to acquire. Voiced consonants are also considered more marked than voiceless consonants. Word-final voicing contrasts are more marked than voicing contrasts found in the word-initial or word-medial positions. Since voiceless consonants are not considered marked cross-linguistically, English learners of Russian should not experience much difficulty acquiring the rule of word-final devoicing, especially taking into account the fact that voiceless consonants occur in word-final position in English. There are a few studies that have investigated the acquisition of marked voiced consonants by speakers of neutralizing languages (Cebrian, 2000; Simon, 2010; Smith, Hayes-Harb, Bruss & Harker, 2009), but almost none that have examined the acquisition of unmarked voiceless consonants by speakers of non-neutralizing languages (Dmitrieva, Jongman & Sereno, 2010). Counter to the predictions made by the Markedness Differential Hypothesis, anecdotal evidence from pronunciation classes in L2 Russian suggests that the phonological rule of word-final devoicing is not readily acquired across the whole proficiency spectrum.

Within the framework of Optimality Theory (Prince & Smolensky, 1993), word-final devoicing is analyzed as the effect of the markedness constraint *VOICED-CODA against voiced consonants word-finally. The markedness constraint, which governs the cross-linguistic tendency towards final devoicing, is more highly ranked than the faithfulness constraint IDENT-IO(voice), which ensures that outputs match inputs in terms of voicing. Consider evaluation of two candidate outputs for the input /zub/ 'tooth' in Russian: (a) [zub] violates *VOICED-CODA, but satisfies IDENT-IO(voice); (b) [zup] satisfies *VOICED-CODA, but violates IDENT-IO(voice). In English, as opposed to Russian, IDENT-IO(voice) dominates *VOICED-CODA, which results in the reverse ranking of faithfulness and markedness constraints. When English learners transfer this ranking into Russian, they preserve the phonological contrast between voiced and voiceless consonants word-finally, which is reinforced by differences in acoustic cues such as duration of the preceding vowel, consonant, voicing into consonant and release. For English learners to acquire the rule of word-final devoicing in Russian, they have to re-rank constraints in such a way that the markedness constraint dominates the faithfulness constraint. The goal of our study is to provide empirical evidence by examining the acquisition of word-final devoicing by American learners of Russian.

Literature Review

Dmitrieva et al. (2010) examined the production of word-final obstruents in Russian by three groups of speakers: monolingual Russian speakers, Russian speakers with knowledge of English and American learners of Russian. In their study, participants were asked to read a list of 34 Russian minimal pairs alternating in word-final voiced and voiceless obstruents. The acoustic analysis was based on four durational measurements: preceding vowel, closure / frication, voicing into closure / frication and release. The findings suggested that American learners of Russian and Russian native speakers used different acoustic cues to encode [+voice]. Russian monolinguals devoiced voiced obstruents word-finally but they did not neutralize the obstruents completely: they produced significant differences in their durations of closure / frication and release. However, monolingual speakers did not produce any differences in the durations of voicing into closure / frication, although it is a very important cue for encoding [+voice] since it indicates how long the vocal cords vibrate to create voicing. Monolingual Russian speakers did not use durations of the preceding vowels either. In English, however, vowel duration is the primary acoustic cue to distinguish between voiced and voiceless consonants (Mack, 1982). Unlike monolinguals, Russian speakers with knowledge of English maintained significant differences in the durations of the preceding vowel and voicing into closure / frication, as well as durations of closure / frication and release. Dmitrieva et al. considered this to be the effect of L2 English on L1 Russian. American learners of Russian produced even greater differences in the durations of the preceding vowel, closure / frication, voicing and release than Russian speakers with knowledge of English did, which suggested that learners did not devoice voiced obstruents similarly to Russian native speakers. However, the most proficient American learners of Russian decreased the durational differences between voiced and voiceless consonants and devoiced word-final obstruents more than the monolingual Russian speakers did.

Target words in Dmitrieva et al.'s study were distributed equally with respect to place and manner of articulation, but the results did not provide any insights into whether neutralization depended on articulatory features. Ohala (1983) noted that aerodynamic requirements and airstream mechanisms involved in the production of obstruents determine how the degree of voicing can be affected by articulatory features. Devoiced fricatives are more common than devoiced stops because voiced fricatives have more exacting aerodynamic requirements and require greater glottal airflow to maintain voicing than voiced stops do. In order to sustain voicing, oral pressure should be low, whereas in order to sustain frication, oral pressure should be high. As for the place of articulation, Ohala (1983) mentioned that labial stops have greater compatibility with voicing than velar stops, since the oral cavity is much smaller for the latter than for the former. Constriction for /b/ is at the lips, whereas constriction for /g/ occurs at the velum. Vibrations of the vocal cords are the source of voicing. Therefore, the distance from the vocal cords to the lips is greater than to the velum.

Following the same line of reasoning, we would also expect that palatalized consonants will be more devoiced than their plain counterparts on the assumption that the production of palatalized consonants requires the tongue to press against the palate, which creates a smaller oral cavity. When producing a plain /b/, the tongue is low and flat and the oral cavity is wide. However, for a palatalized /b^j/, the body of the tongue is raised, and as a result the oral cavity becomes smaller and the channel is narrower. Therefore, a plain /b/ is expected to have more voicing than a palatalized /b^j/. There is no study to date that examines the interaction between palatalized consonants and devoicing. Our study addresses this gap in the literature with an examination of the acquisition of word-final devoicing in Russian by American native speakers, thereby establishing what effect articulatory features can have on the feature [+voice].

Research Questions

The following questions guided the current investigation:

1. Do low-intermediate American learners of Russian devoice word-final voiced obstruents in Russian?

2. Do articulatory features, such as place of articulation, manner of articulation and palatalization, have an effect on the degree of voicing word-finally?

We hypothesize that low-intermediate American learners of Russian will transfer word-final voiced obstruents from English into Russian for a number of reasons. First, according to the Full Transfer / Full Access Hypothesis (Schwartz & Sprouse, 1996), the initial state of interlanguage is the grammar of the native language. Since our participants are low-intermediate, we would expect the effect of their native language to be relatively strong. Second, Russian orthography spells out underlyingly voiced obstruents, similarly to English. This might mislead learners into believing that Russian allows voiced obstruents word-finally. Third, the degree of voicing in word-final obstruents can vary depending on the phonetic environment, functional load and pragmatic reasons (Port & Crawford, 1989). Consequently, American learners may receive input from Russian native speakers, e.g. teachers, with varying degrees of neutralization, including word-final voiced or partially-voiced obstruents in Russian.

With respect to the second research question, it is hypothesized that place of articulation, manner of articulation and palatalization will have an effect on the production of word-final voiced obstruents. We expect that: (a) fricatives will be more devoiced than stops; (b) labials and coronals will retain more voicing than dorsals; and (c) palatalized consonants will be more readily devoiced than their plain counterparts.

METHOD

Participants

The participants of the study were 26 native speakers of American English, adult learners of Russian (11 females, 15 males). The participants' ages ranged from 18 to 35 years old, with a mean age of 23. The age of initial Russian instruction ranged from 15 to 28 years old. The participants were enrolled in levels two and three of an intensive Russian summer program that offers instruction at nine levels. Enrollment in levels was based on the results of an in-house placement test and previous experience with the language. Overall, the level of participants can be characterized as low-intermediate.

Materials

We created 20 target words and 4 distractors. All items had a CVC structure. The onsets were either stops or fricatives. The nuclei were either /u/ or /o/. The codas alternated in target stops /p, p^j, b, b^j, t, t^j, d, d^j, k, g/ or fricatives /f, f^j, v, v^j, s, s^j, z, z^j, ʃ, ʒ/. The dorsals /k, g, ʃ, ʒ/ do not have palatalized counterparts in Russian.

Pseudowords were used because the Russian lexicon did not have enough real words of a CVC structure with the word-final target consonants. The target items were matched to pictures of real objects that were assigned meanings related to the topic of space travel (Figure 1). The target words and distractors were divided into two lists to facilitate the task for participants, who had to memorize 12 words instead of 24. This also helped avoid minimal pairs alternating in plain and palatalized consonants. Thus, each list had four labials, four coronals, two dorsals and two distractors. Six words in each list contained a word-final palatalized consonant, e.g., list 1 had /zop/ and /dos^j/ whereas list 2 had /zop^j/ and /dos/. In order to avoid task effects, minimal pairs, such as /zop/ - /zob/, were avoided; instead, /zop/ alternated with /kob/. Participants were randomly assigned to either of the lists with an equal number of participants allotted to each list. Pictures and memorization were used to reduce the possible effect of orthography during the elicitation stage (Kharlamov, 2014; Port & Crawford 1989).

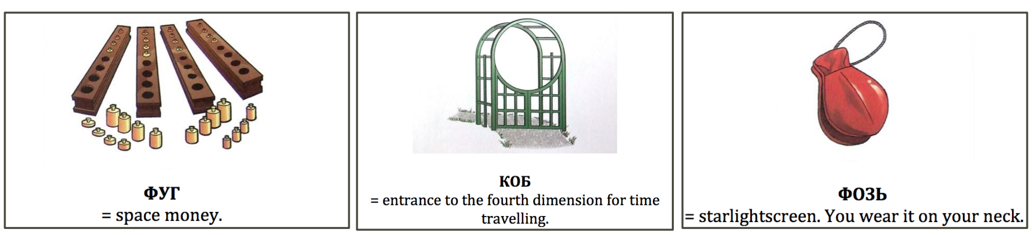

Figure 1. Examples of target words with the pictures and their assigned meaning.

Procedure

The experiment took place in a language lab and lasted about 30 minutes. At the beginning of the experiment, the participants were told that they were going on a space trip and had to learn the names of objects that they would need in their space travel.

The word-learning stage A included four exercises. The DMDX software (Forster & Forster, 2003) was used to present auditory and visual stimuli and record participants' responses. In exercise 1 the participants saw pictures with Russian words and their meanings written in English. They also heard the target words produced by a female Russian native speaker. Each picture was presented for 15 seconds (Figure 1). The participants were asked to memorize the words and their associated pictures. In exercise 2 the participants saw a picture and two Russian words at the bottom. The task was to choose the word that described the picture by pressing "1" or "2". In Exercise 3 the participants saw a picture and a question: "Is it (target word)?" at the top. The task was to decide whether the word in the question matched the picture by pressing "no" or "yes". The participants had two seconds to make their choice. Immediate feedback was provided in both exercises, and the target word was repeated for incorrect answers. In exercise 4 the participants saw a picture and were asked to say a matching word out loud within two seconds. Then the participants saw a picture with a word again and heard its pronunciation.

In stage B the participants performed a picture-naming task. The participants saw a picture and were asked to produce a word that matched the picture using a carrier phrase "Это ф… Это ф…" (e.g., This is f… This is f…). The first letter of the word was provided to facilitate retrieval. If the participants could not recall a word, they were shown the same picture with a sentence, e.g., "Я читаю. Это фуг. Это фуг." (I am reading. This is foog. This is foog). The participants were asked to read the sentence. Their productions were recorded using the software Praat (Boersma & Weenink, 2011). After the recording the participants were asked to fill in a language background questionnaire.

Data Analysis

The productions of the target words were coded based on whether they were produced from memory or by reading a sentence in order to track the potential effects of reading on participants' productions. Four durational measurements were collected from each token: (1) preceding vowel; (2) consonant (closure or frication); (3) voicing into consonant; (4) release (only for stops). The boundaries of each durational measurement were established using textgrids in Praat. Then a Praat script was run on the textgrids to extract the measurements. Voicing ratios were calculated for word-final obstruents using the following formula.

$$\text{Voicing ratio} = \frac{\text{Duration of voicing into consonant}}{\text{Duration of consonant}} \text{ x } 100\%$$

Voicing ratios showed how much voicing each consonant retained. Theoretically, a fully voiced consonant had a voicing ratio of 100%, whereas a fully voiceless consonant had a ratio of 0%.

The analysis revealed that the participants were not able to produce all the target words from memory; they read 185 tokens (36%) out of 510. A series of one-way ANOVAs was run in SPSS on the durations of the preceding vowels, consonants, voicing into consonants and release produced in voiced consonants with the within-participants factor of mode of elicitation (memory or reading). The results showed that there was no significant effect of mode of elicitation on the durational measurements of voiced consonants. Therefore, it was decided to group all tokens for analysis irrespective of the mode of elicitation because an effect of orthographic exposure was not found in the experiment.

RESULTS

The first research question asked whether low-intermediate American learners of Russian devoiced word-final voiced obstruents. The durational measurements obtained from learners' productions demonstrated expected tendencies in the manipulation of acoustic cues to differentiate underlyingly voiced and voiceless consonants, suggesting that they did not devoice voiced obstruents in word-final position. Voiced consonants had longer preceding vowels and durations of voicing into consonants, whereas voiceless consonants had longer durations of consonants and release. A series of one-way ANOVAs was run on the durational measurements to establish whether American learners distinguished voiced and voiceless obstruents in their production (Table 1).

Table 1

Mean durational measurements and standard deviations (in parentheses) for underlyingly voiced and voiceless obstruents.

Duration	**Voiced (ms)**	**Voiceless (ms)**	***p* values**
Preceding vowel	181 (56)	161 (38)	.001*
Consonant	176 (112)	218 (114)	.004*
Voicing into consonant	37 (28)	8 (12)	.000*
Release	109 (61)	119 (69)	.434

Note. * $p < .05$

Low-intermediate American learners of Russian produced significantly longer preceding vowels $F(1,255) = 11.71$, $p < .001$, shorter consonants $F(1,255) = 8.57$, $p < .004$, and more voicing into consonants $F(1,255) = 114.16$, $p < .000$ for underlyingly voiced obstruents. The learners did not employ release durations as an acoustic cue to distinguish voiced and voiceless consonants. Given that learners distinguished voiced and voiceless consonants for three out of four acoustic dimensions, we can conclude that American learners did not successfully devoice word-final voiced obstruents in Russian.

The second research question asked whether articulatory features had an effect on the degree of retained voicing in underlying voiced consonants. A series of one-way ANOVAs was run on the durations of the preceding vowels and voicing ratios only for voiced consonants with the within-participants factors of manner of articulation, place of articulation, and palatalization. The results showed that vowels were significantly shorter before voiced stops (163 ms) than before voiced fricatives (199 ms), $F(1,125) = 14.16$, $p < .000$, whereas voicing ratios were significantly longer in voiced stops (61%) than in voiced fricatives (10%), $F(1,125) = 144.93$, $p < .000$ (Table 2).

Table 2

Mean vowel durations and voicing ratios with standard deviations (in parentheses) for voiced stops and fricatives.

Duration	**Stops**		**Fricatives**	
	[+voice]	**[-voice]**	**[+voice]**	**[-voice]**
Preceding vowel (ms)	163 (44)	147 (34)	199 (61)	175 (37)
Voicing ratio (%)	61 (33)	9 (16)	10 (8)	3 (5)

The voicing ratio of voiced fricatives was very low in comparison to that of voiced stops and close to the ratio for voiceless fricatives, which suggested that the participants might have devoiced fricatives more successfully. A two-way ANOVA was run on the durations of the preceding vowels and voicing ratios with the within-participants factors of voice and manner of articulation to identify whether there was a significant difference between voiced and voiceless fricatives and stops. There was a main effect of voice, $F(1,253) = 13.3$, $p < .000$, and of manner, $F(1,253) = 32.41$, $p < .000$, on vowel durations, but there was no interaction between voice and manner. Indeed, vowels were longer before voiced obstruents. They were also longer before fricatives than before stops. There was also a main effect of voice $F(1,253) = 161.15$, $p < .000$ and of manner, $F(1,253) = 146.29$, $p < .000$, on voicing ratios, which means that voicing ratios were larger in voiced obstruents (as opposed to voiceless ones), and in stops (as opposed to fricatives). There was also a significant interaction between voice and manner $F(1,253) = 95.51$, $p < .000$. Voiced stops displayed a higher voicing ratio than voiced fricatives, $F(1,253) = 236.33$, $p < .000$, but voiceless stops vs. fricatives did not differ. Similarly, for fricatives and stops, the feature [+voice] led to higher voicing ratios, $F(1,253) = 4.25$, $p < .04$ and $F(1,253) = 253.4$, $p < .000$, respectively. Therefore, although it seems that the learners devoiced underlying voiced fricatives, in reality they differentiated both voiced and voiceless fricatives using vowel durations and voicing ratios.

Place of articulation had an effect only on vowel durations $F(2,124) = 5.19$, $p < .007$. Post hoc analysis using Tukey's HSD indicated that vowels before labials were significantly shorter than before coronals ($p = .005$). There was no significant difference in vowel durations between coronals and dorsals. Voicing ratios were not significantly affected by place of articulation (Table 3).

Table 3

Mean vowel durations and voicing ratios with standard deviations (in parentheses) for voiced labials, coronals and dorsals.

Duration	**Labial**	**Coronal**	**Dorsal**	***p value***
Preceding vowel (ms)	164 (50)	198 (58)	180 (53)	.007*
Voicing ratio (%)	38 (38)	36 (33)	31 (33)	.741

Note. * $p < .05$

No statistically significant differences were found in the durations of the preceding vowels or voicing ratios in plain and palatalized consonants. One of the reasons can be that palatalization is a challenging articulatory feature and low-intermediate learners were not able to produce it.

DISCUSSION

The study set out to examine the acquisition of the word-final devoicing rule by low-intermediate American learners of Russian. Although voiceless consonants are unmarked and American learners have the feature [-voice] in their native language, the results suggested that moderately proficient learners of Russian did not devoice word-final voiced obstruents. Underlyingly voiced consonants displayed significantly longer vowel durations and voicing into consonants, as well as significantly shorter consonant durations, which are characteristics of voiced consonants. Differences in release durations were not statistically significant.

Learners might have failed to devoice voiced obstruents for a number of reasons. First, they might have been influenced by their native English phonology, which allows voicing contrasts word-finally. In Optimality Theory terms, learners favored the faithfulness constraint over the markedness constraint. Also, Russian orthography which spells out underlyingly voiced obstruents might have misled learners into believing that Russian has word-final voicing contrasts. Learners could have been aware of the word-final devoicing rule, since they have been learning Russian for more than a year on average. However, they have not fully incorporated it in their second language phonology, at least in production, which suggests that unmarked categories can be as hard to acquire as marked.

The study also attempted to establish the effect of articulatory features, such as manner of articulation, place of articulation and palatalization, on the degree of voicing preserved in voiced consonants word-finally. Manner of articulation seems to have a strong effect on the degree of voicing in word-final consonants. Voiced fricatives have much smaller voicing ratios than stops do, which supports Ohala's claim that "to the extent that the segment retains voicing it may be less of a fricative, and if it is a good fricative it runs the risk of being devoiced" (Ohala, 1993, p. 201). However, despite low voicing ratios, there were significant differences between underlyingly voiced and voiceless fricatives, which indicated that learners do not actually neutralize fricatives. Variation in the degree of voicing in word-final fricatives observed in the productions of American learners can be explained by the airstream mechanism and aerodynamic characteristics of fricatives, rather than by learners' application of the word-final devoicing rule. Moreover, learners used durations of the preceding vowel as an additional way to encode [+voice]. In conclusion, the ability to devoice word-final voiced consonants, even fricatives, which are more susceptible to devoicing, does not seem to be easily acquired by native speakers of non-neutralizing languages such as English.

The finding that manner of articulation has a strong effect on the degree of preserved voicing carries an important methodological implication for studies that seek to investigate voicing neutralization. Data from test materials that include stops and fricatives should be analyzed separately. Otherwise, the results can be skewed in favor of devoicing if fricatives are used in most of the test tokens or, vice versa, in favor of voicing, if stops represent the majority of the tokens.

Place of articulation had a significant effect on preceding vowel durations but not voicing ratios.

However, raw data show that labials have larger voicing ratios than dorsals, which supports Ohala's claim that labials can sustain voicing better than dorsals. Palatalization did not have an effect on the degree of voicing. However, recruiting advanced participants in a future study might reveal this effect more clearly because advanced participants are likely to be more accurate at producing palatalized consonants than low-intermediate learners.

Future research can be directed in two ways. Recruiting advanced participants will answer the question as to whether American learners of Russian learn to devoice word-final voiced obstruents at later stages of acquisition. It will also test the effects of palatalization more efficiently. The second direction will involve recruiting native speakers of Russian and English to investigate the effects of articulatory features on the feature [+voice] in neutralizing and non-neutralizing languages. It will help establish whether such effects are language-general, language-specific or only observed in interlanguage.

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