THE IDENTIFIABILITY AND DISCRIMINABILITY BETWEEN INCOMPLETELY NEUTRALIZED SOUNDS: EVIDENCE FROM RUSSIAN

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ABSTRACT

This paper examines the identifiability and discriminability of speech sounds in a neutralized position. As in other languages, it is reported that Russian word-final devoicing in Russian is shown to be incomplete in production. In order to examine the perceptual status between incompletely neutralized sounds, both identification and discrimination performance were analyzed and compared.

The results revealed that listeners were not only sensitive to slight acoustic differences between the two sounds, but also able to identify them, indicating that voicing neutralization in Russian is incomplete *in perception* as well. Moreover, the comparison between identifiability and discriminability showed the predominance of the latter over the former.

Keywords: speech perception, incomplete neutralization, final devoicing

1. INTRODUCTION

For the last two decades, various phonological models have been reexamined in terms of speech production and perception. One of the widely studied examples is final devoicing, i.e. voicing neutralization in word-final position. In final-devoicing languages, the distinction between voiced and voiceless obstruents is assumed to be lost in word-final position.

Contrary to this assumption, however, a number of studies report that some consistent acoustic differences exist between putative neutralized sounds ([2, 11, 12, 14] and more). These findings suggest that the neutralization is incomplete in production. For example, Dmitrieva [3] and Dmitrieva, et al. [4] examined Russian final devoicing and revealed that the duration of vowels preceding underlying voiced obstruents and voicing into closure/ frication duration were longer than those preceding underlying voiceless sounds. The closure/ frication duration and the release portion of underlying voiceless obstruents were longer than voiced counterparts. Moreover, increasing evidence reveals that in many languages, the realization of neutralized sounds is affected also by various factors [4, 5, 6, 10, 11, 14].

Another long outstanding question is perception in a given position: if such small but consistent differences are available in the neutralized position, are they perceptible? The question is theoretically important, because their perceptual status leads to at least three possible conclusions. Firstly, if the differences are very perceptible for listeners, then it means that those sounds are not neutralized, but rather that such differences actually serve as cues for underlying voicing distinction in the final position. Secondly, if they are not perceptible at all (i.e. chance accuracy), then those sounds are completely neutralized at least in perception. And, thirdly, if they are not very perceptible but accuracy is above chance level, then those sounds are incompletely neutralized, not only in production but also in perception.

Several studies have tried to answer this question in German [7, 11, 12], in Polish [13], and in Dutch [14]. These studies reported that listeners significantly identified two sounds with above-chance-level accuracy, though obviously the accuracy was not very good. The findings from these previous studies suggest that, whereas speakers intended to distinguish the putative neutralized sounds at least in production, listeners often misperceived these sounds.

What, then, causes the sounds to be misperceived? An acoustic subtleness may play a role, at least in part, in the misperception: listeners can not perceive the differences, simply because the differences are acoustically quite small. In any case, it remains unclear what factors make it

difficult to correctly perceive the putative neutralized sounds.

It should be noted that previous studies analyze only the listeners' identification performance. No analyses have hitherto been undertaken on the listener's *discrimination* performance. Thus, the examination of not only identifiablity but also discriminability might shed new light on the perception of incompletely neutralized sounds.

The present study focuses on the identifiability and the discriminability of Russian word-final devoicing. No studies have been conducted to examine perceptual status of Russian final devoicing.

Therefore, the primary aim of the present study is to report the perceptual status of Russian final devoicing by analyzing identification performance, which will enable us to directly compare our results with the results from previous perceptual studies. The secondary aim is to reveal what perceptual events happen in neutralized position, by comparing identification with discrimination performance.

2. METHOD

2.1. Participants

Participants were six Russian-native speakers from several areas of the Russian federation: three from Moscow, one from Saint Petersburg, one from Bryansk, and one from Krasnodar. Of these participants, four were female and two were male. Their ages ranged between 20 and 30. In addition to the Russian language, all of them speak at least English and Japanese as foreign languages, though their proficiencies vary. None of them had a hearing disorder.

Table 1: The duration characteristics of stimuli (ms).

	/rok/ 'fate'	/rog/ 'horn'	difference
Vowel	87	115	28
Voicing into closure	20	26	6
Closure	131	120	11
Release	62	47	15
	/luk/ 'onion'	/lug/ 'meadow'	difference
Vowel	89	95	6
Voicing into closure	17	21	4
Closure	130	110	20
Release	97	75	22

2.2. Stimuli

The stimuli consisted of two minimal pairs contrasting underlying voicing of word-final consonants. The word pairs and their acoustic differences are illustrated in Table 1. All of four tokens were pronounced by a native female speaker and recorded in 2009 as a part of the author's previous study. As shown in Table 1, they contain similar acoustic differences reported by Dmirtieva [3] and Dmitrieva, et al [4].

Tokens were elicited and produced spontaneously. Because they were not read but elicited, pairs of tokens with minimum intonation differences were carefully selected.

2.3. Procedure

Participants completed two kinds of perceptual tasks, described below. Both of the tasks were designed using Praat [1]. All items were presented via the SONY MDR-Z700 headphone.

2.3.1. The discrimination task

In each trial, three items were presented in an AXB format. In this format, A and B were always tokens of minimal pair. X was physically identical either to A or B. Therefore, the task consisted of four trial types: AAB, ABB, BBA, BAA. Participants were asked to respond whether X (the second item) was same as the first or third item by clicking the button on the screen. The task contained 80 trials in 20-trial blocks (two minimal pairs, four trial types, 10 repetition), which were presented in random order. The inter-stimulus interval was fixed on 500 ms.

2.3.2. The identification task

In each trial, one item was presented, and participants were asked to choose the item they heard from two possible choices. The choices were orthographically presented on the screen. For example, if the item /rok/ is presented, the possible choices are "*rok*" and "*rog*". In this case, if the listener responded with "*rok*", then the response is counted as correct. The task contained 80 trials in 20-trial blocks (two minimal pairs, 20 repetitions). Of 20 repetitions of each trial, possible place effect of orthographic representation was counterbalanced: Half of the trials were presented with the "*k*" button on the left and the "g" button on the right, and the other half with the "g" on the left and the "*k*" on the right.

In order to control the possible effect by the task-order, half of participants completed the identification task first, and then the discrimination task. The other half of participants did the tasks in the opposite order. The instructions including the practicing session were all written in Russian and presented by means of Microsoft Powerpoint.

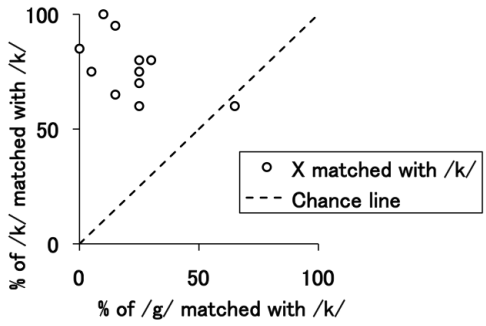
3. RESULTS

Responses were counted per each word pair per each subject, and then converted to percentage values (3.1. and 3.2.) and d' values (3.3.).

3.1. Discriminability

Figure 1 shows the distribution of percentage values of X (the second item in a trial) matched with /k/ and /g/ respectively.

Figure 1: The distribution of percentage values of /g/ stimuli matched with /k/ stimuli (horizontal axis), and /k/ stimuli matched with /k/ stimuli (vertical axis). Each dot indicates each word pair per each subject. The broken line indicates chance line.

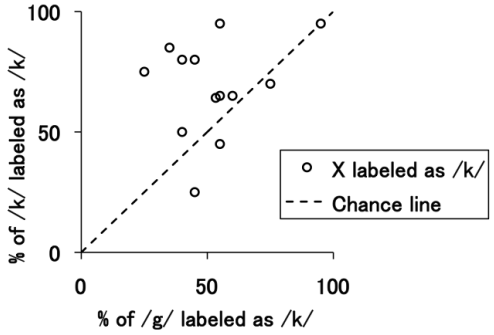


Two-way repeated measures Analysis of Variance (ANOVA) was conducted on the percentage value of 'X-matched-with-/k/' responses, with "Underlying Representation (/k/ vs. /g/)" and "Word Pair (/lug/-/luk/ vs. /rog/-/rok/)" as the factors. The main effect of Underlying Representation was significant ($F(1,5) = 37.355$, $p < .005$). Neither the main effect of Word Pair nor of the interaction were significant ($F(1,5) = .518$, $p = .087$, $F(1,5) = .040$, $p = .850$). The result indicates that listeners significantly discriminate /k/ stimuli from /g/ stimuli.

3.2. Identifiability

Figure 2 shows the distribution of percentage values of 'k' responses to /k/ and /g/ stimuli respectively. Two-way repeated measures ANOVA was conducted on the percentage value of 'k' responses, with "Underlying Representation (/k/ vs. /g/)" and "Word Pair (/lug/-/luk/ vs. /rog/-/rok/)" as the factors. The main effect of Underlying Representation was marginally significant ($F(1,5) = 6.286$, $p = .054$). On the other hand, the main effect of Word Pair was not significant ($F(1,5) = .115$, $p = .748$), nor was the interaction ($F(1,5) = .686$, $p = .445$). The result indicates that listeners could identify these sounds with marginally significant accuracy.

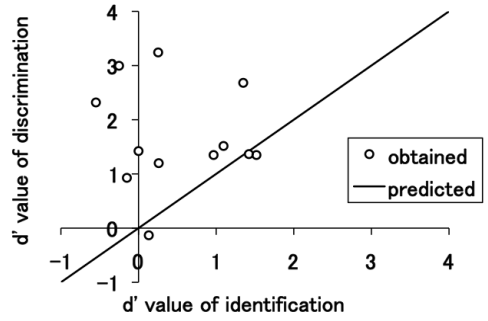
Figure 2: The distribution of percentage values of /k/ responses to /g/ stimuli (horizontal axis) and /k/ responses to /k/ stimuli (vertical axis). Each dot indicates each word pair per each subject. The broken line indicates chance line.



3.3. The comparison between identifiability and discriminability

Like several previous studies (for example, Warner, et al. [14]), d' values were calculated[1] as a measure of sensitivity (Figure 3). The higher value of d' indicates the higher sensitivity.

Figure 3: The distribution of d' values of identification (horizontal axis) and discrimination (vertical axis). Each dot indicates each word pair per each subject[2]. The solid line indicates the predicted line. If the identifiability and discriminability were equal, the dot would be plotted on the predicted line.



Two-way repeated measures ANOVA was conducted on d' values, with "Task (identification vs. discrimination)" and "Word Pair (/lug/-/luk/ vs. /rog/-/rok/)" as the factors. The main effect of Task

was significant ($F(1,5) = 12.565$, $p < .05$). Neither the main effect of Word Pair nor of the interaction were significant ($F(1,5) = .381$, $p = .564$, $F(1,5) = .107$, $p = .757$). The result indicates the listeners' identifiability and discriminability are significantly different.

4. DISCUSSION AND CONCLUSION

The results of the experiment, which examined the perceptual status of Russian final devoicing, support the idea that word-final voicing neutralization in Russian is incomplete, not only in production but also in perception. Firstly, the discrimination task showed that slight acoustic differences were audible to listeners. Secondly, the identification task revealed that listeners could make use of audible differences for identification with above-chance-level accuracy, though the probability is statistically marginal. Lastly, the comparison between the two kinds of tasks revealed that listeners were significantly less sensitive to differences in identification, than in discrimination.

The predominance of discriminability over identifiablity revealed in the present experiment has been suggested by classical studies in speech perception [8].

There is still room for improvement in the experimental design. In the discrimination task, participants were asked to match two physically identical utterances. Under this design, listeners could have responded not on the basis of voicing distinctions but rather of physical differences. Future studies with a more refined method are necessary in order to verify the results of the present experiment.

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[1] The following formula was used: d' = z (H) – z (F). z (H) is the z-transformed probability to response X to X item, and z (F) is the z-transformed probability to response X to Y item (see [9]).

[2] Two cases in the discrimination task were implied infinite d' (i.e. perfect accuracy). In order to avoid the infinite value, they were converted to finite values by applying the strategy suggested in Macmillan and Creelman [9].