The Role of Vocalic Context in the Perception of Polish Sibilants

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ABSTRACT

This paper is a report on a perceptual experiment testing the possible role that cues residing in the vocalic environment may play in the recognition and categorization of Polish sibilant consonants. Five subjects participated in a listening task in which they were exposed to both normal VCV stimuli, as well as ones in which the medial consonants had been cross-spliced. The results show that cues present in the vocalic context may override those coming from the fricative noise. It is suggested that these results may be helpful in explaining an unexpected pattern of mergers found in Polish dialects, with a possible counterpart in varieties of Mandarin.

1. INTRODUCTION

Standard Polish is one of the few languages known to contrast sibilant fricatives and affricates at more than two distinct places of articulation. In Ladefoged and Maddieson [1], the three series are described as "dental", "flat post-alveolar (retroflex)" and "palatalized post-alveolar (alveolo-palatal)", respectively. In this paper, the terms "dental", "retroflex" and "alveopalatal" will be used for simplicity. It should be noted, however, that no claims are made as to the articulatory correctness of this terminology and that it is not uncontroversial (see for instance Hamann [2] for a discussion of the use of the term "retroflex").

An example of a minimal triplet is provided by the following forms: *kasa* "cash register", *Kasia* "Kate" and *kasza* "groats", where the letter *s* and the letter combinations *si* and *sz* correspond to voiceless dental, alveopalatal and retroflex fricatives, respectively. At all of these places of articulation, there occur as well voiced fricatives and both voiceless and voiced affricates.

Consistent anecdotal evidence suggests that speakers of other languages find it very difficult to accurately perceive the contrast between the retroflex and the palatal sibilants. This is unsurprising given the similarity of their spectra, as demonstrated for instance by Kudela [3]. What is surprising is the fact that in those Polish dialects that do not preserve the threefold contrast, the disappearing retroflex sibilants merge with articulatorily and acoustically more distinct dentals (see for instance Klemensiewicz et. al [4]). This is unexpected if sound change is a result of misperception of the acoustic signal, as argued by Ohala [5]. Even more interestingly, the same pattern of mergers occurs in varieties of Mandarin, an unrelated language with a very similar set of contrasts among sibilants (see Duanmu [6]).

A potential answer to this problem lies in the fact that the effect of alveopalatals on the neighboring vowels seems to be rather different than that of both retroflexes and dentals. In the Polish phonetic and phonological literature, it is usually claimed that some vowels have allophones significantly different from their normal variants when they occur in the neighborhood of the alveopalatal consonants. Thus Dukiewicz and Sawicka [7], for instance, conclude that non-high vowels are regularly raised and fronted when they occur between such consonants, and with great frequency if they follow one of them.

Regardless of whether this effect is phonological or phonetic, it is conceivable that speakers of Polish may use the information included in the vocalic context to differentiate between the three types of sibilants. If such cues are strong enough to override the information included in the fricative noise itself, this would make the joint patterning of dentals and retroflexes, to the exclusion of alveopalatals, more natural.

To test this hypothesis, an experiment was conducted, as reported in the remainder of this paper.

2. METHOD

A 23 year old native male speaker of Polish recorded a series of CVCV nonce words. In these words, both consonants and both vowels were identical. The consonants were voiceless sibilant affricates at the three places of articulation (orthographic *c*, *ci* and *cz* for dentals, alveopalatals and retroflexes respectively) and voiceless sibilant fricatives (*s*, *si* and *sz*). The former were combined with the mid front vowel *e*, and the latter with the low back vowel *a* and the mid back vowel *o*. Altogether, nine nonce words were recorded: *cece*, *ciecie*, *czecze*, *sasa*, *siasia*, *szasza*, *soso*, *siosio* and *szoszo*. (Two of them, *sasa* and *soso*, could potentially be proper nouns, other are meaningless).

Next, the initial consonants were removed, together with that part of the first vowel which was judged to contain formant transitions from that consonants (evaluated by observing the displacement of the F1 and F2 from what appeared to be the steady state part of the vowel).

Next, the remaining middle consonants were removed from their original contexts and cross-spliced into the

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words that contained the same vowels, but originally different consonants. In this way, 18 new words were added to the 9 previously created, yielding a total of 27 words. Thus there were now 3 words *ece*, one of them from the original *cece*, another with the *c* spliced in place of the original *ci* in *ecie* and another with the *c* spliced in place of the original *cz* in *ecze.*

In the experiment, a total of 180 tokens were used. Each of the 27 words was repeated 6 times, the only exception being the original words containing the alveopalatals (*ecie*, *asia* and *osio*), which were used 12 times. This was done because, based on the researcher's own perceptions of the cross-spliced words, it was anticipated that in many cases the alveopalatals will not be recognized correctly when removed from their original context. It was feared that subjects in the experiment would become conscious of there being far fewer alveopalatal tokens and that this may bias their decisions. The tokens were then randomized (10 different randomizations were used).

The subjects in the experiment were 5 native speakers of Polish. One of them (#1) was fluent in French and English and has spent several years living outside of Poland. Subject #2 had some competence in German. The other three were virtually fully monolingual. Subject #5 was male, the other were female.

The subjects listened to the tokens separated by 3 seconds of silence each. Their task was to circle the orthographic symbol corresponding to a dental, retroflex or alveopalatal consonant, according to their impression of what the medial consonant in the relevant word was. (The orthographic distinction between these consonants is not ambiguous in Polish when *ć* and *ś* are used to represent the alveopalatals, as was the case here. Notice that these symbols are the non-prevocalic variants of *ci* and *si*, respectively). Only one answer could be chosen, and in no case did a subject decline to make a choice. (Though in some cases they wrote in question marks etc. to indicate strange quality; these additions were ignored altogether).

3. RESULTS AND STATISTICAL ANALYSIS

The results obtained were analyzed separately for each subject using chi-square test for goodness of fit. The responses were divided into those given to stimuli with no cross-splicing and to those given to stimuli with cross-splicing. Each vowel context was treated separately. In each case, the null hypothesis was that the distribution of answers (i.e. the numbers of stimuli categorized as containing a dental, an alveopalatal and a retroflex) will not be different from the distribution of the actual consonants in the stimulus set, ignoring the vowel context in which they appear. The results are summarized in Tables 1-6. Statistically significant results (with $p < .05$ as the minimum criterion) are in bold. In addition, table 7 provides information about the total number of times consonants were incorrectly categorized. (With information pooled together for all subjects and conditions). As can be seen in that table, there were very few confusions of consonants ocurring in their original environments. Among other things, this clearly shows that the consistency of obtained frequencies with expected frequencies in the no-splicing condition was not due to random guessing by the subjects.

Subject	*Answers*			*Chi-square*
	Dental	*Alveop.*	*Retroflex*	*(df=2)*
1	6	12	6	0, ns.
2	7	12	5	.33, ns.
3	6	12	6	0, ns.
4	6	12	6	0, ns.
5	6	12	6	0, ns.
Expected	6	12	6	N/A

Table 1: Results of the perception test of *e* words with no cross-splicing.

Subject	*Answers*			*Chi-square*
	Dental	*Alveop.*	*Retroflex*	*(df=2)*
1	13	1	22	**18.49 p<.005**
2	16	8	12	2.67, ns.
3	14	4	18	**8.67 p<.025**
4	13	9	14	1.17, ns.
5	23	5	8	**15.5 p<.005**
Expected	12	12	12	N/A

Table 2: Results of the perception test of *e* words with cross-splicing.

Subject	*Answers*			*Chi-square*
	Dental	*Alveop.*	*Retroflex*	*(df=2)*
1	6	12	6	0, ns.
2	9	12	3	1.5, ns.
3	8	11	5	0.92, ns.
4	8	11	5	0, ns.
5	9	12	3	1.5, ns.
Expected	6	12	6	N/A

Table 3: Results of the perception test of *a* words with no cross-splicing.

Subject	*Answers*			*Chi-square*
	Dental	*Alveop.*	*Retroflex*	*(df=2)*
1	12	5	19	**8.17 p<.025**
2	20	10	6	**8.67 p<.025**
3	15	3	18	**10.5 p<.01**
4	12	5	19	**8.17 p<.025**
5	18	12	6	**6 p<.05**
Expected	12	12	12	N/A

Table 4: Results of the perception test of *a* words with cross-splicing.

Subject	*Answers*			*Chi-square*
	Dental	*Alveop.*	*Retroflex*	*(df=2)*
1	6	12	6	0, ns.
2	6	12	6	0, ns.
3	6	12	6	0, ns.
4	6	12	6	0, ns.
5	6	12	6	0, ns.
Expected	6	12	6	N/A

Table 5: Results of the perception test of *o* words with no cross-splicing.

Subject	*Answers*			*Chi-square*
	Dental	*Alveop.*	*Retroflex*	*(df=2)*
1	12	12	12	0, ns.
2	12	17	7	4.16, ns.
3	11	10	14	.75, ns.
4	12	5	19	**8.17 p<.025**
5	6	23	7	**15.17 p<.005**
Expected	12	12	12	N/A

Table 6: Results of the perception test of *o* words with cross-splicing.

Consonant type	*Vocalic context*		
	Dental	*Alveopalatal*	*Retroflex*
Dental	90 (90)	76 (90)	89 (90)
Alveopalatal	33 (90)	179 (180)	28 (90)
Retroflex	89 (90)	29 (90)	82 (90)

Table 7: Incorrectly recognized consonants (rows) in the three vocalic environments (columns). Data for all subjects pooled together. The total numbers of relevant stimuli are indicated in brackets.

4. DISCUSSION

The results reported above show that in no case was there any statistically significant difference between the distribution of answers and the distribution of the consonants in the stimuli when no cross-splicing was done. This provides justification for expecting a similar result when cross-splicing has occurred, *unless the vocalic context is an important cue to the identity of the consonant.*

In 10 out of 15 cases analyzed above, there were statistically significant differences between the distribution of answers and the distribution of consonants in the stimuli, showing that cross-splicing the fricatives has made their correct identification more difficult for the subjects. Most strikingly, all subjects had significant differences in the stimuli of the *asa*, *asia*, *asza* type. On the other hand, only subject #5 had significant results in all cases.

The strongest generalization coming from a closer examination of the results shows that in most cases we are dealing with a dramatic reduction in the number of alveopalatals perceived in the stimuli. (This is the case with the results of subjects 1,3 and 5 in *e* words, 1,3 and 4 in *a* words and 4 in *o words*). This fits well with the hypothesis that the vowel context plays an important role in the discrimination of the sibilant fricatives. Since, as argued above, they have the most profound effect on their vocalic environment, it is not surprising that listeners find it this environment the most useful cue in this particular case. (It is also important that dentals and retroflexes are similar to each other in not having such a profound effect on their vocalic environments, and hence in their case using the vocalic cues is much less reliable).

In most cases (subjects 1 and 3 in *e words*, 1, 3 and 4 in *a* words and 4 in *o* words) the reduction in the proportion of answers pointing to alveopalatals is accompanied by a greater increase in retroflex answers (as opposed to dental). This is also an expected pattern, under the following analysis. When the subjects incorrectly decided against categorizing the stimuli in question as containing alveopalatals (because in the cross-spliced condition the vocalic cues were missing), they opted for the retroflex

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answer because that sound type, as argued above, has the most acoustically similar fricative noise.

This leaves unexplained the few cases in which the number of answers pointing to the retroflex sibilants has also decreased in the cross-splicing condition. This is a combination of two factors: increased perception of dentals on the one hand and increased perception of retroflexes as alveopalatals in the alveopalatal context. Interestingly, of four such cases, three represent the results of subject 5 in each of the three vowel conditions. It is unclear what is the reason is for such divergence of this subject's results from this of the other subjects. The fact that he was the only male in the pool seems to be a very unlikely factor, but further investigation is needed.

5. CONCLUSION

The results reported above clearly indicate that the information included in the vocalic environment of the Polish sibilants may be a very robust cue that is capable of overshadowing the properties of the fricative noise itself. As has been suggested in the Introduction, this may have relevance for some questions in the historical phonology of Polish (and perhaps also other languages), in as much as mergers and their directionality can be hoped to be accounted for by phonetically natural principles. Further work is needed however. It is hoped that further tests can be conducted using stimuli in which the vowels preceding the target consonant will not have originally appeared between two such identical consonants. (This was done in this study because the original question was whether there are *any* circumstances under which the vocalic context cues can override the cues coming from the fricative noise of the Polish sibilants). Another important task is determining in a more precise way the nature of the cues present in the vocalic context, especially the relative role of formant transitions and steady states.

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