The Recognition of Geminates in Ambiguous Contexts in Polish

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Abstract

This paper examines the pre-vocalic long fricative /v:/ occurring in a context in which the difference in meaning between two sentences, one with a short fricative and one with a long fricative, is solely dependent on the perception of the consonant length. The goal is to investigate the perception of the segmental duration with the length varying between that of a short and that of long consonant. Perception is measured in terms of responses to stimuli of various lengths produced by 26 Polish subjects and in terms of the melodic variation (F0) found in their responses.

1. Introduction

Polish geminates are either underlying or derived through gemination across morpheme and clitic boundaries. Morphologically complex words can contrast with morphologically simpler words solely on the basis of consonant gemination. For example, the words *wozi* /voʑi/ 'transports' and *wwozi* /v:oʑi/ 'brings in' form a minimal pair which is distinguished by the presence of either the singleton fricative /v/ or the geminate fricative /v:/ formed by the concatenation of the prefix *w-* /v/ (marking the equivalent of the preposition 'in') with the verb root *wozi* /voʑi/ 'transports'.

This pilot study aims to determine the extent to which the variation in duration affects the listener's ability to discriminate between a short and long fricative; and, to investigate if there is any correlation between the long fricative and the duration of the following vowel. Also examined is the correlation between consonant length and fundamental frequency variation in the sentence, that is the intonation of the sentence [4, 7,9].

The results shed light not only on the phonetic but also the non-phonetic nature of the perception of geminate fricatives. The perception of the geminate /v:/ correlates with morphological complexity introduced by this geminate and with the nonpredictability of the meaning from the context.

1.1 Geminate fricatives

Although geminate fricatives have not been studied as often as geminate stops, there is some literature on them [5, 6]. Acoustic studies dealing with prevocalic geminate fricatives point to duration as the primary cue for perception [1]. In his study of Pattani Malay geminates, Abramson (1998) found the fundamental frequency ratio and the amplitude ratio of the first syllable to the second syllable for words beginning with short and long continuants (fricatives, nasals and laterals) to be important secondary cues.

2. Experiment

2.1. Methodology

The methodology, adopted from earlier studies on geminates [8], was to use stimuli with their length varying between that of a non-geminate and that of a geminate.

2.2. Procedure

26 native speakers of Polish were recorded. They all were speakers of standard Polish; no one had any known record of speech or hearing disorders, nor any indication of such. Each subject was asked to repeat 57 Polish sentences after the investigator. The two target sentences were:

1. Ona **wozi** mleko. 'She transports milk.'
2. Ona **wwozi** mleko. 'She brings in the milk.'

The sole difference between sentence 1 and sentence 2 was the difference between the short fricative /v/ and the long fricative /v:/. The length of long /v:/ ranged from 110 to 340 ms.

The subjects spoke into a Sony microphone IMP 3000Q from a distance of about 40 cm. The data were recorded on a Sony MZ-R37 recorder and processed with Macquirer and PitchWorks. The speech was digitized at a sampling rate of 11, 025 Hz.

2.3. Measurements

Measurements were taken from each digitized sound file using wave form and spectrographic displays in addition to the sound of the token. The beginning of the fricative was taken to be the termination of F2 in the preceding vowel. The end of the fricative was taken to be the end of the frication noise and the onset of F2 of the following vowel.

3. Results

3.1. Duration of the fricative /v:/

Twelve subjects heard long fricatives /v:/ of 147 ms or longer. In response, nine of them produced a long fricative; three of them produced a short fricative (see section 3.1.1).

There was a discrepancy between the length of the /v:/ the subjects needed to perceive a /v:/ and the length of the /v:/ that they produced in response. In the experiment the difference in the meaning of sentences was always coded solely by consonant length; under these conditions, the subjects required /v:/ to be at least 147 ms before they responded with a long consonant. In their own responses, however, the fricative was sometimes below 147 ms, namely, it was sometimes between 120 and 132 ms.

In table 1, two sets of durational values of the long fricative /v:/ are presented. In the first part, STIMULI, the lengths of /v:/ produced by the investigator for each subject are given. In the second part, RESPONSE, the lengths of /v:/ produced by each speaker are given.

	STIMULI	/v:/	RESPONSE	/v:/
1	to EM	152 ms	EM	120 ms
2	to AAg	154 ms	AAg	128 ms
3	to HJ	167 ms	HJ	130 ms
4	to BT	153 ms	BT	132 ms
5	to JZg	147 ms	JZg	174 ms
6	to KA	238 ms	KA	193 ms
7	to JP	164 ms	JP	250 ms
8	to LS	167 ms	LS	277 ms
9	to MTg	341 ms	MTg	309 ms
	MEAN	187 ms	MEAN	190 ms

Table 1: Durations of /v:/ in /v:oʑi/

The mean duration of /v:/ was 190 ms, well over twice as long as the duration of the short fricative produced by the same subjects, which was 71 ms. The mean singleton-to-geminate duration ratio was 1:2.5; the individual duration ratios varied considerably, from 1:1.6 to 1:3.1.

3.1.1 Singletons in responses.

Three speakers produced a singleton, even though the fricative they had heard in /v:oʑi/ was clearly a long consonant, ranging from 152 to 261 ms. In table 2, the durational values for the fricative and for the following vowel as produced by the investigator and by the subjects are given.

STIMULI	/v:/	/o/	RESPONSE	/v/	/o/
to MS	152 ms	140 ms	MS	54 ms	80 ms
to AN	261 ms	166 ms	AN	83 ms	71 ms
to ZO	219 ms	154 ms	ZO	95 ms	91 ms

Table 2: Singletons in responses

Two of the subjects who were asked to repeat the sentence with the target word /v:oʑi/ at the end of the recording session once again produced a short fricative. Interestingly, however, they produced a long vowel.

STIMULI	/v:/	/o/	RESPONSE	/v/	/o/
to MS 1	152 ms	140 ms	MS 1	54 ms	80 ms
to MS 2	153 ms	150 ms	MS 2	78 ms	134 ms
to AN 1	261 ms	166 ms	AN 1	83 ms	71 ms
to AN 2	238 ms	150 ms	AN 3	97 ms	133 ms

Table 3: Singletons in responses

The misidentification of the long fricative /v:/ points to a preference for the monomorphemic word /voʑi/ over morphologically more complex /v:oʑi/ in an ambiguous context.

3.1.3. Vowel length

The mean duration for the vowel /o/ in a syllable following the short fricative /v/ was 95 ms; the mean duration of the vowel /o/ in a syllable following the long fricative /v:/ was 120 ms. A tabulated comparison between the duration of /o/ with the singleton /v/ and the geminate /v:/ for the nine speakers is presented below.

	SPEAKER	/o/ in /voʑi/	/o/ in /v:oʑi/
1	JZg	95 ms	88 ms
2	JP	110 ms	93 ms
3	BT	99 ms	108 ms
4	HJ	99 ms	109 ms
5	EM	75 ms	117 ms
6	AAg	89 ms	119 ms
7	LS	103 ms	145 ms
8	MTg	104 ms	150 ms
9	KA	81 ms	154 ms
	MEAN	95 ms	120 ms

Table 4: Duration of /o/

The duration of the vowel /o/ varied considerably in the responses given by the nine speakers. 78% of the time, the vowel /o/ was longer in the syllable with the long fricative; the mean ratio of /o/ in /voʑi/ to /o/ in /v:oʑi/ was 1:1.4. 22% of the time, the duration of /o/ was shorter in the syllable with the geminate /v:/ than in the syllable with the singleton /v/.

3.2. Perception of /v:/ with shorter durations

Of the 26 recorded subjects, 14 heard geminates /v:/ with shorter durations, ranging from 110 to 135 ms. In response, they all produced the singleton /v/.

STIMULI	/v:/	/o/	RESPONSE	/v/	/o/
to HS	110 ms	107 ms	HS	75 ms	43 ms
to AX	110 ms	120 ms	AX	81 ms	72 ms
to DG	110 ms	125 ms	DG	73 ms	86 ms
toAWg	112 ms	122 ms	AWg	68 ms	72 ms
to AIg	115 ms	158 ms	AIg	97 ms	77 ms
to DW	117 ms	142 ms	DW	70 ms	94 ms
to KS	119 ms	138 ms	KS	61 ms	107 ms
to IZg	121 ms	147 ms	IZg	57 ms	106 ms
to KR	122 ms	131 ms	KR	87 ms	144 ms
to AA	123 ms	104 ms	AA	87 ms	79 ms
to DM	123 ms	117 ms	DM	83 ms	74 ms
to AGg	130 ms	117 ms	AGg	93 ms	132 ms
to AG	135 ms	147 ms	AG	81 ms	94 ms
to AK	135 ms	109 ms	AK	78 ms	69 ms
MEAN	120 ms	127 ms	MEAN	78 ms	89 ms

Table 5: Perception of geminates with shorter durations

The data show that, although the vowel /o/ was longer when a geminate rather than a singleton was in the onset, if the fricative itself was not long enough, the greater vowel length did not lead the subjects to perceive the phonetically long fricative as geminate.

STIMULI	/v:/	/o/	RESPONSE	/v/,/v:/	/o/
to DG1	111 ms	125 ms	DG 1	73 ms	86 ms
to DG2	178 ms	130 ms	DG 2	218 ms	119 ms
toAIg1	115 ms	158 ms	AIg 1	97 ms	77 ms
toAIg2	237 ms	157 ms	AIg 2	161 ms	97 ms

Table 6: From the singleton to the geminate

Subsequently, an increase in the consonant length gave the subjects the right cue for the long consonant /v:/. Subjects DG and AIg produced /v:/ when consonant length was increased.

3.3. F0 patterns

The sentence *Ona wozi mleko* /ona voʑi mleko/ was produced with a falling F0 by 23 speakers (88%) and with a level-falling F0 by 3 speakers (12%). The falling F0 had a slope between 13 and 69 Hz on /vo/ in /voʑi/ and between 14 and 64 Hz on /mle/ in /mleko/. The level-falling F0 had a slight slope, falling between 2 and 6 Hz on /vo/ in /v:oʑi/ and between 13 and 27 Hz on /mle/ in /mleko/ [3].

In the group of 9 speakers who produced the long fricative /v:/, four uttered the sentence *Ona wwozi mleko* /ona v:oʑi mleko/ with a slightly falling F0 on /v:o/ and on /mle/.

Speaker	F0 on /na/	Falling F0 on /v:o/	Falling F0 on /mle/
EM	212 Hz	208 Hz	205 Hz
JP	115 Hz	122 Hz	117 Hz
AAg	224 Hz	210 Hz	187 Hz
BT	226 Hz	220 Hz	201 Hz

Table 7: Falling F0

Five other speakers produced a very different F0 contour, one that occurred neither with the sentence with the short fricative /v/, nor with the remaining 55 non-target sentences. The new F0 contour is characterized by a rising F0 on /v:o/, pitch height maintenance on /ʑi/ and a drop on /mle/ (a flat hat).

Speaker	F0 on /na/	Rising F0 on /v:o/	Falling F0 on /mle/
JZg	210 Hz	227 Hz	213 Hz
KA	234 Hz	262 Hz	217 Hz
MTg	144 Hz	162 Hz	117 Hz
LS	168 Hz	216 Hz	177 Hz
HJ	190 Hz	225 Hz	183 Hz

Table 8: Flat hat F0

The F0 rise on /v:o/ was from 17 to 48 Hz, with the following syllable /ʑi/ either at the same height or raised higher (10 Hz by one speaker and 27 Hz by another); the F0 fall on /mle/ was from 23 to 72 Hz.

The 17 speakers who produced a short fricative /v/ in response to hearing the long fricative /v:/ patterned with the group of speakers that produced the long fricative. 11 of them produced a falling F0.

Speaker	F0on /na/	Falling on /vo/	Falling on /ʑi/	Falling on /mle/
AK	218 Hz	216 Hz	200 Hz	189 Hz
DW	230 Hz	208 Hz	208 Hz	204 Hz
AAg	231 Hz	205 Hz	205 Hz	189 Hz
KR	256 Hz	223 Hz	205 Hz	179 Hz
AIg	216 Hz	196 Hz	188 Hz	175 Hz
ZO	250 Hz	239 Hz	221 Hz	222 Hz
AX	246 Hz	230 Hz	225 Hz	220 Hz
AAg	231 Hz	205 Hz	205 Hz	189 Hz
AG	262 Hz	225 Hz	225 Hz	201 Hz
HS	226 Hz	183 Hz	183 Hz	155 Hz
MS	297 Hz	244 Hz	243 Hz	226 Hz
DG	246 Hz	243 Hz	229 Hz	218 Hz

Table 9: Falling F0

Six speakers produced a flat hat F0.

Speaker	F0 on /na/	Rising on /vo/	Level F0 on /ʑi/	Falling on/mle/
AGg	282 Hz	290 Hz	290 Hz	254 Hz
IZg	216 Hz	241 Hz	240 Hz	221 Hz
AWg	252 Hz	279 Hz	280 Hz	241 Hz
BS	202 Hz	249 Hz	250 Hz	210 Hz
DM	227 Hz	275 Hz	278 Hz	219 Hz
		Rising on /ʑi/	Rising on /mle/	Falling on /ko/
KS	213 Hz	221 Hz	253 Hz	208 Hz
AN	208 Hz	262 Hz	275 Hz	190 Hz

Table 10: Flat hat F0

An upward F0 glide from the lower value of the preceding syllable /na/ into the target syllable /vo/ was from 8 to 48 Hz, and the fall on the next syllable /mle/ was from 19 to 59 Hz. For two speakers, an upward F0 glide started later on the last syllable /ʑi/ of the target word /voʑi/ and the fall started later on the last syllable /ko/ of /mleko/.

4. Discussion

The goal of the present research was to investigate the perception of Polish geminate /v:/, when length was varied between that of a short and that of long consonant.

The study shows that when duration of a long consonant falls below a certain threshold, the status of the consonant as a singleton or geminate becomes somewhat indeterminate to the listener; in such cases, consonant gemination is perceptually ambiguous, and a singleton reading, which involves interpreting the word as monomorphemic, is favored over a geminate one, which requires the word to have a morphologically-complex reading.

The subjects were found to be sensitive to durational differences that they heard. When the prompt was sufficiently long, they almost always interpreted it correctly. When it fell below a specific threshold (147 ms), their responses can be interpreted as prosodic evidence that they were having trouble interpreting the

prompt: 42% of the time, in response to a prompt with a long fricative, the subject's response includes a distinctive pitch pattern: a rising F0 in the first syllable, pitch height maintenance on the second syllable, and a drop after the second syllable. This so called flat hat correlates directly with the subject's indeterminacy about whether the stimuli included a singleton or a geminate, that is, the subjects often specifically marked their own areas of processing difficulty with a flat hat in their response.

5. References

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