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MEASURING VOWEL DURATION VARIABILITY IN NATIVE ENGLISH SPEAKERS AND POLISH LEARNERS[1]

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Abstract

This paper presents a set of simple statistical measures that illustrate the difference between native English speakers and Polish learners of English in varying the length of vocalic segments in read speech. Relative vowel duration and vowel length variation are widely used as basic criteria for establishing rhythmic differences between languages and dialects of a language. The parameter of vocalic duration is employed in popular measures such as ΔV (Ramus et al. 1999), VarcoV (Dellwo 2006, White and Mattys 2007), and PVI (Low et al. 2000, Grabe and Low 2002). Apart from rhythm studies, the processing of data concerning vowel duration can be used to establish the level of discrepancy between native speech and learner speech in investigating other temporal aspects of FL pronunciation, such as tense-lax vowel distinction, accentual lengthening or the degree of unstressed vowel reduction, which are often pointed out as serious problems in the acquisition of English pronunciation by Polish learners. Using descriptive statistics (relations between personal mean vowel duration and standard deviation), the author calculates several indices that demonstrate individual learners' (13 subjects) scores in relation to the native speakers' (12 subjects) score ranges. In some tested aspects, the results of the two groups of speakers are almost cleanly separated, which suggests not only the existence of specific didactic problems but also their actual scale.

1. Introduction

Foreign language (FL) pronunciation is traditionally assessed by the teacher on the basis of immediate subjective impressions. Although in classroom teaching practice this will probably remain the basic approach, the recent development of PC-operated methods of speech analysis has made them available to people outside the circle of professional laboratory phoneticians, including FL teachers, who can now consider the use of acoustic analysis as an interesting accessory didactic aid.

Not all speech signal parameters can be easily employed for pedagogical purposes, but speech unit duration measurement is relatively reliable and informative. The segmentation of speech chain is not always an easy task even if clear and consistent criteria are applied, and it is time-consuming, but before the automatic methods are made fully reliable, manual segmentation gives the researcher a better insight into the data.
The duration of speech units provides a researcher with a lot of useful information. Vowel length appears to be a particularly interesting aspect of speech timing from the

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point of view of the Polish learner of English (cf. Waniek-Klimczak 2005). This is because relative vocalic duration in English can cue

- tense/lax vowel contrast (as an accessory cue)
- fortis/lenis contrast in coda
- prominence distribution
- prosodic domain boundaries
- rhythm patterns

Polish, however, is characterised by

- no tense/lax vowel distinction
- the voiced/voiceless contrast neutralised in coda
- very little unstressed vowel reduction
- allegedly weaker accentual lengthening.

Moreover, although final lengthening and initial strengthening are said to be universal phenomena, we may face cross-linguistic discrepancies in the scale of their effects on prosodic unit duration. Finally, Polish gives the listener more syllable-timing impression despite extremely complex consonant clusters.

All these discrepancies may lead to cross-linguistic interference in the process of FL learning. A number of researchers dealing with English phonetics pedagogy indeed report problems with insufficient intrinsic vowel length distinction (Sobkowiak 1996, Szpyra-Kozłowska 2003, Nowacka 2008, Bryła 2010), insufficient unstressed syllable reduction and too short prominent syllables in Polish learners (Avery and Ehrlich 1996, Hewings 2004, Dziubalska-Kołaczyk et al. 2006, Gonet et al. 2010) and especially insufficient vowel reduction in Polish learners of English (Luke and Richards 1982, Sobkowiak 1996, Hewings 2004, Nowacka 2008, Gonet et al. 2010, Porzuczek 2010). Most opinions, however, are formulated with reference to auditory assessment and pedagogical experience.

2. Objectives of the present study

There are two main objectives of the present study:

- to provide evidence for vocalic timing differences between native English speakers and Polish learners that will illustrate the scale of learners' problems with the 'short'/'long' and stressed/unstressed temporal vocalic contrasts,
- to illustrate the developmental tendencies in the learners' speech by repeating the testing procedure after 7 months of study including a course of practical phonetics.

The obtained evidence can also be used for further investigations into the rhythmic patterns of the Polish learner's English speech.

3. Method

The subjects were 13 Polish first-year students of English at a teacher training college. Their performance (2 recording sessions – October 2006, May 2007), originally recorded for a more comprehensive study of EFL speech timing (Porzuczek, in press), was analysed in comparison to the performance of 12 English secondary school students in Cambridge, downloaded from the IViE database (Grabe et al. 2001). The participants

read the Cinderella passage (Grabe et al. 2001, see Appendix). They had been given time to practise the reading prior to the recording.

The tested material included 46 vocalic syllable nuclei (see Appendix):

- 20 unstressed reduced vowels (17 non-phrase-final)
- 20 stressed monophthongs (10 non-phrase-final), (5 'long' vowels, 12 'short' vowels, 3 æ's)
- 6 stressed diphthongs (3 non-phrase-final)

Vowels adjacent to approximants and phrases showing significant interspeaker differences in prominence distribution were avoided. Stressed syllables were thus lexically and syntactically determined. This approach helps to reduce the problems which call for automatic segmentation (e.g. Loukina et al. 2011). The acoustic analysis for the purposes of the present research was based on manual segmentation and measurement (standard criteria) from the spectrograms and waveforms using the PRAAT software (Boersma 2001). The data analysis involved descriptive statistics including group and personal vowel duration medians, means and standard deviation. Raw measurements were normalised for speech rate by using proportions of vowel class mean durations and VarcoV (Dellwo 2006, White and Mattys 2007). VarcoV is calculated as the percentage proportion of standard deviation from mean vowel duration (SD) to mean vowel duration (VarcoV=SD*100%/meanV, where V=vowel duration).

Acoustic research tools based on duration, such as the recent rhythm measures, yield results marked with significant individual variation. As Loukina et al. (2011) notice, in cross-linguistic rhythm studies more variation is often found between individual speakers than between languages. The same problem may therefore appear in comparing native and non-native speech within one language. This poses a problem of data interpretation, especially for normative didactic purposes. It seems justified though to assume that results out of the range of native speakers' scores indicate non-native-like pronunciation features.

4. Results

Predictably, group means show significant differences between native and non-native English speech in both investigated aspects. Mean stressed vowel durations are presented in Table 1.

group\V class	D	L	A	S	text grand mean
PL1	199	147	120	98	133 (SD=65=48%)
PL2	176	137	115	91	122 (SD=58=48%)
ENG	203	147	137	85	130 (SD=72=55%)

Table 1: Mean durations (ms) of particular vowel classes (D=diphthong, L=long, A=ash, S=short) in stressed syllables and vowel length variability (Porzuczek, in press).

The general results suggest similar articulatory rates in both groups of subjects, as indicated by similar mean vowel durations. Stressed vowel duration variability is higher in native speakers (ENG). After the training (PL2), the learners noticeably accelerate, but the variability index (SD/mean duration) remains identical. There is also a larger

temporal difference between particular vowel classes in the pronunciation of native speakers.

Table 2 presents more information concerning the performance of individual speakers, which is important in the context of teaching groups of learners and setting the norms.

group\V class	D:S	L:S	A:S
PL1	1.8-2.25 (**2.1**)	1.22-1.75 (**1.5**)	.92-1.51 (**1.25**)
PL2	1.57-2.33 (**1.9**)	1.21-1.78 (**1.5**)	.94-1.59 (**1.33**)
EN	1.95-2.82 (**2.4**)	1.47-2.29 (**1.7**)	1.12-1.85 (**1.69**)

Table 2: Vowel class mean length proportions in individual speakers' score ranges. Group medians in parentheses.

It turns out that the learners' group medians for L:S ratio (1.5) in both recordings approximate the native speakers' minimum (1.47). However, the ranges largely overlap and, despite significant group differences, most Polish learners fall within the norms of native-like performance. Individual speakers' scores are shown in Appendix B.

The results indicate that the duration contrasts between vowel classes are clearer in native speakers. Still, even though group scores differ significantly, there are a number of native speakers who show less vowel length variation. This may suggest that either many Polish learners make a proper distinction between the vowel classes, at least for the 'long'/'short' vowel contrast, or that the scale of this quantitative distinction is irrelevant as long as a minimum contrast level is reached, e.g. approximately a 1.5:1 ratio for the present text. In order to account for possible effects of extraneous variables, we tried to observe the impact of pre-fortis clipping and final lengthening. The relevant calculations showed 15% shorter vowels in pre-fortis positions in the native performance. The learners made such vowels 8% shorter in the first recording and 16% shorter in the second. There was more difference in final lengthening, however, which made the native vowels three times longer than in non-phrase-final syllables, while the Polish learners made their vowels in prepausal syllables twice as long (Table 3). The ratio, which we call FLQ (final lengthening quotient), is obtained by dividing a subject's mean vowel duration in phrase-final syllables by mean vowel duration in non-phrase-final syllables.

group	FLQ = mean final (N=7): mean non-final (N=19)
PL1	1.64-2.51 (1.95)
PL2	1.63-2.75 (2.09)
EN	2.28-3.32 (2.9)

Table3: Personal final lengthening quotient (FLQ) ranges and group medians (in parentheses).

The same data, illustrating individual subjects' performance, are also presented in Fig. 1 below.

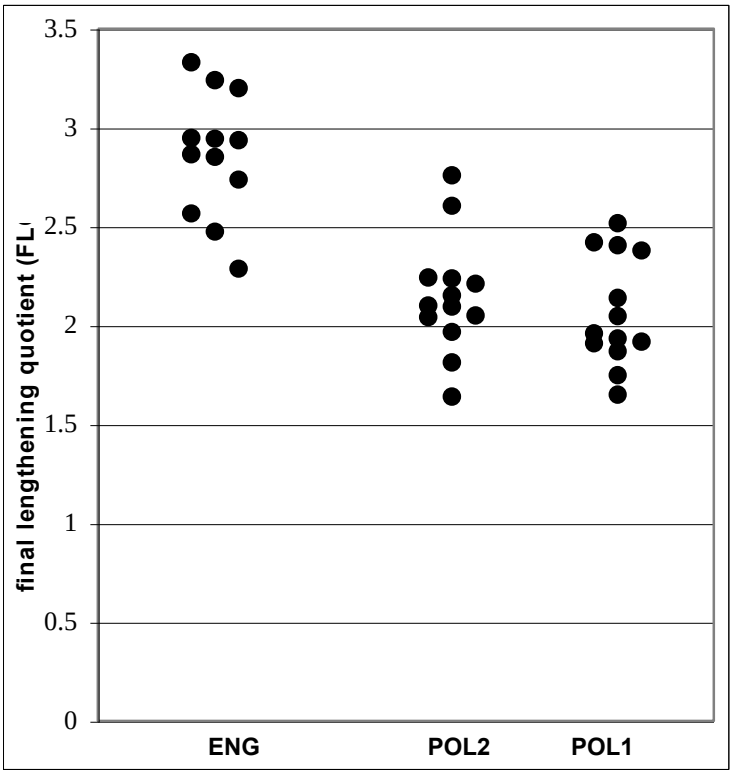

Fig. 1: Individual final lengthening quotient (FLQ) in English and Polish speakers.

The strong effect of final lengthening makes it advisable to present the results of the research with respect to non-phrase-final syllables as well as the overall scores, even though the process does not seem to have a very strong effect, for instance, on L:S ratios (Table 4) or general vowel length variability (Table 5), especially in terms of score ranges.

group\V class	L:S (non-final)	L:S (overall)
PL1	1.35-2.18 (**1.7**)	1.22-1.75 (**1.5**)
PL2	1.24-1.79 (**1.6**)	1.21-1.78 (**1.5**)
EN	1.5-2.32 (**1.7**)	1.47-2.29 (**1.7**)

Table 4: Personal 'long':'short' vowel ratio ranges and group medians.

1	2	3	4	5	6
group	overall (26)	non-final (19)	group mean VarcoV	overall (26) VarcoV	non-final (19) VarcoV
PL1	112-160 (132)	94-127 (108)	48	39-55 (49)	33-51 (39)
PL2	100-140 (127)	82-119 (106)	48	39-62 (47)	30-49 (36)
EN	106-155 (127)	87-121 (100)	55	44-63 (53)	30-51 (44)

Table 5: Personal mean vowel duration ranges and group medians (2-3). Personal vowel length variation (5-6).

Apart from final lengthening and pre-fortis clipping, there is yet another potential extraneous variable, viz. the complex and gradient nature of prominence. As was already mentioned earlier, because of the lack of a continuous scale that could be used to measure prominence taking into account all its components and their contribution, we can only try to control its effects on duration by careful selection of contexts where structural prominence is unambiguously distributed.

Generally, two conclusions can be formulated with respect to stressed vowel length variability. Firstly, all native speakers and a majority (2/3) of Polish speakers before training make the long vowels at least 50% longer than the short ones.

Secondly, final lengthening appears much stronger in the pronunciation of native speakers.

Far more spectacular results are obtained if vowels in both stressed and unstressed syllables are taken into consideration. The differences can be captured by both VarcoV and vowel reduction quotient (VRQ), calculated for individuals by dividing their mean unstressed vowel duration by mean stressed vowel duration. Tables 6 and 7 show the relevant VarcoV (SD:M) results[2] for non-final contexts and all tested vowels. Native speakers' codes are shown in bold. Polish learners' codes are followed by "1" (1st recording) or "2" (second recording).

subject	**M**		subject	**SD:M**
CSM	**62**		**CSM**	**0.72**
AK2	**62**		**CER**	**0.71**
CHB	**63**		**CPT**	**0.68**
AS2	**63**		**CHB**	**0.68**
CTG	**64**		**CMF**	**0.67**
CMF	**68**		**CLP**	**0.66**
CER	**69**		**CTG**	**0.64**

subject	**M**		subject	**SD:M**
CTG	**81**		**CHB**	**0.78**
AK2	**81**		**CJE**	**0.77**
AS2	**82**		**CLH**	**0.77**
CSM	**82**		**CSM**	**0.75**
RM2	**83**		AK2	**0.75**
CHB	**87**		**CMF**	**0.74**
MG2	**88**		**CER**	**0.74**

[2] The figures are not multiplied by 100 as in the original VarcoV formula.

subject	**M**		subject	**SD:M**
CMA	**69**		**CLH**	**0.63**
RM2	**70**		**CJE**	**0.63**
CPT	**72**		AS2	**0.62**
CJE	**73**		AK2	**0.62**
AS1	**78**		**CJI**	**0.61**
CLP	**78**		**CMC**	**0.57**
MG2	**79**		AK1	**0.55**
PA1	**82**		PS2	**0.55**
AO2	**82**		**CMA**	**0.54**
RM1	**82**		PS1	**0.52**
PS2	**84**		AS1	**0.52**
CLH	**84**		JK2	**0.52**
AK1	**87**		PA1	**0.51**
CMC	**87**		RM2	**0.51**
PA2	**87**		MG2	**0.5**
CJI	**91**		AO2	**0.5**
PO2	**91**		LK1	**0.5**
AJ2	**92**		DK2	**0.49**
DK2	**92**		AO1	**0.48**
JK2	**93**		PA2	**0.48**
LK2	**93**		DK1	**0.48**
MG1	**95**		AJ1	**0.47**
AO1	**95**		MG1	**0.46**
LK1	**99**		PO1	**0.46**
JK1	**100**		MB1	**0.45**
AJ1	**101**		PO2	**0.44**
DK1	**101**		LK2	**0.43**
PS1	**101**		JK1	**0.43**
MB2	**102**		AJ2	**0.42**
PO1	**104**		RM1	**0.41**
MB1	**112**		MB2	**0.36**

Table 6: Non-final mean vowel duration (M) and duration variability (SD:M) (19 stressed vowels + 17 schwas)

subject	**M**		subject	**SD:M**
CMA	**90**		**CLP**	**0.7**
CPT	**91**		**CPT**	**0.7**
CER	**91**		**CMA**	**0.69**
CMF	**92**		AS2	**0.68**
RM1	**98**		**CTG**	**0.68**
AO2	**99**		**CJI**	**0.66**
AS1	**99**		AK1	**0.64**
PS2	**103**		**CMC**	**0.63**
CJE	**103**		AS1	**0.61**
CLP	**104**		PA1	**0.61**
PA2	**104**		PS2	**0.59**
LK2	**104**		PO1	**0.58**
PA1	**105**		PA2	**0.57**
CMC	**105**		RM2	**0.57**
PO2	**107**		JK2	**0.56**
DK2	**108**		PS1	**0.56**
JK2	**108**		DK1	**0.55**
MG1	**109**		AO2	**0.54**
AK1	**110**		DK2	**0.54**
AJ2	**111**		MG2	**0.52**
AJ1	**111**		AO1	**0.51**
AO1	**112**		MB2	**0.51**
LK1	**114**		LK1	**0.51**
JK1	**115**		AJ2	**0.5**
CLH	**116**		PO2	**0.5**
CJI	**118**		AJ1	**0.49**
DK1	**120**		RM1	**0.49**
PS1	**123**		JK1	**0.49**
MB2	**123**		MG1	**0.48**
PO1	**126**		MB1	**0.47**
MB1	**129**		LK2	**0.47**

Table 7: Overall mean vowel duration and duration variability (SD:M) (26 stressed vowels + 20 schwas)

The data from Tables 6 and 7 are also presented as a graph in Figure 2 for a clearer illustration of cross-group and individual differences.

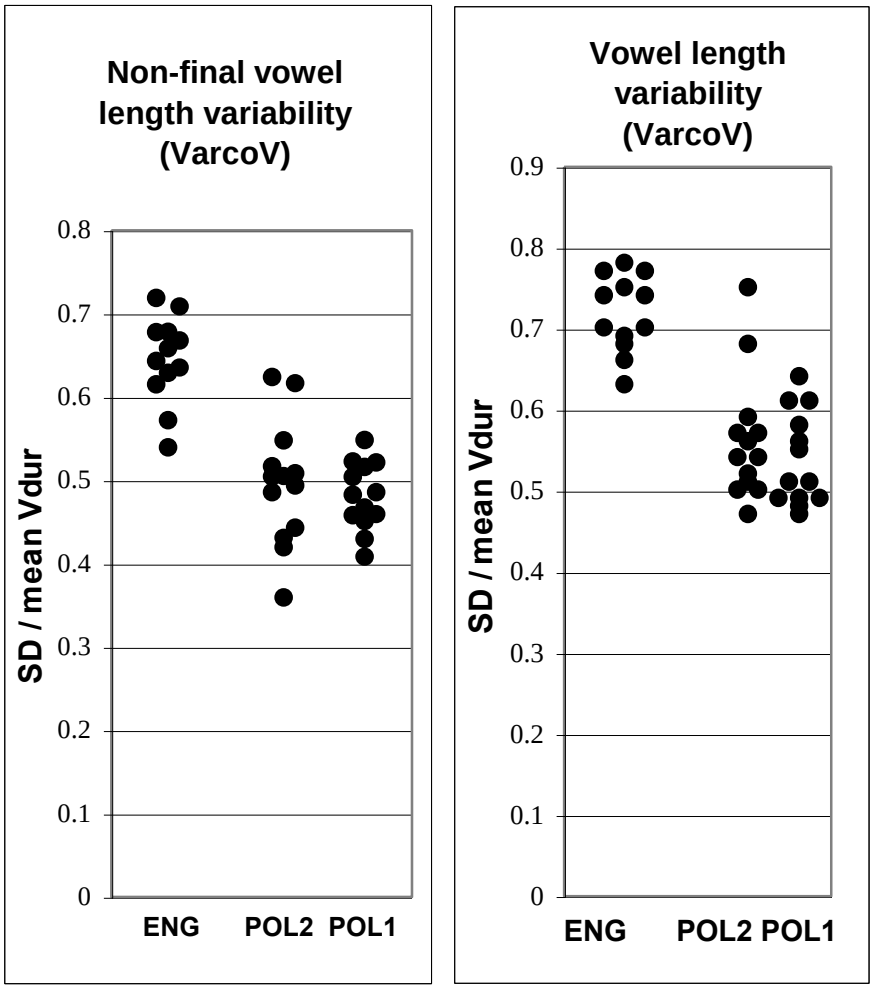

Figure 2: Vowel duration variability.

VarcoV shows the general vowel length variability, which may be influenced by other factors, while VRQ focuses on the stressed/unstressed distinction, and shows the scale of quantitative vowel reduction. It is presented in Table 8 and Figure 3.

S	**MstrV**		S	MstrV	**Mschwa**	S	**VRQ**
AK2	**82**		**CSM**	89.8	**31**	**CSM**	**0.34**
RM2[3]	**84**		**CHB**	90.2	**32**	**CHB**	**0.36**
AS2	**84**		**CMF**	98.1	**35**	**CMF**	**0.36**
CTG	**87**		**CER**	100	**36**	**CER**	**0.36**
MG2	**88**		**CTG**	87.1	**39**	**CMC**	**0.43**
CSM	**90**		AS2	84.1	**40**	**CLP**	**0.43**
CHB	**90**		AK2	82.2	**40**	**CPT**	**0.43**
CMA	**91**		**CPT**	98.8	**42**	**CJE**	**0.43**
RM1	**94**		**CJE**	100	**43**	**CTG**	**0.45**
AS1	**95**		**CMA**	91.1	**45**	**CLH**	**0.46**
CMF	**98**		**CLP**	107	**46**	**CJI**	**0.47**
AJ1	**99**		**CMC**	119	**51**	AS2	0.47
CPT	**99**		**CLH**	113	**51**	AK2	0.49
MG1	**99**		*RM2*	**83.5**	**55**	**CMA**	**0.5**
CER	**100**		AO2	106	**55**	AO2	0.52
CJE	**100**		PA1	106	**56**	PA1	0.53
PS2	**102**		**CJI**	121	**57**	DK2	0.54
AJ2	**105**		AS1	94.6	**59**	PA2	0.56
PA1	**106**		PA2	109	**61**	JK2	0.57
LK2	**106**		PS2	102	**64**	PO2	0.58
AO2	**106**		AK1	107	**64**	AK1	0.6
AK1	**107**		DK2	119	**64**	PO1	0.61
CLP	**107**		PO2	113	**66**	PS1	0.62
LK1	**108**		JK2	116	**67**	AS1	0.62
PA2	**109**		MG2	88.2	**68**	PS2	0.63
MB2	**109**		*RM1*	**93.8**	**69**	*RM2*	**0.65**
AO1	**112**		AO1	112	**77**	DK1	0.65
CLH	**113**		PS1	124	**77**	AO1	0.68
PO2	**113**		PO1	127	**77**	JK1	0.69
JK2	**116**		DK1	120	**79**	*RM1*	**0.74**
JK1	**118**		AJ2	105	**79**	LK2	0.74
DK2	**119**		LK2	106	**79**	MB1	0.75
CMC	**119**		JK1	118	**81**	AJ2	0.75

[3] The case of subject RM is an outstanding argument for the necessity to normalise the data for speech rate. Together with CMC, CLH and CLP it may also convince learners that high speed does not equal proficiency in FL speech performance.

S	**MstrV**		S	MstrV	**Mschwa**	S	**VRQ**
DK1	**120**		LK1	108	**87**	MG2	0.77
CJI	**121**		MG1	98.8	**91**	LK1	0.81
PS1	**124**		MB2	109	**93**	MB2	0.85
PO1	**127**		MB1	127	**95**	MG1	0.92
MB1	**127**		AJ1	98.5	**103**	AJ1	1.05

Table 8: Quantitative vowel reduction scale in native English speakers and Polish learners. S=subject, MstrV=mean stressed vowel duration, Mschwa=mean reduced vowel duration, VRQ=Mschwa:MstrV. Native speakers' codes in bold. Polish learners' codes followed by "1" (1st recording) or "2" (second recording).

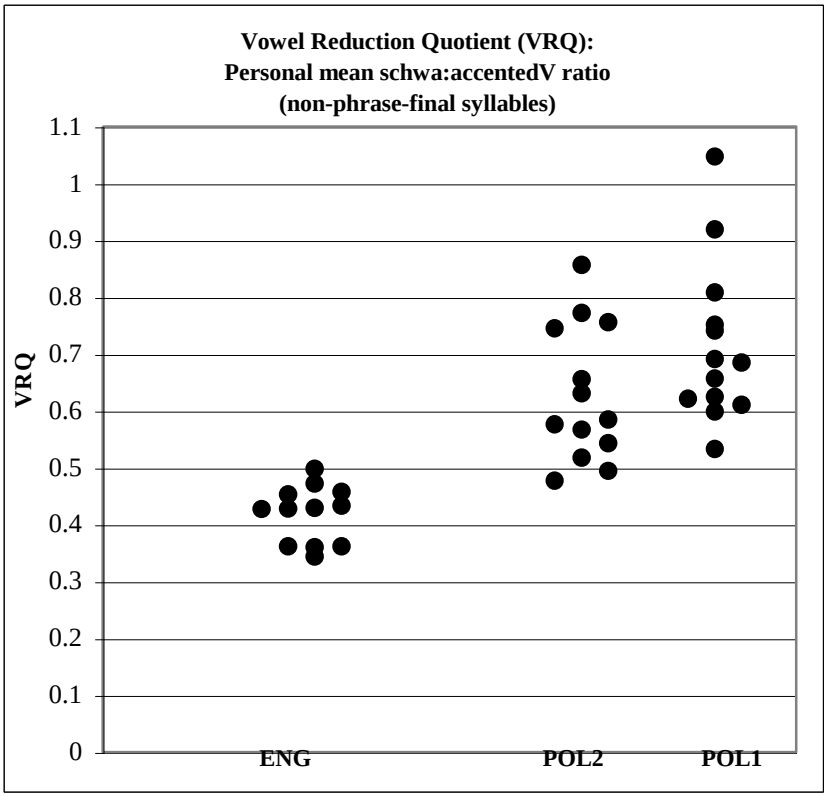

Figure.3: Vowel Reduction Quotient.

The VRQ scores suggest that in native English speech the unstressed vowels are at least 50% shorter than the stressed ones. Polish learners, even after pronunciation training, hardly ever reach this level of vowel reduction. The significant difference between the

groups is also reflected in group median differences. Table 9 presents both raw schwa durations and measures normalised for speech rate (VarcoV, VRQ).

measure\group	ENG	POL2	POL1
schwa median (ms)	42	64	77
VarcoV median	65	50	48
VRQ median	.43	.58	.68

Table 9. Group medians for vowel reduction and duration variability measures.

5. Conclusions

Simple descriptive statistics concerning vowel duration which were used in this study help to provide evidence supporting the following statements:

1. In Polish learners' read speech, there is less difference between 'long' and 'short' vowels than in native production (but the evidence is rather weak).
2. Final lengthening is considerably stronger in native speakers.
3. Vowel reduction is a serious problem for Polish learners, who produce too long unstressed vowels in terms of both absolute and relative durations. Despite some progress, this remains difficult even after training.
4. Considering all duration determinants combined, the Polish learners vary their vocalic length far less than do native English speakers, even though fluency problems, typical of learner speech, should probably contribute to more variation.
5. VarcoV and VRQ are efficient measures which show differences between native and Polish-accented English speech timing.
6. VRQ appears resistant to individual speech rate differences.
7. Because duration statistics are text-dependent, cross-linguistic studies are difficult to conduct. Useful data about native and non-native speakers can be gathered if standardised tests are introduced.

The measures presented in this paper show general differences between native English and Polish learner pronunciation but they can also serve as immediate didactic help in practical phonetics courses to enhance the learners' awareness of cross-linguistic differences and similarities and may help set concrete targets for practical pronunciation training.

References

Avery, P. and S. Ehrlich. 1992. *Teaching American English Pronunciation.* Oxford: Oxford University Press.

Boersma, P. 2001. Praat, a system for doing phonetics by computer. *Glot International* 5 (9/10): 341-345.

Bryła, A. 2010. Phonetic properties of Euro-English – empirical evidence. In *Issues in accents of English 2: Variability and norm*, ed. E. Waniek-Klimczak, 37-60. Newcastle-upon-Tyne: Cambridge Scholars Publishing.

Dellwo, V. 2006. Rhythm and Speech Rate: A Variation Coefficient for ΔC. In: *Language and Language-processing*, eds. P. Karnowski and I. Szigeti, 231-241. Frankfurt am Main: Peter Lang.

Dziubalska-Kołaczyk, K., A. Bogacka, D.Pietrala, M. Wypych and G. Krynicki. 2006. PELT: an English language tutorial system for Polish speakers. *MULTILING-2006*, paper 012.

Gonet, W., J. Szpyra-Kozłowska, and R. Święciński. 2010. The acquisition of Vowel Reduction by Polish students of English. In *Issues in accents of English 2: Variability and norm*, ed. E. Waniek-Klimczak, 291-308. Newcastle-upon-Tyne: Cambridge Scholars Publishing.

Grabe, E., B. Post and F. Nolan. 2001. *The IViE Corpus*. Department of Linguistics, University of Cambridge. http://www.phon.ox.ac.uk/IViE. [Retrieved 7 September 2006].

Grabe E. and E. L. Low. 2002. Durational variability in speech and the rhythm class hypothesis. In *Laboratory Phonology* 7, eds. C. Gussenhoven and N. Warner, 515-546. Berlin, New York: Mouton de Gruyter.

Hewings, M. 2004. *Pronunciation Practice Activities.* Cambridge: Cambridge University Press.

Loukina, A., G. Kochanski, B. Rosner, C. Shih and E. Keane. 2011. Rhythm measures and dimensions of durational variation in speech. *Journal of the Acoustal Society of America* 129/5: 3258-3270.

Low E. L., E. Grabe and Nolan F. 2000. Quantitative characterisations of speech rhythm: syllable-timing in Singapore English. *Language and Speech* 43: 377-401.

Luke, K.-K. and J. C. Richards. 1982. English in Hong-Kong: Functions and status. *English World-Wide* 3: 147-164.

Nowacka, M. 2008. *The Phonetic Attainment in Polish University and College Students of English. A Study in the Productive and ReceptivePronunciation Skills.* Unpublished Ph.D. dissertation. Maria Curie-Skłodowska University, Lublin.

Porzuczek, A. 2010. The weak forms of TO in the pronunciation of Polish learners of English. In *Issues in accents of English 2: Variability and norm*, ed. E. Waniek-Klimczak, 309-324. Newcastle-upon-Tyne: Cambridge Scholars Publishing.

Porzuczek, A. (in press). *The timing of tone group constituents in the advanced Polish learner's English pronunciation.* Katowice: Wydawnictwo Uniwersytetu Śląskiego

Ramus, F., M. Nespor and J. Mehler. 1999. Correlates of linguistic rhythm in the speech signal. *Cognition* 72: 1-28.

Sobkowiak, W. 1996. *English Phonetics for Poles*. Poznań: Bene Nati

Szpyra-Kozłowska, J. 2003. The Lingua Franca Core and the Polish Learner. In *Dydaktyka fonetyki języka obcego*, eds. W. Sobkowiak and E. Waniek-Klimczak, 193-210. Płock: Wydawnictwo Naukowe PWSZ w Płocku,.

Waniek-Klimczak, E. 2005. *Temporal Parameters in Second Language Speech.* Łódź: Wydawnictwo Uniwersytetu Łódzkiego.

White, L. and S. L. Mattys. 2007. Calibrating rhythm: First language and second language studies. *Journal of Phonetics* 35: 501-522.

Appendix A

The read text and tested vowels. Unstressed reduced vowels in *italics*, stressed vowels in **bold**.

Once upon a time there was *a* girl called Cinderella. B*u*t everyone called h*er* C**i**nd*er*s. C**i**nd*er*s lived with her mother and two stepsisters called Lily and Rosa. Lily and Rosa were very unfriendly and they were lazy girls. They spent all their time buying new clothes and going t*o* p**ar**ties. Poor Cinders had to wear all their old hand-me-downs! And she h**a**d t*o* do the cleaning!
One day, a royal messenger came to announce a ball. The ball would be held at the Royal Palace, in h**o**nour of the Queen's only s**o**n, Prince William. Lily and Rosa th**ough**t this was div**i**ne. Prince William was g**or**ge*ou*s, and he was l**oo**king for a bride! They dreamed *o*f wedding bells!
When the evening of the ball arrived, Cinders had to help her sisters get ready. They were in *a* b**a**d m**oo**d. They'd want*e*d t*o* b**uy** some new g**ow**ns, but their m**o**ther said that they had en**ou**gh g**ow**ns. So they st**ar**t*e*d sh**ou**ting *a*t C**i**nd*er*s. 'Find my jewels!' yelled one. 'F**i**nd my h**a**t!' howled the other. They wanted hairbrushes, hairpins and hair spray.
When h*er* s**i**st*er*s h*a*d g**o**ne, Cinders felt very down, and she cried. Suddenly, a voice said: 'Why are you crying, my dear?'. It was h*er* fairy g**o**dm**o**ther!

Appendix B

Individual speakers' vowel class length ratios. Native speakers' codes in bold. Polish learners codes followed by "1" (1st recording) or "2" (second recording)

subject	**D:S**
CJE	**2.82**
CLH	**2.71**
CMA	**2.52**
CTG	**2.51**
CPT	**2.44**
CMF	**2.43**
CLP	**2.39**
AK2	2.33
CER	**2.32**
CHB	**2.3**
CJI	**2.3**
AS2	2.27
PS1	2.25
DK1	2.23
CSM	**2.14**
PO1	2.14
LK1	2.14
PA1	2.13
PS2	2.12
MB2	2.08
AK1	2.06
AS1	2.05
RM1	2.03
RM2	2.02
PA2	1.98
AO1	1.97
MG2	1.95
CMC	**1.95**
AJ1	1.93
JK2	1.92
JK1	1.91
LK2	1.9
PO2	1.88
MG1	1.87
AJ2	1.83
MB1	1.8
DK2	1.72
AO2	1.57

subject	**L:S**
CJE	**2.29**
CLH	**2**
CPT	**1.89**
CLP	**1.88**
CTG	**1.81**
AK2	1.78
MG1	1.75
PS2	1.73
CMA	**1.72**
CJI	**1.7**
DK1	1.7
PA1	1.67
PO1	1.67
RM2	1.64
PS1	1.59
MG2	1.59
AS2	1.59
PO2	1.59
CMF	**1.58**
DK2	1.55
RM1	1.53
CER	**1.52**
MB2	1.52
CMC	**1.52**
AK1	1.5
CSM	**1.48**
LK2	1.47
CHB	**1.47**
JK2	1.46
AJ2	1.45
LK1	1.44
AJ1	1.42
MB1	1.39
AS1	1.37
JK1	1.34
PA2	1.33
AO1	1.22
AO2	1.21

subject	**A:S**
CPT	**1.85**
CHB	**1.79**
CMA	**1.78**
CTG	**1.76**
CSM	**1.74**
CER	**1.7**
CJE	**1.68**
CJI	**1.64**
PO2	1.59
AS2	1.55
CLP	**1.52**
PS1	1.51
CLH	**1.5**
PS2	1.5
CMF	**1.48**
LK2	1.45
MB2	1.4
PO1	1.37
DK1	1.35
AS1	1.35
JK1	1.34
MG2	1.33
AK2	1.33
JK2	1.29
AK1	1.28
MG1	1.25
MB1	1.23
DK2	1.2
AO1	1.16
RM1	1.13
PA1	1.12
CMC	**1.12**
PA2	1.05
RM2	1
AO2	0.96
AJ2	0.94
AJ1	0.92
LK1	0.92