

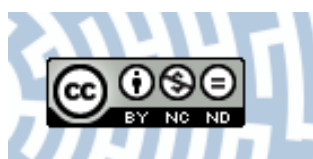


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**Title:** The phonological functions of segmental and subsegmental duration

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**Citation style:** Porzuczek Andrzej, Rojczyk Arkadiusz. (2015). The phonological functions of segmental and subsegmental duration. W: D. Gabryś-Barker (red.), "Topics in applied psycholinguistics" (S. 29-50). Katowice : Wydawnictwo Uniwersytetu Śląskiego.



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## **The phonological functions of segmental and subsegmental duration**

The paper discusses the role segmental and subsegmental duration in the organization of a sound system in English and Polish. It analyses how duration contributes to signaling phonological phenomena such as voicing, words stress and word boundary. Special emphasis is put on cross-linguistic differences between English and Polish and how those differences emerge in the process of learning English by speakers of Polish.

Artykuł omawia rolę długości na poziomie całego segmentu oraz jego poszczególnej cechy w organizacji systemu dźwiękowego języka angielskiego i polskiego. Analizuje on, jak długość wykorzystywana jest w realizacji zjawisk fonologicznych, takich jak dźwięczność, akcent wyrazowy czy granica słowa. Główny nacisk położony jest na kontrastywne różnice między językiem angielskim i polskim oraz na to jak różnice te ujawniają się w procesie uczenia się języka angielskiego przez Polaków.

### **1. Introduction**

Speech is organized in two core dimensions. Firstly, sounds have acoustic structure that makes them distinctive. Manipulation of articulatory configurations results in production of sound categories that are perceived as different, for instance, retracting the tongue from the front position for /i/ and adding lip rounding will produce a vowel /u/. However, distinctive spectral characteristics of individual sounds are not sufficient to make speech intelligible. Since speech unfolds in time, it needs specific timing of sounds in order to be processed by listeners. This timing or duration is crucial in signaling many phonological contrasts on a segmental level as well as on the level of prosody and rhythm. The role of duration in speech may be compared to that observed in music. Both pitch and temporal structures are two main dimensions in music and neither melody nor harmony can be activated without rhythm (Schön and Besson 2002). Relating this to speech, the meaning conveyed by spectral properties of sounds cannot be effectively activated without maintaining relevant durations of those sounds.

All languages differ, to a lesser or greater extent, in how they use duration to cue phonological contrasts as well higher-level prosodic structures. All learners of a foreign language are challenged by the task of identifying and learning those, very often subtle, fine-grained durational differences between their native and foreign language. Production of durational cues that diverge significantly from the patterns typical from those found in native

speech will lead to strong non-native accent and, most probably, to serious breakdowns in communication. In the following sections, we look at segmental and subsegmental duration and its function in signaling phonological contrasts, commencing with the identity of individual speech sounds up to the role of duration in syllable prominence and identification of word boundaries. We specifically concentrate on duration in English and Polish, discussing how those two languages differ typologically in exploiting duration in order to organize their sound systems.

## **2. Intrinsic vowel duration**

While all languages have vowels that are distinguished in terms of their quality (spectral properties produced by the configuration of the tongue and jaw) (Crothers 1978; Maddieson 1984), not all languages use quantity (vowel duration) as a distinctive feature of a vowel. For example, in Czech vowel duration is encoded phonologically, which means that increasing or reducing duration of the same vowel category leads to a change in word meaning, as in /sa:t/ 'to suck' and /sat/ 'orchard' (Chládková et al. 2013). Other languages belonging to *quantity* languages are Finnish, Estonian, Hungarian, Japanese, Mongolian, Swedish and Thai (Eerola et al. 2012). English is an interesting case that is a hybrid of a *quality* and *quantity* language. It is considered to have both short and long vowels that will differ in duration in the same phonetic context (Roach 2000). The problem is that short and long vowels differ substantially in their quality, in that there is no one same vowel category that is distinguished only by duration. Moreover, short vowels may be longer than long vowels in phonological positions that promote an increase or decrease in vowel duration, such as the voicing of a following consonant or a position in a stressed or unstressed syllable. There is also observable difference in muscular tension in the production of English short and long vowels, that is why they are often referred as lax and tense to better capture their articulatory nature (Chomsky and Halle 1968; Jakobson and Halle 1964).

The analysis of native speakers' productions shows consistently that they distinguish phonologically short and long vowels by a combination of spectral energy (quality) and duration, in which long vowels are longer in the same position than short vowels (Crothers 1978; Crystal and House 1998b; Hillenbrand et al. 1995; Ladefoged and Maddieson 1996). In perception, however, native English speakers rely predominantly on spectral properties in identification of vowels, duration playing only a secondary role (Ainsworth 1972; Hillenbrand et al. 2000). Studies with perception of English vowels by non-native speakers have

demonstrated that non-native speakers, unlike native speakers, exploit duration in the absence of sufficient sensitivity to spectral cues (Cebrian 2006; Escudero 2006; Escudero and Boersma 2004; Escudero et al. 2009; Flege et al. 1997; Kondaurova and Francis 2008, 2010). More interestingly, it occurs for speakers of languages that do not have durational variability of vowels in their native language. Escudero and Boersma (2004) suggested that overreliance on vowel duration is accounted for by the application of an L1 acquisition mechanism that detects the statistical distribution of duration in English productions. Bohn (1995) proposed a desensitization hypothesis in which he argued that L2 learners are sensitive to non-native duration differences "whenever [L1] spectral differences are insufficient to differentiate [L2] vowel contrasts because previous linguistic experience did not sensitize listeners to these spectral differences" (Bohn 1995: 294-295).

Polish does not encode duration into phonology of its vowels and any durational variability resulting from the differences in articulation is negligible (Jassem 1962; Klessa 2012; Richter 1973). However, as predicted above, Polish learners of English will resort to duration in identification of English vowels. Bogacka (2004) showed that Poles relied primarily on vowel duration in perception of English 'beat' - 'bit' vowels. Rojczyk (2011a) looked into the perception and production of vowels 'ash' and 'strut' by Polish learners. In production those two vowels were subsumed by the Polish vowel /a/ as shown by overlapping formant frequencies. Similarly, in perception they were not identified effectively as two separate categories. However, the participants relied heavily on duration in both production and perception. They increased duration to dissimilate 'ash' from 'strut' and perceived vowels with increased duration as 'ash' rather than 'strut'. This suggested that they processed duration as a primary cue in the absence of sensitivity to spectral cues.

### **3. The voicing contrast**

Although voiced and voiceless consonants are traditionally described as those characterized by vocal fold vibration and those produced with vocal folds spread, the actual realization of voicing is much more complicated and largely language specific. In fact, it is a combination of durational and spectral parameters that contribute in different degrees to the perception of voicing. In the following subsections, we discuss the most robust durational cues to voicing in consonants.

#### **3.1. Voice Onset Time**

Voice Onset Time (VOT) is considered to be the most robust cue in the implementation of voicing in syllable-initial stops across the world's languages. It is defined as "the time interval between the burst that marks release and the onset of periodicity that reflects laryngeal vibration" (Lisker and Abramson 1964: 422). In other words, it is a time span between the release of a stop and the vocalization of a vowel. Although it is not the only cue to signal initial voicing, it is the most robust perceptually (Abramson and Lisker 1985; Lisker 1978; Summerfield and Haggard 1977). The parameter of VOT puts Polish and English into two classes of languages. English is an aspirating language with long VOTs for /p, t, k/ and short VOTs for /b, d, g/ (Keating et al. 1983; Lisker and Abramson 1967). As a result, the claim that English has voiced and voiceless stops word-initially is a phonological claim. Phonetically, English has 'voiceless' and 'very voiceless' stops word-initially, as there is no voicing in the occlusion of English /b, d, g/ in most cases, even though some speakers may also produced those stops with closure voicing (Kessinger and Blumstein 1997; Magloire and Green 1999; Miller et al. 1986). Polish, on the other hand, belongs to a class of prevoicing languages (Keating 1980; Keating et al. 1981; Kopczyński 1977; Mikoś et al. 1978). Polish phonologically voiced /b, d, g/ word-initially are also voiced phonetically, because voicing begins during occlusion of a stop and prior to the release burst, resulting in negative VOT values. At the same time phonologically voiceless /p, t, k/ have short-lag VOTs, which means that voicing of a following vowel commences within the range of 0 ms to 50 ms, depending on the place of occlusion.

The cross-linguistic differences in the implementation of VOT as a durational parameter in the realization of the syllable-initial voicing contrast in English and Polish stops lead to two possible pronunciation difficulties for Polish learners of English. English /b, d, g/ will be produced with considerable prevoicing while /p, t, k/ will be produced with insufficiently long VOTs, which means that they will be unaspirated. The first scenario will result in, at worst, the perception of a slight non-native accent or will possibly even pass unnoticed, because native English speakers also prevoice in some contexts and speaking modes. The latter scenario has serious consequences not only because it leads to the perception of strong foreign accentedness but also because it will seriously impede communication. Polish voiceless /p, t, k/ have VOT values of English phonologically voiced /b, d, g/ and thus the production of insufficiently long VOTs by Polish learners will change the category from voiceless into voiced. Waniek-Klimczak (2005) reported that Polish speakers of English typically do not produce long enough VOTs to match native speakers' productions, however most recently Szpyra-Kozłowska et al. (2014) showed that long VOTs can be taught to Polish intermediate

learners with relative success. Three studies in our lab investigated the perception and production of English long VOTs by Poles. Rojczyk (2011b) manipulated the continuum of positive VOT values in 10-ms steps to investigate the categorization between short-lag and long-lag VOTs by native English speakers and Polish learners. The results revealed that the native speakers had a categorical shift from voiced into voiceless with increasing VOT values. On the other hand, Polish learners very often perceived short VOTs as already voiceless in accord with the pattern they had in their native language. Rojczyk (2012) tested if, and to what degree, English long VOTs in voiceless stops can be imitated by Polish learners. Two types of imitation were used: immediate imitation after exposure and distracted imitation. The results showed that the learners significantly increased their VOTs in immediate imitation and produced intermediate VOTs in distracted imitation compared to a baseline condition in which they read a list of words. Finally, Rojczyk (in press) used FL accent imitation in L1 to investigate if Polish learners are able to transplant long VOTs from English into Polish to imitate English accent in Polish. The measurements demonstrated that long VOTs were used as a characteristic feature of English and were transferred into Polish to give the impression of English accent. This was taken as evidence that long VOTs are perceived as a salient and characterizing feature of English pronunciation.

### **3.2. Vowel duration**

Vowel duration is a strong perceptual cue to voicing or voicelessness of following consonants in English. English is a language that maintains phonetic cues to voicing of word final consonants, even though, in terms of pure laryngeal vibration, may very often be partially or fully devoiced (Catford 2001; Gimson 2008; Gonet 2010, 2012; Roach 2000). This voicing contrast is cued by duration of vowels, in which vowels are longer before voiced and shorter before voiceless consonants (Peterson and Lehiste 1960). A vowel preceding a voiceless consonant will be two-thirds to one-half of that preceding a voiced consonant (Raphael et al. 1975). English native speakers are sensitive to this durational variability in that increasing vowel duration will lead to the perception of voiced consonants (Chen 1970; Raphael 1972; Summerfield 1975). Opposite to English, Polish is a language that neutralizes voicing in absolute coda, which means that words such as 'kod' and 'kot' have the same phonetic output and there are no reliable cues that would signal the difference between /d/ and /t/ in this position. Although some studies reported that voicing neutralization might be incomplete in Polish and that vowels might be longer before phonologically voiced consonants (Richter 1973; Slowiaczek and Dinnsen 1985), it was later argued to be an artifact of orthography

(Jassem and Richter 1989) and was not a reliable cue in perception (Słowiacek and Szymanska 1989). As a result, Polish learners of English are faced with a learning task to increase English vowels before voiced stops and decrease them before voiceless stops. Waniek-Klimczak (2005) demonstrated that Polish speakers of English do not produce sufficient durations of vowels before voiced consonants and do not sufficiently reduce durations before voiceless consonants. Szpyra-Kozłowska et al. (2014) reported that this durational variability is one of the most difficult allophonic phenomena to teach to Polish learners.

Three studies in our lab dealt with English vowel duration as a cue to voicing. Rojczyk (2010) manipulated acoustically vowel duration to investigate how increasing durations would change a following percept from a voiceless to voiced stop. The stop was manipulated to be acoustically ambiguous to its voicing status. Native English speakers were sensitive to increasing vowel durations and identified the following stop as voiced when preceded by longer vowels. Polish learners did not follow the native English pattern and their performance was characterized by considerable insensitivity to this durational cue. Rojczyk (2008) attempted to prime vowel duration a cue to the voicing status of a following consonant in Polish by presenting English and Polish words interchangeably in a reading time-limited task. The durational measurements showed that this English durational feature was transferred into Polish due to the fact that the participants could not separate the two languages in rapid code switching. Finally, Zając and Rojczyk (submitted) used vowel duration to test the magnitude of convergence in imitation using two model talkers: a native speaker of English and a speaker of Polish. The participants converged more with the native model, however the magnitude of convergence was limited.

### **3.3. Consonant duration**

Duration of consonants in English is also influenced by their phonological voicing or voicelessness. For stop consonants closure is shorter when a stop is voiced and longer when a stop is voiceless (House and Fairbanks 1953; Peterson and Lehiste 1960). This consistent durational variability has been demonstrated to contribute to the perception of voicing, in which decreasing or increasing closure duration is identified as voiced or voiceless stop (Lisker 1957; Repp and Williams 1985). A similar effect of the voicing contrast on consonant duration is found for fricatives. Crystal and House (1988a) reported mean frication noise for voiceless to be 97 ms for voiceless and 50 ms for voiced fricatives. Stevens et al. (1992) found that the duration of /s/ and /z/ was 108 ms and 78 ms respectively. This durational

variability is a strong cue in perception. Decreasing or increasing frication noise changes the fricative percept into voiced or voiceless (Cole and Cooper 1975; Flege and Hillenbrand 1986; Stevens et al. 1992). The data for Polish show some similar variability in closure duration for voiced and voiceless stops. While the report that word final phonologically voiced stops are shorter than voiceless stops (Slowiaczek and Dinnsen 1985) as evidence for incomplete neutralization is questionable (Jassem and Richter 1989), the observation that it is the case in intervocalic position (Keating 1980) seems to be reliable. No data have been reported, to our knowledge, on duration of Polish voiced and voiceless fricatives.

In our lab, Rojczyk (2010) studied the perception of closure duration and frication noise on voicing judgments by native English speakers and Polish learners. Native speakers were significantly more sensitive to decreased closure durations as a cue to voicing than the Polish learners, however the magnitude of a shift from voiceless to voiced was limited. For fricatives, native speakers were strongly affected by decreased frication noise in identification of voiced fricatives, as opposed to Polish learners for whom the effect was less pronounced.

#### **4. Prominence**

Longer duration, alongside intensity and pitch change, is an important cue for prominence in world's languages (Maddieson 1997, Waniek-Klimczak 2005). Evidence for English, concerning both word stress and phrasal accent has been provided, respectively, by Klatt (1974), Umeda (1977), Crystal and House (1988a), Sluijter and van Heuven (1996); Pierrehumbert and Talkin (1992), Beckman and Edwards (1994), Turk and White (1999), and Choi (2003). The domain of accentual lengthening is normally the syllable but not all its constituents are affected to the same degree. According to Crystal and House (1988a), the syllable nucleus is lengthened more than the consonants in accented syllables. The claim, however, has not been universally supported. For instance, Eefting (1991) has reported that, for Dutch, it is rather onsets and codas that are lengthened more than vowels under accent. It is interesting that, as reported by Sluijter (1995) and Turk and White (1999), accentual lengthening may not only affect the adjacent syllables, especially the following ones, but also the following word, even though word boundaries usually strongly attenuate or block the lengthening. Generally speaking, accentual lengthening is mainly a domain-span process, one that influences all elements of the unit (White 2002).

The reported scale of segmental lengthening in accented syllables differs across studies. Crystal and House (1988a) have found consonants to be 30% longer and vowels 80-100% longer in stressed syllables, while stressed diphthongs are on average 50% longer. Moreover,



Crystal and House (1988b) conclude that inherently long vowels are lengthened more under stress than the 'short' ones.

For Polish, Jassem (1959) has observed stressed vowels in citation forms to be 17% longer than the unstressed ones. Nowak (2006) finds 22% difference in an extensive study encompassing diverse speech styles, while Rojczyk (2010b) reports a 30% difference in reiterant speech. On the other hand, Dogil (1999) claims that vowel duration is not a word stress correlate in Polish.

In many languages, prominence is indicated not only by increased duration, intensity and pitch but also by the reduction of unstressed speech units (cf. de Jong 2000). Reduction may be manifested in both the spectral qualities of the unit and its shorter duration. Its domain being the syllable, the reduction is not confined to individual segments, e.g. the vocalic nucleus, although vowel reduction is investigated far more frequently. There is evidence that consonants are also reduced in unstressed contexts but the scale of reduction largely depends on the consonant type (eg. Jassem et al. 1984; Byrd 1994; Keating et al. 1994; Schmidt and Flege 1995; Van Son and Van Pols 1996). Lindblom (1990) and Cole et al. (2007) point out that quantitative consonant reduction results from narrower space taken by consecutive articulatory gestures and considerable gesture overlap in unstressed contexts.

Vowel reduction in unstressed positions is a universal phenomenon but its scale differs across languages. The stress-timed ones, like English, tend to shorten unstressed vowels very strongly, often leaving the syllable with no vocalic segment, especially between voiceless consonants and before sonorant codas. Reduction is less radical in syllable-timed languages, where a vowel can disappear occasionally only in fast and careless speech. Jassem (1959) claims that there is little correlation between stress and vowel reduction in Polish. Recent studies mentioned above (Nowak 2006, Rojczyk 2010) provide evidence for prominence-dependent vowel length variation but even Rojczyk's results for reiterant speech confirm the common belief that Polish and English differ considerably. Thus we can agree with Nowak (2006: 378), who concludes that the lack of vowel reduction in Polish may be "constrained by the admittedly limited durational variation of Polish vowels (vis-à-vis many other languages)."

Segmental and prosodic differences between L1 and FL often lead to interference in learners' speech. The proper use of accentual lengthening and unstressed vowel reduction is important for EFL learners because robust indication of prominence is crucial for successful communication (cf. Bogle 1996; Kenworthy 1987; Celce-Murcia et al 1996; Jenkins 2000). Therefore Polish learners, who often follow L1 temporal patterns in that respect (Luke and

Richards 1982; Sobkowiak 2001; Hewings 2004; Dziubalska-Kołaczyk et al. 2006; Nowacka 2008; Gonet et al. 2010), "should be given activities that practice reduction of unstressed syllables and lengthening of stressed ones" (Avery and Ehrlich 1996:145).

The duration of individual segments is interrelated with at least the surrounding elements within a speech unit and it would be hardly justified to claim that the duration of a single speech sound alone can efficiently cue the presence or absence of prominence. However, it appears that, considering the mechanics of speech production, especially the articulatory energy distribution, we may suspect that focusing on vocalic length adjustment, given the acoustic and auditory saliency of syllable nuclei, may enable the speaker to establish proper temporal relations between accented and unaccented units.

Porzuczek's (2010, 2013) studies of Polish-accented English speech provide data illustrating the discrepancies in unstressed vowel duration between native English speakers and advanced Polish learners. The former investigates the duration of unstressed preposition *to*. The measured stretch of speech comprises the aspiration immediately following the release of /t/, the reduced vowel and the occlusion phase of a stop beginning the next word. It turns out that, typically, no vocalic element is found in native English pronunciation of unstressed *to* before fortis stops. Before lenis stops, 50% of the responses were also fully voiceless. The Polish speakers rarely (4-16%, depending on proficiency and length of training) pronounced the preposition without a vowel. This was obviously correlated with significantly longer mean duration of the vowel in Polish respondents. The other study is devoted to the pronoun *her*. The absolute and relative duration of the function word was measured acoustically and attention was paid to all segments. Polish learners again made the pronoun longer than native speakers. The effect was magnified by stronger pronunciation of /h/, often dropped by English speakers, and /r/ in the coda, silent in standard British speech.

The results of the research described above do not explicitly indicate phonological problems in the English speech of Polish learners, but the significant deviations from native norms suggest problems with clear indication of prominences and provide evidence to support Avery and Ehrlich's (1996) and the other observations cited earlier in this section. Measuring segmental duration in order to find differences between foreign-accented and native pronunciation of the same language, especially in connected speech, rarely leads to clear categorical conclusions. Individual variation in native speakers makes it difficult to establish native reference values.

Porzuczek (2012a) has attempted to investigate the general vocalic length variation in native speakers' and Polish learners' read speech in order to observe how prominence levels

influence vowel duration. The recorded performance of 13 Polish students of English and 12 British secondary school students was analysed acoustically with focus on the duration of 26 vowels in stressed positions and 20 unstressed vowels. Among other calculations, two ratios were particularly indicative of the differences between native and non-native speech. First, calculated on the basis of 19 stressed vowels and 17 schwas in the read text,<sup>1</sup> standard deviation from personal mean vowel length was divided by personal mean vowel length to control for speech rate variability (cf. VarcoV used by Dellwo 2006 and White and Mattys 2007). This ratio ranged between .54 and .72 for native speakers and between .36 and .62 for Polish learners, but only two<sup>2</sup> of them exceeded the level of .55. However, the other ratio, vowel reduction quotient (VRQ) proved to be even more powerful in that it almost cleanly separated the two groups of speakers. VRQ is a simple proportion of personal mean stressed vowel length to personal mean unstressed vowel length. The native speakers' VRQs ranged from .34 to .5, while the corresponding Polish respondents' scores ranged from .47 to 1.05 (see Figure 1), where again only the two most proficient students managed to match the native speaker's scores indicating relatively low reduction levels.

Figure 1: Vowel Reduction Quotient (Porzuczek 2012b: 210)

Porzuczek's studies suggest that it is easier to prove vowel reduction discrepancies between native English speakers and Polish learners than discrepancies in accentual lengthening, where the naturally slower speech rate of the learners may compensate for potentially shorter duration of stressed vowels. It appears that the investigation of the other cues for prominence might show more conspicuous differences between the two groups of speakers. Generally, however, we can conclude that the phonological category of prominence is signalled in native English by maintaining the minimum duration proportion of 2:1 between vowels in stressed and unstressed syllables. This ratio is difficult to achieve for Polish learners, although the results show significant approximation to native norms in the course of phonetic training.

## 5. Prosodic domain boundaries

The most salient prosodic boundary, the pause, is regularly used to mark top level domains, i.e. utterances and intonational phrases. The lower the level in the prosodic hierarchy, the

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<sup>1</sup> Only non-phrase-final syllables were considered in order to eliminate the effects of final lengthening.

<sup>2</sup> These two students achieved best results in practical pronunciation course.

lower the frequency of pauses. Native speakers do not normally separate individual words by pauses. Moreover, FL learners' problems with accurate speech segmentation into words often hinder their listening comprehension, which may suggest insensitivity to FL word boundary cues or the lack of such cues in regular native speech at least where communication is effective and comfortable. Numerous studies, however, suggest that the boundaries of speech units are marked by longer duration of boundary-adjacent elements. Such processes, influencing only the segments near unit boundaries are classified as domain-edge processes by White (2002). The best documented ones are initial strengthening and final lengthening.

Initial strengthening consists in longer duration of articulators contact and wider linguopalatal contact in stops. The process has been observed, for instance, in English, French, Korean and Taiwanese by Fougeron and Keating (1997), Byrd and Saltzman (1998), Fougeron (2001), Cho and Keating (2001), Keating et al. (2003). Initial strengthening is said to be magnified at boundaries of higher-rank domains (Cooper and Paccia-Cooper 1980, Gee and Grosjean 1983, Wightman et al. 1992, Fougeron and Keating 1997, Yoon et al. 2007). It affects mainly the onset consonants in syllables immediately following the boundary (Bombien et al. 2006, Cho and Keating 2001), while vowels are typically more sensitive to accent (Cho and Keating 2001). The scale of lengthening may also depend on the initial consonant type (Oller 1973).

Final lengthening affects preboundary segments, particularly vowels. Abundant evidence for the process has been provided for English by Martin (1970), Lehiste (1972), Oller (1973), Klatt (1975, 1976), Edwards et al. (1991), Gussenhoven and Rietveld (1992), Byrd (2000) and Byrd et al. (2006); for Dutch by Nooteboom and Doodeman (1980) and Cambier-Langeveld (2000); and for Hebrew by Berkovits (1994). Pre-boundary segments tend to be the longest in the phrase-final, and especially in the utterance-final position (e.g. Lindblom and Rapp 1973). However, according to Klatt (1976), only sonorant and fricative codas are significantly lengthened. Wightman et al. (1992), and Gussenhoven and Rietveld (1992) have observed longer duration of pre-boundary syllables, while Berkovits (1994) and Shattuck-Hufnagel and Turk (1998) suggested that final lengthening begins with the last stressed syllable (or vowel – cf. Wightman et al 1992) in the phrase and affects all segments up to the boundary.

Before lower-level domain boundaries the effects of both processes appear less systematic. A number of studies have been devoted to word boundaries, especially important for FL learners. Boundary-adjacent segments may be lengthened both word-initially and word-finally. Oller (1973) and Cooper (1991) have observed that word-initial syllable onset consonants tend to be longer than similar word-medial ones. Moreover, whole syllables

(Klatt 1975) or at least syllable rhymes (e.g. Beckman and Edwards 1990, Wightman et al. 1992) are often longer before a word boundary, even in non-phrase-final positions.

Research methods leading to these conclusions make use of acoustic analysis of the recorded speech signal in identical phonemic sequences, differing in word boundary distribution. For instance, Turk and Shattuck-Hufnagel (2000) measured boundary-adjacent segments in *tuna choir* vs. *tune acquire* and found that word-initial /k/ in *choir* was longer than the word-medial consonant in *acquire*. With respect to final lengthening, Turk and White (1999) observed that the first syllable in sequences such as *shakedown stairs* vs. *shake downstairs* was longer in the latter example, i.e. before a word boundary.

A similar study has been conducted for Polish by Porzuczek and Rojczyk (2011), where two sentences with identical phonemic content were read by Polish respondents. The stimuli only differed in lexical content in such a way that one contained an additional word boundary: *Lubi Doda Wanię?* vs. *Lubi dodawanie?* After the analysis of measured segment durations it turned out that the pre-boundary vowel /a/ in *Doda* was not prolonged by the speakers, but significant lengthening of the word-initial consonant /v/ in *Wanię* was observed, as well as slight but significant lengthening of the following vowel /a/. These results are in line with the evidence for word initial lengthening in English, French, Korean and Taiwanese, referred to earlier in this section, but they also suggest that the word may not constitute a domain for final lengthening.

Final lengthening, at least at the phrase level, seems to be stronger in English than in Polish, which is suggested by Porzuczek (2012b), who found that vowels produced by native English speakers in phrase final accented syllables were 113% longer than in medial positions. The same vowels were lengthened only by 77-79% in Polish learners' production.

## 6. Conclusion

The studies described in the present paper indicate that although segmental duration is highly sensitive to a lot of interacting factors, including large individual variation, it is used as an important indicator of a variety of phonological categories both on the phonemic and the prosodic levels. This makes it important for communication and, by the same token, for foreign language learning. Duration is a highly contrastive phonetic parameter that contributes to the distinctiveness of sound categories. Due to significant cross-linguistic differences in durational variability, duration is also a parameter that must be considered in both studies dealing with foreign-language speech as well as in foreign-language pronunciation pedagogy.

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