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Evaluating two ways for marking Swedish phonological length in written text

A production study

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The study compares two different graphic marking systems designed to help L2 learners of Swedish notice and realize phonological length. In System A, 22 L2 learners read aloud three /V:C/ words with length marked under long vowels and three /VC:/words with dots under short vowels. Twenty-two other L2 learners read the same words marked by the other system (System B) that underlines long vowels and long consonants. As a control group, 20 native Swedish speakers read the same words without any marking. We measured and compared the temporal realizations of the six words by all the three groups. System B readers realized Swedish phonological length more closely to the way that native speakers did, compared to System A readers. These results suggest that prompting both long vowels and long consonants can be more effective than marking long and short vowels.

Keywords: Swedish as a second language, pronunciation teaching materials, prosody, phonological length, graphic marking, stress, quantity

1. Introduction

It has been suggested that the goal of teaching L2 pronunciation should be helping learners to achieve intelligible speech (e.g., Abercrombie, 1949; Derwing & Munro, 2015; Levis, 2005; Munro & Derwing, 2013). It is argued that, to be understood well, the L2 speaker does not need to acquire every phonetic feature of the target language and sound nativelike. It would thereby be strategic to identify phonetic features crucial for intelligible and functional speech and help learners to focus on these important features. This argument would be particularly relevant to helping adult learners who are not likely to achieve nativelike pronunciation for various reasons including the factor of the age of learning (AOL) (Abrahamsson & Hyltenstam, 2009; Piske, MacKay, & Flege, 2001).

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The idea of prioritizing specific phonetic features for promoting intelligible L2 pronunciation was mostly developed in the context of English as a second language or international lingua franca. For example, Jenkins (2000, 2002) suggested a set of Lingua Franca phonetic core features that needed to be pronounced clearly in international communications, while Derwing and Munro (2015) have suggested certain pronunciation features important for immigrants in Canada.

The same idea of identifying and prioritizing phonetic features for intelligibility in pronunciation teaching is found in teaching Swedish as a second language (SSL). With its immigration policy over the last decades, Sweden has become a multicultural country, and speakers of more than 150 different first languages now use Swedish as an intranational lingua franca (Parkvall, 2016). For these immigrants, who have great need for acquiring the language, the intelligibility principle has been suggested. For example, Bannert (1980) classified Swedish phonetic features into two groups - one important for intelligibility and therefore necessary to be prioritized in pronunciation teaching and the other less important for intelligibility.

Among the Swedish phonetic features that Bannert (1980) considered important for intelligible pronunciation, the prosodic contrasts of word stress and quantity have greater importance for intelligibility (e.g., Bannert, 1987; Gårding, 1979; Abelin & Thorén, 2017). Particularly, the perception experiments by Bannert (1987) and Abelin & Thorén (2017) confirmed that the two prosodic features have a clear impact on intelligibility.

The present study aims to determine which of two marking systems that SSL textbooks use more effectively helps adult SSL leaners to notice and realize the Swedish contrasts of stress and quantity. As shown in Figure 1, one of the two marking systems, System A, marks phonologically long and short vowels, while the other, System B, marks long vowels and long consonants in stressed syllables, where the complementary vowel and consonant length (i.e., either /V:C/ or /VC:/) appear (e.g., Elert, 1964). Given the extensive use of the two systems in books for SSL learners, determining the effectiveness of the two marking systems would have practical values for learners, teachers and developers of teaching materials.

As a way to evaluate the two marking systems, we compare two groups of Swedish L2 speakers who read sequences of words marked by Systems A and B respectively. We also compare the two groups with a group of Swedish L1 speakers reading the same sequences of words without any marking. Although not aiming to promote nativelike pronunciation or accent for every single phonological feature as the goal that SSL learners should achieve, we assume that phonetic productions of L1 speakers can be a good reference for evaluating L2 speakers'

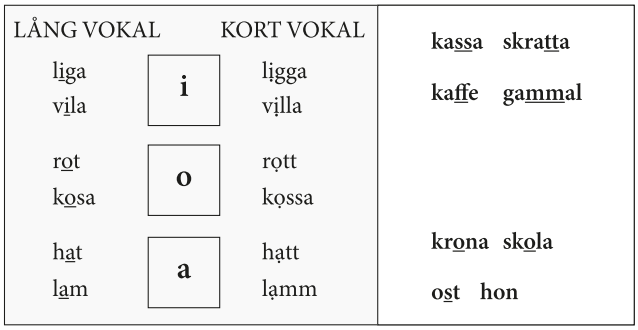


Figure 1. System A on the left (source: Ballardini, Stjärnlöf & Viberg, 1997) and System B on the right (source: Fasth & Kannermark, 1989)

realizations of the two mentioned prosodic contrasts that are important for intelligibility (Abelin & Thorén, 2017).

The three research questions for comparing specific features of the two marking systems are:

1. System A indicates long and short vowels, while System B underlines phonologically long vowels and long post-vocalic consonants. Which is more effective for helping L2 learners to realize phonological length in Swedish?
2. System B lacks shortening symbols for short vowels. Does System B induce L2 learners to pronounce phonologically short vowels too long, in comparison to Swedish L1 speakers?
3. System A does not indicate phonologically long consonant sounds. Do the readers of System A lengthen phonologically long consonant sounds sufficiently, in comparison to Swedish L1 speakers?

2. Background of the study

2.1 Swedish word stress and quantity contrasts and their significance for intelligibility

Swedish has three phonemic prosodic contrasts; stress contrast *between* syllables, quantity contrast *within* a syllable, and the tonal word accent realized by superimposing tonal rises and falls on the word stress pattern (Bruce, 1977). Here we discuss only the two that our study is concerned with – stress and quantity contrasts.

We use the terms *stress* and *quantity* when we refer to the abstract phonological phenomena, *length* when we refer to the abstract variable of quantity

and *duration* when we refer to the measurable acoustic correlate of phonological length. The term *spectral* is used mainly used to describe quality differences between vowel allophones.

First, the stress contrast *between* syllables can be realized in the dynamic (intensity), tonal (fo/pitch) and spectral domains (voice and sound quality), but in Swedish most prominently in the temporal domain. In the tonal and spectral domains, the stressed syllable often involves a tonal rise or fall, more clearly articulated vowels and changed voice settings (Fant and Kruckenberg, 1994). Then in the temporal domain, the contrast between stressed and unstressed syllables is created by how they are sequenced. For example, *racket* /ˈrakːət/ 'racket', which has a trochaic stress pattern (i.e., stressed-unstressed), contrasts with *raket* /raˈkeːt/ 'rocket', which has an iambic stress pattern (i.e., unstressed-stressed). This stress contrast between the two alternating sequences of prominent and non-prominent syllables extends to sentence stress placement contrast between verb + unstressed preposition and verb + stressed particle phrases. For example, '***hälsa*** *på N.N.* 'greet somebody' contrasts with *hälsa* '***på N.N.*** 'visit somebody'. Swedish stress is also temporal in its acoustic realization of syllables, where stressed syllables have longer duration than unstressed ones. Already in the late 19th century, Aurén (1869) presented his intuitive observation that stressed syllables are long and unstressed ones are short in Swedish. His insight was confirmed by Fant and Kruckenberg (1994) who found that, although all of the temporal, tonal and spectral cues contribute to signal syllable prominence in Swedish, the temporal cue, that is, duration contrast between stressed and unstressed syllables, is the most reliable signal.

The quantity contrast that occurs *within* the stressed syllable, has traditionally been described as a vowel quantity contrast signaled by vowel duration and by spectral/quality difference between long and short vowels. Spectral differences between Swedish long and short vowels have been found to play role for quantity category perception. However, Hadding-Koch and Abramson (1964), Behne, Czigler and Sullivan (1997), Thorén (2003) agree that relative vowel duration is the most reliable perceptual cue to the Swedish quantity contrast. This vowel-based view of quantity contrast has been widely applied to Swedish curriculums in the educational context for many decades. For example, when learning orthographic rules, Swedish L1 children are taught from primary school that the consonant after a long vowel is represented with one single letter (e.g., the long vowel /ɛː/ in *väg* 'road') and that the consonant after a short vowel is spelled with double letters (e.g. the short vowel /ɛ/ in *vägg* 'wall'). What we note here is that consonant length is hardly mentioned in this L1 teaching context. Some studies, like Hadding-Koch and Abramson (1964), Traunmüller and Bigestans (1988), and Behne, Czigler and Sullivan (1998), supported this long-short vowel view.

They found that relative vowel duration is the main perceptual cue used by native Swedish listeners to identify quantity categories.

There is, however, a well-known trading relation between vowel and consonant durations within the Swedish stressed syllable, resulting in either a long vowel followed by a short consonant /V:C/ or a short vowel followed by a long consonant /VC:/. This relation was intuitively propagated by Aurén (1869) and later confirmed by Elert (1964), who provides robust evidence with substantial data comprising the duration measurement of approximately 40,000 words (400 words each produced by 100 native Swedish speakers).

The role of the post-vocalic consonant as a possible cue to the quantity contrast within the stressed syllable has been examined by several researchers. Among them, Hadding-Koch and Abramson (1964) and Behne et al. (1998) concluded that changes in consonant duration alone did not affect the perception of native Swedish listeners, while changes in vowel duration did. By contrast, Thorén (2005) found that the duration of the post-vocalic consonant could be a decisive factor for native Swedish listeners' perception of quantity categories, particularly when vowel duration is ambiguous and does not clearly signal the /V:C/ and /VC:/ values. The study emphasized that relative duration expressed as vowel duration divided by consonant duration (V/C) seems to be what Swedes sensitively react to in discerning word meanings. In a similar vein, Behne et al. (1998) suggested that the post-vocalic consonant works as a 'buffer' to maintain appropriate length of stressed syllables, playing an important role for Swedish rhythm.

Recently, Abelin and Thorén (2017) examined the impact of both word stress, quantity, and tonal accents on Swedish listeners' word recognition. The researchers manipulated words in a way that trochaic words were pronounced with the iambic stress pattern and vice versa. /V:C/ words were pronounced with /VC:/ quantity and the tonal accent categories accent 1 (acute) and accent 2 (grave) were also reversed. Native Swedish listeners were asked whether the words with changed phonological categories were real words or not. The analysis revealed that the distorted quantity caused most no-answers, and the distorted word stress caused significantly more no-answers than the distorted tonal word accent. It therefore confirmed the impact of word stress and quantity contrast within the stressed syllable on intelligibility.

Swedish has been known to be a language that heavily depends on word stress and quantity distinctions for conveying meaning, and native Swedish speakers do not understand some Swedish rhymes and jingles that distort these stress patterns. Research on determining the importance of Swedish phonetic features for intelligibility is still in its infancy, and the relative importance of prosodic features among all Swedish phonetic features in pronunciation teaching has not been clearly determined yet. Nevertheless, an overview of the stress and

quantity contrasts in Swedish prosody and their impact on Swedish listeners' perception, which this section has presented, suggests that they are important for intelligibility. What is also critically informed by this section is, those prosodic contrasts are realized mainly by the duration of one segment in the stressed syllable. Based on this information, we suggest that helping SSL learners to notice, and properly realize the duration of segments in the stressed syllable can improve their intelligibility.

2.2 Word stress and quantity contrast and pronunciation teaching

We have argued that word stress and quantity contrasts can be core phonetic features in Swedish with respect to intelligibility. Swedish L1 speakers have implicit phonological knowledge, and they therefore can realize stress and quantity contrasts clearly, irrespective of what theoretical concepts about phonological contrast and its acoustic realization they learn in school. However, for Swedish L2 learners, particularly for adult learners, explicit, theoretical knowledge about the two contrasts is probably what they mainly rely on in the process of learning Swedish pronunciation, once it is introduced to them.

Some SSL teachers and textbook writers propose that lengthening either the vowel or the post-vocalic consonant in a stressed syllable should be promoted, as it is important to increase the duration of the correct segment in the stressed syllable and signal the respective quantity category more clearly (e.g., Kjellin,1978; Fasth & Kannermark, 1989; Slagbrand & Thorén, 1997; Thorén, 2007, 2008; Althén, Ballardini, Stjärnlöf & Viberg, 2012). Based mainly on Elert (1964) and Fant and Kruckenberg (1994) we argue that lengthening of the correct segment is assumed to signal both word stress and quantity. First, a syllable with increased duration in either the vowel or the consonant signals that the syllable is stressed. Second, what is also importantly perceived by the listener is whether the long segment in the stressed syllable is the vowel (i.e., /V:C/) or the post-vocalic consonant (i.e., /VC:/). For example, in the word *racket* ['rakːət] 'racket' the occlusion of the /k/ should be longer than the average segment to signal that the first syllable is stressed, and that the first syllable is of the /VC:/-type but not /V:C/. On the other hand, in *raket* [ra'keːt] 'rocket' the /e/ is long, signaling that the second syllable is stressed, and also that it is a /V:C/ word, since the vowel is long. This understanding of the interplay between the Swedish stress and quantity contrasts can be of great importance for SSL learners.

2.3 Hypothesizing the effects of the two text marking systems

The two systems this study compares have been utilized side by side in SSL teaching materials for more than 40 years. Samples of the two systems are presented in Figure 1 in the introduction and in Figure 2 in the methods. We now seek to relate the theoretical understanding of word stress and quantity contrast, which we discussed in the previous sections, to hypothesizing which text marking system, System A or System B, is better for aiding beginner learners to grasp Swedish word stress and quantity categories.

Firstly, we hypothesize that System A may not be effective for helping beginner learners notice and realize Swedish word stress and quantity contrasts. The system, which is seemingly a direct transfer of the long-short vowel concept from the Swedish school curriculum to SSL teaching, is exclusively concerned with the length of the vowel in a stressed syllable. As discussed previously, Swedish native speakers, by the time they begin their schooling, have already acquired the entire Swedish phonology and therefore they would easily relate information about 'long and short vowels' to the internalized implicit sound categories of vowel duration and vowel quality. By contrast, it may be unrealistic to expect beginner learners, who do not have such implicit knowledge of Swedish phonology, to automatically discover the complementary nature of vowel and consonant length in stressed syllables, if they are guided by System A, which only informs them of vowel length.

Secondly, we hypothesize that System B, which is aligned with the idea of the SSL educators underpinned by Aurén (1869) and Elert (1964), may be more effective than System A for helping beginner learners notice and properly realize Swedish word stress and quantity distinctions. The complementary length of the segments in the stressed syllable in Swedish is rare and is shared only with two or three languages – with Norwegian and Icelandic and partially with Italian. We assume that many L2 speakers that are not familiar with the Swedish prosody, are likely to pronounce all vowels and consonants in a similar length, particularly if their first languages are syllable timed. Some may regulate only vowel length to realize word stress, if their first languages are like English. The overt indicating of phonological length in stressed syllables in Swedish by System B may guide beginner SSL learners to notice and realize the phonologically long segment (either the vowel or the consonant) in the stressed syllable, which they may not be able to achieve without explicit guidance.

3. Method

3.1 Subjects

Forty-four international students at a Swedish university from 14 different first language backgrounds were recorded reading the prepared word sequences. They were all beginner learners in their first couple of weeks of a Swedish as a second language course and had not acquired any habits from reading aloud in Swedish. Their teacher said that the students were all fluent in English and had been exposed to some aspects of Swedish pronunciation, but not to any prosodic features like stress or quantity. Based on their first language backgrounds, we assigned the students into two groups as evenly as possible. One group comprising 22 students read according to System A (long-short vowel), and the other with 22 students read according to System B (long vowel or long consonant). Twenty native Swedish speakers served as a control group. They were from different parts of Sweden, but none from the southernmost parts, where the complementary vowel-consonant length pattern is unstable and sometimes absent (Gårding, Bannert, Bredvad-Jensen, Bruce, & Nauclér, 1974). The L2 participants' first languages are listed in Table 1, where the L1s that have any kind of quantity contrast have a '(q)' after them. 12 of System A readers and 11 of System B readers had an L1 with a quantity distinction. Information about quantity in languages are from Garlén (1988).

Table 1. Readers of System A and System B and their first languages
The symbol (q) indicates that the L1 has quantity in vowels, consonants or both.

Language	System A readers	System B readers
Albanian	0	1
Arabic (q)	1	1
Dutch	1	1
English	1**	1
French	2	4
German (q)	6	6
Italian (q)	2	3
Japanese (q)	1	0*
Mandarin	2	2** Taiwan
Polish	1	1
Russian / Georgian	1	0
Spanish	1	0
Czech (q)	2	1
Uzbek	1	0

* None of the words were possible to parse or measure.

** One of the words was not possible to parse or measure.

3.2 Material

3.2.1 *Words and carrier phrases*

The carrier phrases that participants read are:

1. *Vill du ha kaffe och kaka?* 'Would you like coffee and biscuit?'
2. *Barnen leker i soffan* 'The children are playing in the sofa',
3. *Två, fyra, fem, åtta* 'two, four, five, eight'

The words with length markings were content words whose quantity category would be realized by naturally receiving prominence in a sentence. Among them, four were nouns (*kaffe, kaka, barnen* & *soffan*), four were numerals (*två, fyra, fem* & *åtta*), and one was a verb (*leker*). For measurement, we wanted an equal number of /V:C/ and /VC:/ words and the initially intended test words were *kaffe, kaka, barnen, leker, soffan, fyra, fem, åtta*, that is, four with /V:C/ quantity and four with /VC:/ quantity. However, after the initial attempt to measure the length of the first vowels, subsequent consonants and entire words, *barnen* and *fem* were removed from the target words, as they were too difficult to measure, due to the non-distinct boundary between the vowel and the following /r/ or nasal consonant. In standard central Swedish, *barnen* is pronounced with /r/ and /n/ merged into a supradental [ɳ], which most of the L2 readers did not do. Therefore, the words that we analyzed in the end were the three /V:C/ quantity category words *kaka, leker* and *fyra* and the three /VC:/ quantity category words *kaffe, soffan* and *åtta.*

3.2.2 *Graphical marking of words*

Figure 2 shows the visuals of Systems A and B that guided the L2 readers. As shown in the figure, System A underlines long vowels in *kaka, barnen, leker, två* and *fyra*. The vowels in *kaffe, soffan, fem* and *åtta* had a dot under the letter representing the phonologically short vowel. System B underlined long vowels the same way as System A, while the long consonants in *kaffe, soffan, fem* and *åtta* were also underlined to indicate the phonologically long consonant.

System A	**System B**
Vill du ha kạffe och kạka?	Vill du ha kaffe och kạka?
Bạrnen lẹ̣ker i sọffan	Bạrnen lẹ̣ker i soffan
tvạ̊ fy̲ra fẹm åṭta	tvạ̊ fy̲ra fem̲ åtta

Figure 2. Systems A and B used for marking phonological length in the test material

3.3 Data collection

First, we showed the carrier phrases to the L2 participants and checked their understanding. To those who did not understand the meaning of the phrases, we provided translations. System A readers were instructed to lengthen segments represented by underlined letters and to shorten segments represented by letters with a dot underneath. System B readers were instructed to lengthen segments represented by underlined letters representing either long vowels or long post-vocalic consonants (see Figure 2). When not making any audible compliance with the instructions, readers were asked to read again, "following the markings better", but no details were given as to where or which word or sound should be improved. This happened to one reader of System A and three readers of System B. When a participant produced a second version, that version was included in the study, irrespective of which version complied best with the instructions.

The speech productions were recorded with a Røde NT3 condenser microphone connected to a laptop via a Sound Blaster external sound card at a sampling frequency of 22050 Hz, in a small room, where temporary sound treatment was made with soft portable screens and blankets. A pre-test recording showed that echo-effects were small and did not hamper the measuring of recorded speech sequences. In addition, through double checking – during and after the recording, we assured that none of the L2 readers was hesitant or disfluent between sound segments within words, although they as beginner learners overall read more slowly than L1 readers.

3.4 Considerations in measurements and comparisons

The first thing we considered in measuring segment duration was that duration is more reliable than spectrum (vowel quality/timbre) as a perception cue to the Swedish quantity category. It was also important for us that consonant duration served as an auxiliary cue to quantity categorization when the vowel duration is unclear (Thorén, 2005), and as a 'buffer' to maintain the appropriate length of stressed syllables (Kjellin, 1978; Riad, 1997; Behne et al., 1998).

In addition, we adopted the quantity measure suggested by Elert (1964): vowel duration divided by consonant duration (V/C). The higher the ratio, the clearer signaling of /V:C/ and the lower the ratio, the clearer signaling of /VC:/. This measure complies with the smallest unit that can signal quantity in Swedish, for example, short words like *en* [eːn] 'juniper' – *en* [ɛnː] 'one', *al* [ɑːl] 'alder' – *all* [alː] 'all', *Ohm* [oːm] 'unit for electric resistance' – *om* [ɔmː] 'if', *ät* [ɛːt] 'eat!' – *ätt* [ɛtː] 'family', *in* [iːn] 'i-letters' – *in* [inː] 'in'. If our participants had been fluent speakers, we may have considered using vowel or consonant duration related to

the duration of the entire utterance (Traunmüller & Bigestans, 1988). However, since the present study examined early learners with little or no training in reading aloud, the duration of the entire utterance would probably differ too much between readers. We therefore decided to use the V/C ratio, a gauge that is sensitive only to the durations of relevant segments.

Moreover, since the V/C ratio is sensitive to both shortening and lengthening of the included segments, we also wanted to see how much our participants actually increased the duration of the appropriate segments, as an objective measure of their compliance with the underlining in both A and B systems. For this purpose, we divided the duration of the phonologically long sound (S:) by the duration of the entire word (W) yielding S:/W, the measure used by Thorén (2010) and by Thorén and Jeong (2016). To compare the realizations of phonologically short vowels and answer the second research question, we added the ratio of vowel duration divided by word duration (V/W). The latter measure is not completely insensitive of consonant duration, but less sensitive than the V/C ratio, yielding lower values for relatively shorter vowels. Table 2 shows how the ratios were affected by lengthening and shortening of vowels and consonants respectively.

Table 2. Effects of changes in vowel/consonant duration on different ratios. Single + or – means increase and decrease respectively; ++ and – – means bigger changes

		S:/W		
	V/C	**if V:**	**if C:**	**V/W**
Vowel lengthened, consonant not	+	+	–	+
Vowel lengthened; consonant shortened	+ +	+ +	– –	++
Vowel shortened, consonant not	–	–	+	
Consonant lengthened, vowel not.	–	–	+	–
Consonant lengthened, vowel shortened	– –	– –	+ +	– –
Consonants shortened, vowel not.	+	+	–	+

One weakness of word duration as a measuring reference is the phenomenon of final lengthening, as discussed by Klatt (1975) and Fischer-Jørgensen (1986). This means that the last syllable before a pause and the last segment(s) of that syllable tend to have a longer duration than the same syllable or segments in a non-pre-pausal position. This phenomenon may affect the S:/W and the V/W ratios although we regard word duration as the most reliable reference unit at hand.

Finally, we could not apply classical syllable boundaries, since they would yield different syllable boundaries for /V:C/ and /VC:/ words. With classical syllable boundaries, *kaka* would be parsed into [ka.ka], while *kaffe* would be parsed as [kaf.e] or possibly [kaf.fe]. Instead, we follow Fant and Kruckenberg (1989,

p. 11), who discussed this issue and concluded that the VC-sequence should be kept intact as a unit, since relative duration between V and C is integral to stress-induced syllable lengthening.

3.5 Segmentation, measurement and analysis

As mentioned before, three measures assessed relative duration: vowel duration divided by consonant duration (V/C), the duration of phonologically long sound divided by the duration of the word (S:/W), and phonologically short vowel divided by word duration (V/W).

Segmentation and measurement were performed in Praat (Boersma & Weenink, 2015) by the first author, a trained phonetician. The five words – *kaffe, kaka, leker, soffan*, and *åtta* – all had clear boundaries between the vowel and the subsequent voiceless obstruent in the stressed syllable. This facilitated segmentation and measurement. The software showed where glottal pulses commenced and ceased, and we measured the duration of the first vowel and the inter-vocalic /f/ and /t/ by measuring the voiced parts (vowels) and the voiceless part (consonants) between the first and the second vowel. The word *fyra* required analysis of formant patterns, and the formant patterns of the first and second vowels gave sufficient contrast to the /r/. The beginning of *fyra* was a bit tricky since the /f/ sound, in some recordings, gradually increased its intensity from zero to clear fricative noise. Thus, the measurement of the word might have lower validity than that of the other words. However, we viewed this as a minor issue, since the two marking systems are identical for /V:C/ words and differ in treating /VC:/ words *kaffe, soffan, åtta*, and our study was centrally concerned with these /VC:/ words.

We calculated descriptive and inferential statistics and produced boxplots for group comparisons. Our data, like most datasets with a small sample size, were not normally distributed. To compensate, we performed robust inferential tests using the WRS2 package (Wilcox & Schönbrodt, 2015) in R, following the advice by Larson-Hall (2015) and Turner (2014)

Finally, regarding comparisons, the main interest of the study was which system yielded more native-like relative duration and clearer signaling of stress and quantity categories, for which the relevant words were the /VC:/ words. However, we decided to provide group-wise significance tests for both /V:C/ and /VC:/ words readings, because, if the two systems readers did not show statistically significant difference in reading /V:C/ words, it would ensure their homogeneity in terms of using the marking systems.

4. Results

Overall, the results confirmed our hypotheses stated in Section 2.3: System B was more effective than System A for facilitating L2 readers' realization of phonological length in stressed syllables. Here we first report the absolute durations of the six target words and of the vowels and consonants in the stressed syllables, as they provide a background to the relative values central to our study. After that, the ratios of vowel duration divided by consonant duration (V/C) are presented, to show how the readers signaled quantity categories. Then we present the ratios of phonologically long sound duration divided by word duration (S:/W), to show to what extent the readers signal word stress and quantity categories simultaneously by increasing the duration of the appropriate segment. Finally, we present the ratios of short vowel duration divided by word duration (V/W) for the /VC:/ words.

The results reported in this section will be summarized in the discussion section following, in a way to answer the three research questions.

4.1 Absolute durations

As shown in Table 3, word and segment durations overall were longer among L2 speakers than among L1 speakers. For /V:C/ words for which both the systems had the same marking – underlining of phonologically long vowels, there was no statistical difference between System A readers (L2A) and System B readers (L2B): robust $t(22.7) = 1.83$, $p = .08$. For /VC:/ words that the two systems marked differently, the word durations by the two group readers differed significantly: robust $t(15.7) = 4.20$, $p = .00071$.

Table 3. Absolute durations in milliseconds of words and target segments. Mean values for words, segments and speaker groups

	All words	/V:C/ words	/VC:/ words	Long vowels	Long consonants	Short vowels
L1	462.63	483.42	441.85	162.62	190.67	77.17
L2B	723.63	699.31	747.57	232.1	258.57	133.79
L2A	595.74	644.48	547.74	208.05	170.82	114.46

Both L2 groups showed significantly longer vowel durations than the L1 speakers for both /V:C/ and /VC:/ words. Consonant duration in /VC:/ words, however, differed significantly between the L2 groups. L2B, who were prompted to lengthen consonants, produced longer consonants: robust $t(13.9) = 4.12$, $p = .00106$. They also produced slightly longer vowel durations than L2A, who

were prompted to shorten vowels in /VC:/ words, but the difference was not statistically significant ($p = .21$). For consonant durations in /V:C/ words, where both L2 groups saw a preceding underlined vowel, the L2 readers on the whole had somewhat longer durations than the L1 readers, while the absolute consonant durations in /V:C/ words among the L2 readers were inconsistent.

4.2 Relative durations

First, the V/C values and S:/W values for /V:C/ words are presented. Then we report the V/C values, S:/W values and V/W values for the /VC:/ words, including boxplots displaying the distribution of all observations, mean values and inferential statistics.

4.2.1 *V/C values for /V:C/ words*

As expected, robust one-way ANOVA and *post hoc* tests showed that there was no significant difference in duration values between L2A and L2B for /V:C/ words that both systems marked the same way ($.16 \leq p \leq .88$). In all, the L2 speakers had higher values compared to the L1 speakers. All three speaker groups produced substantially higher ratios for the word *fyra* compared to other words, by pronouncing very short /r/ segments.

4.2.2 *S:/W values for /V:C/ words*

The readings by the two L2 groups overall had high S:/W values for /V:C/ words, indicating that they were properly guided by the two systems that equally promoted signaling of stress in the first syllable and /V:C/ quantity category. No group difference was found ($.64 \leq p \leq .80$), suggesting their homogeneity.

The longer absolute vowel durations in the L2 productions (see Table 3) disappeared in the relative measure: S:/W = .33 for L1 and L2B, and .32 for L2A. For *fyra* all three groups had values close to one another. Although not statistically significant, in *kaka*, both L2 groups had somewhat higher values than the native Swedish readers, and for *leker*, both L2 groups had lower values than the L1 readers. There was also a generally higher dispersion within the L2 readers compared to L1 readers. Standard deviations were .055 for L1, .087 for L2A and .1 for L2B.

4.2.3 *V/C values for /VC:/ words*

Figure 3 presents the boxplots, mean values and data distribution and Table 4 shows the inferential test results regarding the readings of /VC:/ words by the three speaker groups. Outliers in some boxplots come from those following the instructions in an exaggerated way, either exaggerating the length of the intended sound or giving exaggerated length to the wrong sound. A low value shows high

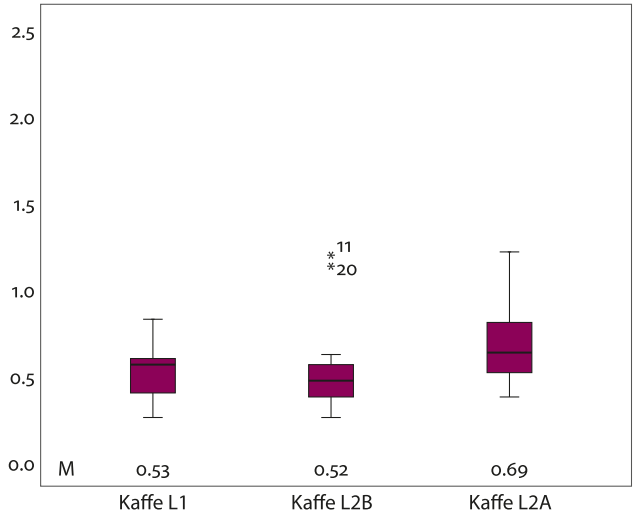
compliance with the instructions either by shortening of vowels (System A) or by lengthening of consonants (System B). It also indicates the clear signaling of the /VC:/ quantity category.

L2B had lower V/C ratios than L2A and they were also closer to the values of L1. Differences between A and B groups were significant for *kaffe* and *soffan*. The boxplots and the inferential statistics for the two words indicate a "tit tat toe" order with L2A and L1 furthest apart, with L2B in the middle. We note that for *kaffe*, L2B even exceeded L1 speakers with respect to the low value. For *åtta*, the difference between L2A and L2B was not significant but the boxplots and mean values in 3c still indicate the "tic tac toe" order. Furthermore, L2A differed significantly from L1, while L2B did not.

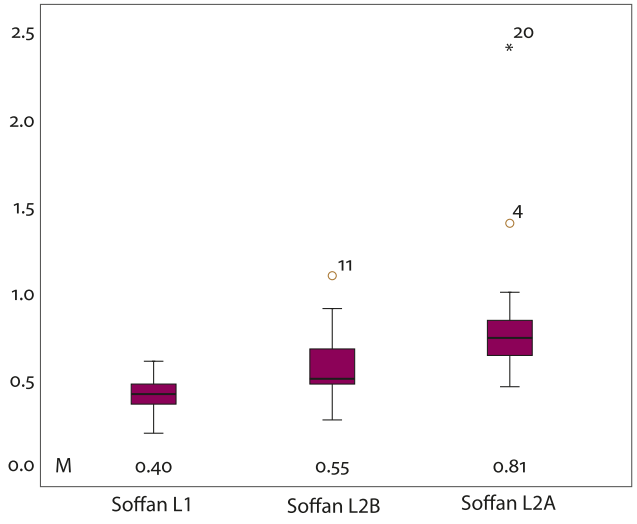
Table 4. Robust ANOVA and pairwise post hoc tests for V/C values of /VC:/ words ($p < .01$)

Target words	F	*p*	Effect size	Pairs compared	Test value	*p*-value
Kaffe	(2, 23.66) = 4.56	.02114 (<.05)	.55	L1 vs. L2B	.07	.16463
				L1 vs. L2A	−.12	.06671
				L2B vs. L2A	.19	.00599*
Soffan	(2, 22.27) = 41.1	0 (<.05)	.72	L1 vs. L2B	.05	.00944*
				L1 vs. L2A	.11	.00000*
				L2B vs. L2A	.07	.00173*
Åtta	(2, 23.65) = 9.82	.00079 (<.05)	.61	L1 vs. L2B	−.13	.05551
				L1 vs. L2A	−.4	.00016*
				L2B vs. L2A	−.3	.08200

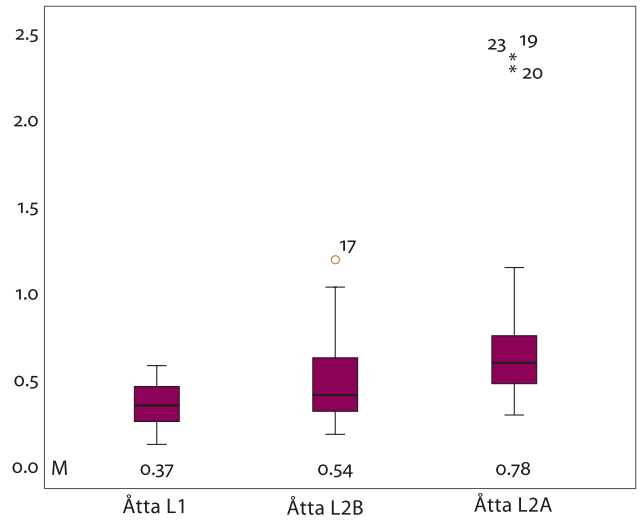
* Significant *p* value


2.5
2.0
1.5
1.0
0.5
0.0
11
20
M
0.53
0.52
0.69
Kaffe L1
Kaffe L2B
Kaffe L2A

a.


2.5
2.0
1.5
1.0
0.5
0.0
20
4
11
M
0.40
0.55
0.81
Soffan L1
Soffan L2B
Soffan L2A

b.

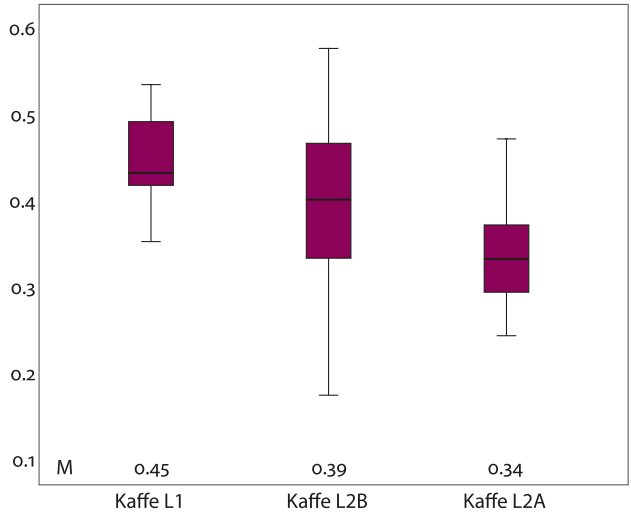


c.

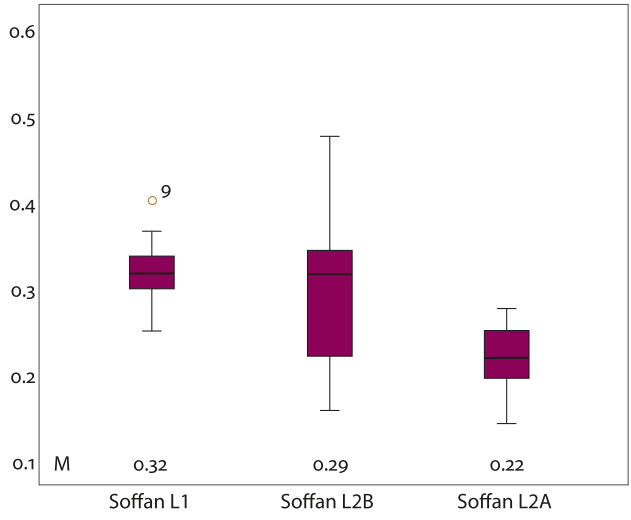
Figure 3. Distribution of V/C-ratios for the /VC:/ words *kaffe, soffan* and *åtta* and the mean values for each speaker group under each boxplot

4.2.4 *S:/W values for /VC:/ words*

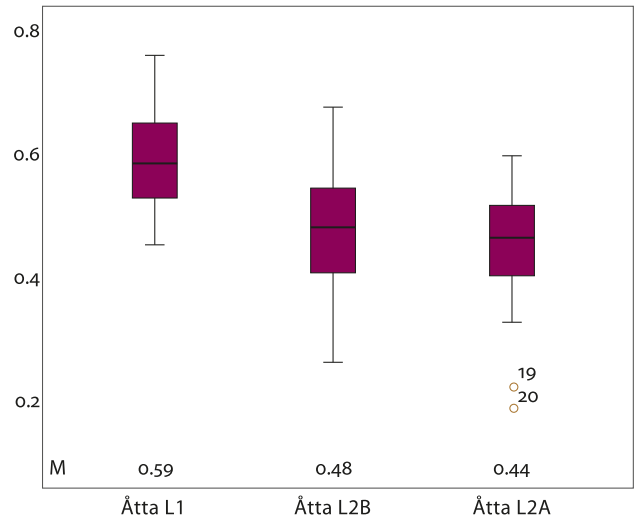
Figure 4 shows the data distribution of S:/W values for *kaffe, soffan, åtta* and Table 5 shows the results of three sets of ANOVA and pairwise significance tests. The ideal compliance with instructions in this case is a high value, that is, the phonologically long segment should take up a big portion of the entire word. The mean values of the reader groups lined up with System A lowest, System B in the middle and L1 readers highest. The differences between L2A and L2 B were significant for *kaffe* ($p < .05$) and for *soffan* ($p < .01$) but not for *åtta*.


0.6
0.5
0.4
0.3
0.2
0.1
M
0.45
0.39
0.34
Kaffe L1
Kaffe L2B
Kaffe L2A

a.


0.6
0.5
0.4
0.3
0.2
0.1
9
M
0.32
0.29
0.22
Soffan L1
Soffan L2B
Soffan L2A

b.



c.

Figure 4. S:/W values for the three words of /VC:/ category (note other values on the Y-axis in panel C.)

Table 5. Robust ANOVA and pairwise post hoc tests for S:/W values of /VC:/ words ($p < .01$)

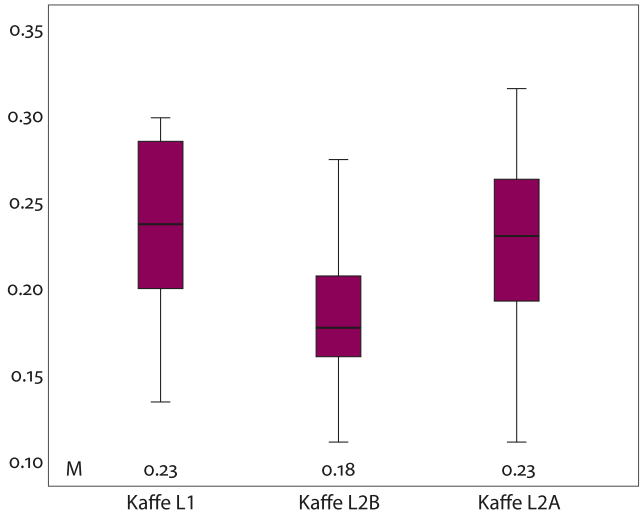
Target words	F	*p*	Effect size	Pairs compared	Test value	*p*-value
Kaffe	(2, 23.03) = 16.46	.00004 (< .05)	.62	L1 vs. L2B	.05	.08055
				L1 vs. L2A	.11	.00001*
				L2B vs. L2A	.07	.02347
Soffan	(2, 23.03) = 16.46	0 (< .05)	.66	L1 vs. L2B	.03	.21381
				L1 vs. L2A	.1	.00000*
				L2B vs. L2A	.07	.00510*
Åtta	(2, 23.55) = 11.35	.00035 (< .05)	.61	L1 vs. L2B	.1	.00335*
				L1 vs. L2A	.12	.00011*
				L2B vs. L2A	.02	.46584

* Significant *p* value

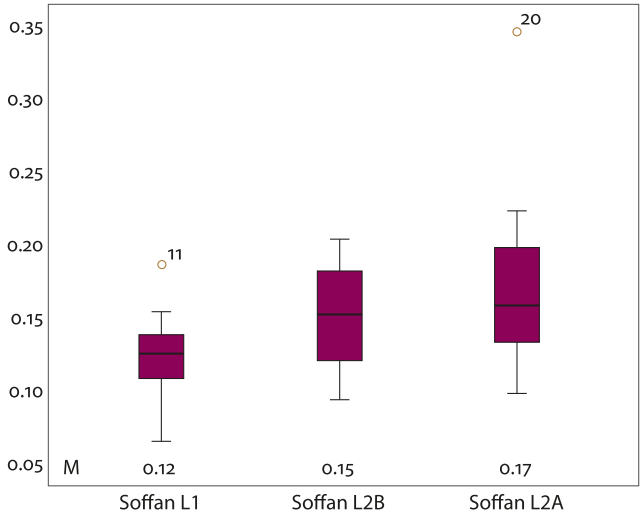
4.2.5 *V/W values for the three words of /VC:/ category*

As mentioned above, a suitable, small V/C value can be obtained either by shortening the vowel or lengthening the consonant. Figure 3 shows that L2B had lower and more native-like V/C values than L2A. The V/W measure, which is less sensitive to consonant duration, confirms that System B did not yield longer relative durations than System A for phonologically short vowels in /VC:/ words.

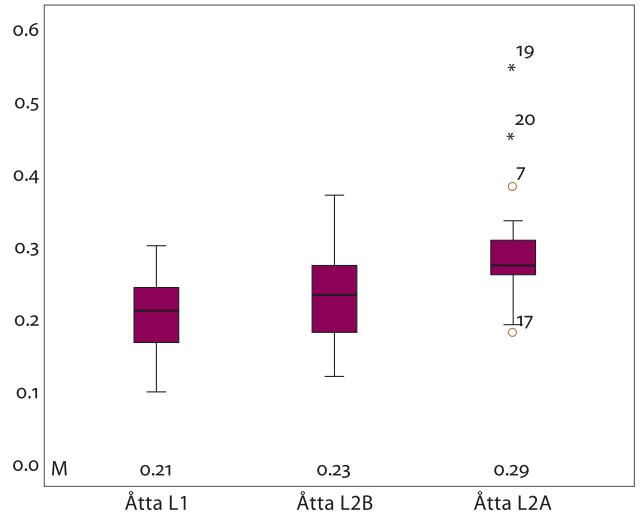
For *kaffe*, L2A were closer to L1, compared to L2B. However, as seen in Figure 5a, it can also be interpreted as L2B made a larger distinction than both L1 and L2A, since L2B had the shortest relative vowel duration, which may also indicate the clearest realization of the /VC:/ category.



a.



b.



c.

Figure 5. V/W values for the three words of /VC:/ category (note other values on the Y-axis in panel C)

5. Discussion

5.1 Summary of the results: Addressing the research questions

5.1.1 *Between Systems A and B, which is more effective for helping L2 learners to realize phonological length in Swedish?*

The answer for the question is that System B was generally more effective in helping learners reach relative durations close to those of the native Swedish speakers. For /V:C/ words, the two systems had the same marking and, as expected, the differences in relative durations between L2A and L2B were not significant. For /VC:/ words, however, L2B always performed better than L2A. By 'better' we mean lower values for V/C and V/W and higher values for S:/W as well as values closer to those of L1 speakers. Differences between L2A and L2B were always in favor of System B, and they were usually statistically significant in the three comparisons. Concerning the presence of quantity in the L2 speakers' L1's, the difference between the groups was very small (12 in A and 11 in B) and if that difference had played a role in the result, it would have been in favor of the System A readers.

In the case of *åtta*, where the difference between A and B readers was not significant in either V/C or S:/W, the mean value for B readers was still closer to L1 readers. We speculate that lengthening the voiceless stop /t/ may have been harder than lengthening the fricative /f/ in *kaffe* and *soffan*. In /t/, the occlusion phase before the burst must be sustained, which is probably more complex and challenging than simply sustaining the voiceless fricative /f/.

5.1.2 *Does System B induce L2 learners to pronounce phonologically short vowels too long, in reference to Swedish L1 speakers?*

There was a small difference in absolute durations between L2A and L2B with respect to phonologically short vowels, with slightly higher values among L2B. However, for both the relative values of V/C and V/W, L2B showed lower and hence more native-like values. In the case of *kaffe* (Figure 3a and Figure 5a), L2B even exceeded L1 speakers by having lower V/C and V/W values. This could be regarded as deviating from the native norm, but we consider it a positive exaggeration towards the right direction (Riad, 1997), suggesting the effectiveness of System B. We think it is a better strategy for L2 learners, at least at a beginner level, to aim for 'over-clear' signaling of important contrasts, rather than aiming for 'barely clear' signaling. This strategy may help them find a more targetlike level of clearness when they become more competent speakers of Swedish (Kjellin, 1978).

5.1.3 *Do the readers of System A lengthen phonologically long consonant sounds sufficiently, in reference to Swedish L1 speakers?*

System A did not seem to lead L2 readers to lengthen phonologically long consonants after short vowels. L2A consistently got higher V/C values and lower S:/W values for /VC:/ words than the L2B, as shown in Figures 3 and 4. This result was expected, since the lengthening of post-vocalic consonants is not prompted by System A.

5.2 Absolute and relative durations of segments

Although absolute durations were not the focus of the present study, we have included them to compliment the results about relative segmental durations. A general observation of absolute duration is that word durations, as well as segment durations, were longer among both L2 groups compared to L1 readers. This can be attributed to the fact that the beginner learner participants could not read words as fast as native speakers do.

A further look at the absolute segment durations shows that vowel durations in /V:C/ words were generally higher for all L2 readers compared to L1 readers, although relative S:/W durations were very similar for all the three speaker groups, as stated in Section 4.2.2 previously. This means that all L2 speakers produced S:/W values in /V:C/ words that were similar to L1 speakers, whereas, for /VC:/ words, the L2B indeed performed better than L2A although they often did not reach nativelike values. We speculate that this better compliance with instructions for vowel length compared to consonant length in both L2 groups reflects a greater ease in exaggerating the duration of vowels. Previous studies (e.g., Lehiste, 1976) show that vowel quantity is more common among the world's languages than consonant quantity. Furthermore, a high portion of the L2 speakers in the present study had German as their L1, which can be a factor in favor of vowel lengthening, since vowel length is a familiar feature for proficient speakers of German.

When looking at the /VC:/ words, however, there was a systematic difference between the A and B groups, in the marking of the text (see Figures 1 and 2) as well as in the productions. As shown in Table 3, L2B produced longer absolute word durations as well as vowel durations in /VC:/ words compared to the L2A readers, but L2B still had lower V/C ratios, as they compensated for their somewhat longer durations in the phonologically short vowels by lengthening the consonants. As mentioned earlier, short segments can be assumed to be default among most L2 learners, which leads us to the following conclusion: a segment that is already short has some physical limitations regarding exaggerating shortness,

while most sound segments can be given exaggerated length, up to several seconds if required.

5.3 Measures

The ratio between vowel and consonant duration is assumed to be a reliable gauge for quantity realization, since it captures the sequence of segments which can constitute minimal word pairs with respect to quantity. Furthermore, speaking rate is not likely to change significantly from one segment to the next segment within the same word. The phonologically long sound divided by entire word duration (S:/W) and the short vowel divided by entire word duration (V/W) are tentative since the duration of the second syllable in the target words is more likely to vary due to disfluencies in reading as well as to final lengthening (Fischer-Jørgensen, 1986; Klatt, 1975). We state, however, that all target words but *kaffe* had a natural pre-pausal position and could therefore be expected to result in a similar degree of final lengthening in all speaker groups. Furthermore, the different parts of the result show a clear tendency with some significant differences between L2A and L2B. There are possible small biases in the accuracy of measuring vowel, consonant and word durations, but apart from the word *fyra*, mentioned in Section 3.5, the test words allowed high accuracy in duration measuring.

5.4 Pedagogical implications

The two marking systems reflect different theoretical views of Swedish prosody, and System B includes the two phonemic contrasts – stress and quantity, suggested to be highly important for intelligibility. Marking long consonants as well as long vowels promotes the lengthening of all stressed syllables, both the /V:C/ and /VC:/ categories. On the other hand, System A involves stress only with respect to vowel quantity and aids the learner to lengthen stressed syllables only in /V:C/ words. Our findings suggest that System B promotes lengthening of all stressed syllables and gives it a pedagogical advantage. Segments produced by L2 learners were short as default. Perhaps, in the context of Swedish as a second language, shortness may not have to be prompted or taught, but for phonologically long segments, learners need to be explicitly guided to lengthen them properly. We therefore believe that System B is more suitable for the learners of Swedish.

5.5 Limitations

As mentioned in Section 2, previous research indicates that word stress and quantity are phonological contrasts that have great influence on intelligibility in spo-

ken Swedish. We also mentioned studies indicating that duration is one of at least two perceptual cues for quantity and that duration is one of several perceptual cues to stress. Since we looked only at duration, our result cannot clearly say that recorded words showing more ideal relative durations (V/C, S:/W and V/W) are automatically more intelligible or sound more natural than those showing less ideal relative durations. However, the aim of the study was to make an evaluating comparison of the effectiveness of two existing marking systems that address only segment length, exclusively looking at durational aspects of the speech material.

Regarding the normality of our data, there were outliers. To tackle this issue and not to over-interpret the results, we performed robust inferential tests not assuming normal distribution. However, although we did not remove the outliers, in order to keep the data as natural as possible, we may still need to discuss tendencies that possibly caused outliers. First, outliers among L2 readers often suggest that the speakers pronounced durations contrary to the marking systems. For example, the Chinese and French L1 readers in L2A produced extreme values in all three ratios: V/C, S:/W and V/W, by lengthening the /o/ in *åtta*, which the marking actually meant to shorten. Second, among the 15 outliers, all of which appeared to be caused by exaggerating durations contrary to the markings, 11 were produced by L2A and 4 by L2B. This could lead to the speculation that System B was generally easier to follow. However, we also observed that more System B readers than System A readers were reminded to follow the markings better. Taken together, we conclude that clearer instructions could have been given to L2 readers to minimize the number of outliers. Second, as for two outliers produced by two different Swedish L1 readers (see Figures 4b and 5b), auditory checking confirmed that they both sounded natural.

6. Conclusion

The results suggest that System B helped its readers to realize phonological length within the Swedish /VC:/ words, quite closely to the native Swedish speakers. System B readers also seemed to signal quantity and word stress categories more clearly than System A readers. Moreover, the slightly higher absolute durations of phonologically short vowels for System B readers did not cause any disadvantage since the relative measures (V/C, S:/W and V/W) of them were closer to L1 readers, compared to those of System A readers.

In future studies, we want to test the naturalness of the productions pronounced after the use of A and B systems respectively, to see if naturalness is correlated to 'idealness' in relative durations. We also want to test and evaluate teaching methods based on our findings. It will be necessary to see if L2 learners in gen-

eral need guidance for lengthening (but not shortening), in order to achieve clear realization of Swedish stress and quantity. We would also like to identify suitable teaching methods and types of feedback for helping learners perceive and produce the stress and quantity distinctions clearly.

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