

The role of duration in vowel categorization Flemish vs. Dutch listeners: a case study

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This paper studies the effect of the regional background of listeners on vowel perception. In Germanic languages such as English, German and Dutch, phonological descriptions of vowel systems distinguish between ‘long’ or ‘tense’ vowels on one hand and ‘short’ or ‘lax’ vowels on the other hand. Both categories may differ in pitch, intensity, vowel quality and duration. This paper focuses on the perceptual role of vowel duration in vowel categorisation. Durational measurements were made of unstressed Standard Dutch vowels in spontaneous speech samples of native speakers originating from Flanders (Belgium) and the Netherlands. Only for the Dutch listeners did vowel duration seem to be one of the parameters determining the location of the phoneme boundary between tense and lax vowels. For the Flemish listeners this boundary could not be determined on the basis of our stimuli.

1. Introduction

The acoustic characteristics of sounds vary substantially depending on all kinds of linguistic and extralinguistic factors. Nevertheless, the human perceptual system is able to handle this variability in physical characteristics. A listener, so to speak, is able to classify sounds into discrete categories. This phenomenon is called *categorical perception* (e.g. Liberman et al. 1957, Harnad 1987, Schouten 2004). A variable that clearly influences perception is the linguistic background of the listener. Listeners who are confronted with sounds from a language they are not familiar with can have difficulties recognizing the sounds. Listeners with a different mother tongue (e.g. English vs. Chinese) even appear to label the same sounds differently (e.g. Van Heuven et al. 1985, Wang & Van Heuven 2004). Other studies focused on the repercussions of the listeners’ dialect

background. However, here the findings are quite diverse. Fox (1974), for example, did not find significant differences between the strategies of two groups of American listeners, originating from Chicago and Oklahoma respectively. Janson (1981), on the other hand, did find differences between the vowel categorization of native speakers of Swedish originating from Stockholm and Helsinki.

A crucial question, however, is whether the differences in vowel categorization found by Janson (1981) are caused by the different dialect background of the listeners. In fact, his listeners did not only speak a different Swedish dialect, but also had another *national variety* of Swedish as their mother tongue: Swedish-Swedish for the listeners from Stockholm, Finnish-Swedish for the listeners from Helsinki (e.g. Reuter 1992).

Remarkably enough, the influence of listeners' national variety has not received much attention in the literature. In Coussé & Gillis (2006) and Kloots et al. (2006) a first attempt was made to study the influence of this factor for Dutch. Just like Swedish, Dutch is a pluricentric language (Clyne 1992). It is the official language of the Netherlands, Flanders (= the northern part of Belgium), Surinam, the Dutch Antilles and Aruba.¹ Since the present study builds strongly on Kloots et al. (2006), the method and the results of this study will be briefly summarized.

In a listening experiment the unstressed vowels of the words *manier*, *moment* and *probeer(t)* (in the first syllable each time) were categorized into eight phonological categories by three Flemish and three Dutch listeners. The stimuli were taken from a corpus of spontaneously spoken Standard Dutch², produced by 160 teachers of Dutch (see also section 2). The dialect background of the six listeners was kept constant: they all grew up in the cross-border dialect area Brabant, in the provinces of Antwerp (Flanders) and Northern Brabant (The Netherlands). The dialects of this area all belong to the so-called "southern central dialects" of Dutch (Weijnen 1966). Although the speech in Antwerp and Northern Brabant is undoubtedly colored by a different national variety (Belgian-Dutch vs. Dutch-Dutch), their dialect basis is the same.

The labelers all had a linguistic background and (at least) a basic knowledge of Dutch phonetics and phonology. The listeners labeled the stimuli individually, at their own pace and using a computer of their choice. All six had experience with listening tasks. Every labeler heard the items in a different random order. When necessary, the stimuli could be replayed several times, but going back and changing answers was not possible.

¹ Information on the history and the linguistic structure of Dutch can be found in De Schutter (1994).

² For a compact description of the pronunciation of Standard Dutch in the Netherlands and Flanders, see Gussenhoven (1999) and Verhoeven (2005), respectively.

Every stimulus was categorized into one of eight categories: ‘long’, ‘short’, ‘schwa’ and ‘zero’, as well as their intermediate values ‘long/short’, ‘short/schwa’ and ‘schwa/zero’. The eighth category was ‘unintelligible’. The six labelers received the same instructions, together with some prototypical (listening) examples of the four main categories (‘long’, ‘short’, ‘schwa’, ‘zero’).

‘Long’ and ‘short’ vowels differ (at least) in quality, duration and intensity (Rietveld & van Heuven 1997). When subjects – as part of a listening task – have to decide whether they hear a ‘long’ or a ‘short’ vowel, they make rather global judgements, since it is impossible for them to separate aspects like quality and duration on a purely perceptual basis (e.g. Van Heuven et al. 1985, Nootboom & Cohen 1988). As a consequence, an experimenter cannot ask the listeners to focus strictly on one aspect and completely ignore the other(s). Only acoustic measurements can give an insight in the specific role of the individual aspects. In this contribution a first attempt is made to study the role of duration, which can be expressed in milliseconds. In our listening task the term ‘long’ (also: ‘tense’) refers to the series /a/, /o/, /e/, /i/, /y/, /u/ and /ø/ whereas ‘short’ (also: ‘lax’) refers to /ɑ/, /ɔ/, /ɛ/, /ɪ/ and /ʏ/ (e.g. Booij 1995).³ The labelers were explicitly asked to interpret both series in their phonological, that is, abstract sense. They were not asked to pay specific attention to vowel duration.

The label ‘schwa’ represents the central vowel of Dutch, whereas the category ‘zero’ refers to deleted vowels (e.g. *moment* > *ment*). Since the listeners all had a linguistic background the concepts ‘schwa’ and ‘deletion’ did not need an exhaustive explanation. The category ‘unintelligible’ was used when the listeners were not able to recognize the word, and, consequently, were not able to judge the vowel. The inter-labeler agreement was discussed in Coussé et al. (2004). More details concerning the labeling procedure can be found in Kloots et al. (2006).

Figure 1 shows the main results of the listening task. Although the Flemish and the Dutch listeners listened to exactly the same stimuli, it is clear that they did not classify the unstressed vowels into the same categories. The most striking difference between the two groups of listeners concerns the labels ‘long’ (= category 1) and ‘short’ (= category 3). Whereas the Dutch listeners use both labels quite frequently, their Flemish counterparts clearly prefer the label ‘short’.

³ Not every ‘long’ vowel has long duration. This holds especially for /i/, /y/ and /u/, which belong to the ‘long’ vowels but – in Standard Dutch – have fairly short duration (e.g. Nootboom 1972, Rietveld et al. 2004).

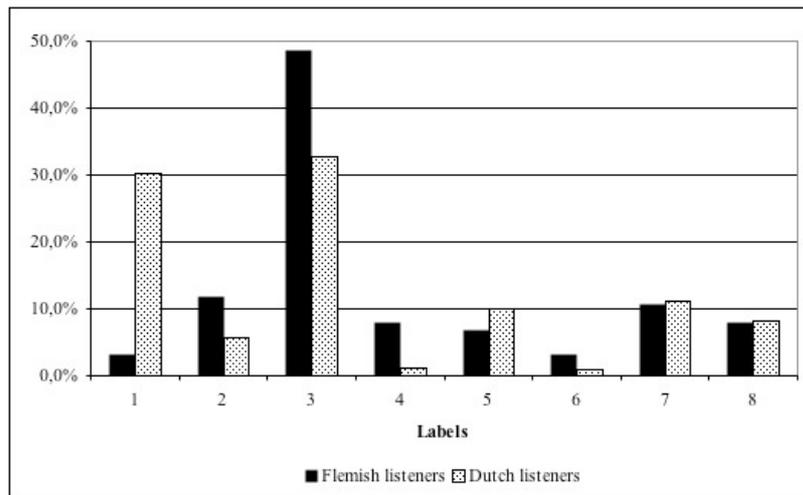


Figure 1: Use of the eight categories (in %) by the Flemish and the Dutch listeners: 1 = long, 2 = long/short, 3 = short, 4 = short/schwa, 5 = schwa, 6 = schwa/zero, 7 = zero, 8 = unintelligible (both for the Flemish and the Dutch listeners n = 2439)

The discrepancy between the Flemish and the Dutch listeners could not be explained at the time. In itself, it is quite possible that Flemish and Dutch listeners have used different strategies in vowel categorization. After all, Belgian-Dutch and Dutch-Dutch are two varieties of a pluricentric language. Sociolinguistic studies have shown that the pronunciation of Standard Dutch in Flanders and the Netherlands has become increasingly different (e.g. Van de Velde 1996). Moreover, there is only limited contact between Flemings and Dutchmen (e.g. Kloots 2001). Neither is the preference for the label ‘short’ inspired by some normative tradition, since according to Flemish pronunciation guides the unstressed vowel in *manier*, *probeer(t)* and *moment* should be pronounced as a ‘long’ vowel. However, what is most striking is that apparently the differences in perception between Flemish and Dutch listeners had not earlier caught the attention of Flemish and/or Dutch linguists. This contribution contains an attempt to fill this gap.

Since the discrepancy between the two groups of listeners concerns the categories ‘long’ and ‘short’ in particular, the present study concentrates mainly on vowel duration. Kloots et al. (2006) hypothesized that Flemish and Dutch listeners have other expectations with respect to the duration of ‘long’ and ‘short’ vowels. In this follow-up study the duration of the (same) unstressed vowels is measured and the role of duration in vowel categorization is assessed.

2. Method

2.1 Stimuli

This follow-up study is based on the same spontaneous speech samples as the study by Kloots et al. (2006). These samples, produced by 80 Flemish and 80 Dutch teachers of Dutch, were originally collected as part of a sociolinguistic project (van Hout et al. 1999). At present these speech samples are also included in the *Spoken Dutch Corpus*.⁴ The teachers spoke freely about various topics, e.g. literature, education, holidays and pets. The Flemish and the Dutch recordings were made by a Flemish and a Dutch researcher respectively.

The speakers were carefully selected. Both for Flanders and the Netherlands the informants were stratified for *sex* (2), *age* (2) and *region* (4). For both countries, the sample consisted of 40 female and 40 male teachers. Half of them were born before 1955, the other half after 1960. Furthermore, in both countries four regions were selected, on the basis of linguistic, geographical and socio-economic criteria. Speech samples were collected of teachers with a stable dialect background, i.e. teachers who had grown up and had always lived in one and the same region. A more detailed description of the sampling criteria can be found in Van Hout et al. (1999) and Kloots (2008).

From the spontaneous speech of the teachers, three highly frequent words were selected: *moment*, *manier* and *probeert(t)*.⁵ These three words have a similar phonological structure: they are disyllabic, stress is on the second syllable, the first syllable is unstressed and ends in a vowel. This study focuses on the unstressed vowels in the first syllable. The teachers' corpus yielded 813 stimuli (*moment*: 291, *manier*: 236, *probeert(t)*: 286).

2.2 Measuring vowel duration

The duration of the unstressed vowels was measured by an experienced phonetician on the basis of a broad-band spectrogram which was time-aligned with a waveform representation of the sound. In order to measure the duration of the vowels between nasals in *moment* and *manier*, the segmenter primarily focused on the obvious break in spectral structure in the transition between the vowel and the nasals. In *probeert*, the unstressed vowel is preceded by a trill and

⁴ Information on the *Spoken Dutch Corpus* can be found on the following websites: <<http://lands.let.kun.nl/cgn/home.htm>> and <<http://www.tst.inl.nl>> (see "Producten").

⁵ The *Spoken Dutch Corpus* contains 1378 realizations of *probeert(t)*, 2815 realizations of *manier* and 4607 realizations of *moment*. (Source: frequency list 'arealph.frq', available with the Spoken Dutch Corpus).

followed by a stop. The duration of this vowel was measured from the last vertical striation associated with the trill to the point of minimal energy in the waveform corresponding to the stop. The original dataset consisted of 813 stimuli. For four stimuli, however, it was impossible to generate a reliable spectrogram. These stimuli were excluded from the dataset.

The consistency of the durational measurements was checked in 160 (80 Flemish and 80 Dutch) randomly chosen stimuli by three independent segmenters. The results of consistency tests indicate that there is very good agreement between the measurements, which suggests that the values obtained in this experiment are reliable.⁶

2.3 Data reduction

In order to correlate the judgments of the labeling panel in Kloots et al (2006) to the measurements of vowel duration obtained in this study, a single consensus label was assigned to each stimulus on the basis of the actual data from the Belgian and Dutch labelers. This consensus label corresponded to the label that was used by at least two labelers in each group. If all three labelers in the group had used a different label, the target word was excluded from the study. As a result, 123 words had to be excluded for the Belgian and 124 for the Dutch labelers.

2.4 Research questions

Explaining and interpreting the tendencies of a vowel categorization task in terms of acoustic features is complex. Several features could play a role, e.g. vowel duration, vowel quality and intensity. In this study the focus will be on vowel duration, since Kloots et al. (2006) already hypothesized that this factor was very important. We will proceed in three steps. To get a clear picture of the differences between Flemish and Dutch listeners, the results for both groups are analyzed separately. First, we check if the eight categories ('long', 'long/short', 'short', 'short/schwa', 'schwa', 'schwa/zero', 'zero', 'unintelligible') – globally – have a significantly different duration. Next, we concentrate on the labels 'long' and 'short', and compare their average duration. Finally, we focus on the vowels with the longest duration and check how many of them were categorized as 'long' and 'short' respectively.

⁶ The average difference in duration between the four measurements turned out to be 12.2 ms (with a standard deviation of 2.1 ms.). When we selected the maximal difference in duration for every stimulus, the average maximal difference appeared to be 22.3 ms.

3. Results

In this section the duration of the unstressed vowel in *moment*, *manier* and *probeer(t)* is investigated and the durational measurements are connected to the results of the listening experiment described in section 1. An interpretation of these results can be found in the next section.

The average duration of the eight categories for both Flemish and Dutch listeners is shown in Figure 2. There is a striking similarity between the two groups. The duration of the eight categories is significantly different, both for the Flemish listeners ($F(1, 7) = 117.20, p < 0.01$) and their Dutch counterparts ($F(1, 5) = 209.82, p < 0.01$).

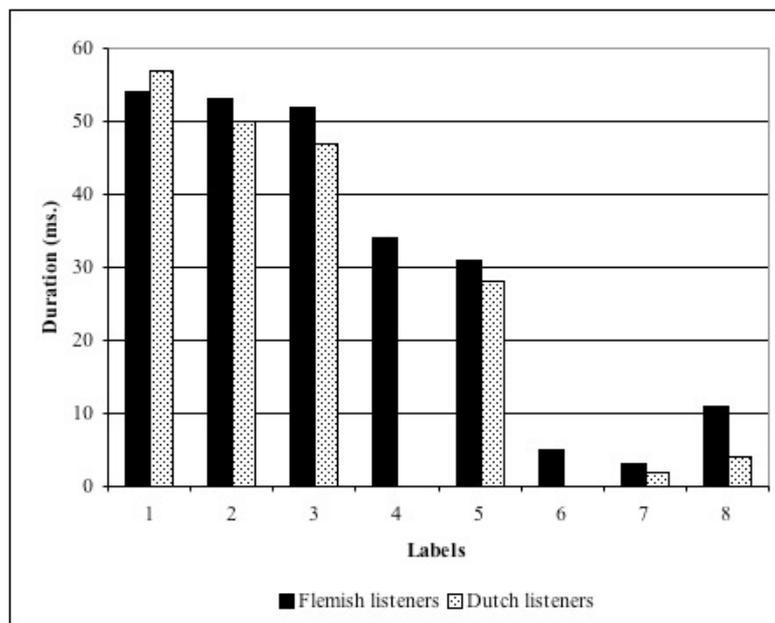


Figure 2: The average duration (in ms.) of the eight categories for Flemish and Dutch listeners: 1 = long, 2 = long/short, 3 = short, 4 = short/schwa, 5 = schwa, 6 = schwa/zero, 7 = zero, 8 = unintelligible (Flemish listeners: $n = 686$, Dutch listeners: $n = 685$)

In Table 1 the data are examined in more detail. Mean and median duration are quite comparable, except for the category 'unintelligible' of the Flemish listeners. In this case the mean duration is clearly higher than the median duration (11.2 ms. vs. 0.0 ms.). Furthermore, there is a remarkably high standard deviation for the label 'long' of the Flemish listeners. However, it is important to

emphasize here that the label ‘long’ is extremely unpopular with the Flemish listeners. Mean, median and standard deviation for the category ‘long’ (Flemish listeners) are only based on 11 tokens. The Dutch labelers clearly distinguish between ‘long’ and ‘short’ vowels, whereas the Flemish listeners almost exclusively use the category ‘short’ (cf. Figure 1).

Category	Flemish listeners				Dutch listeners			
	n	mean	median	s	n	mean	median	s
1. long	11	54.4	56.8	31.4	232	56.9	57.0	18.3
2. long/short	48	52.8	54.9	15.1	7	50.1	51.0	13.3
3. short	402	52.0	51.1	18.1	248	46.7	47.3	16.9
4. short/schwa	28	34.0	36.4	12.8	0	-	-	-
5. schwa	45	30.9	32.2	15.0	56	27.6	29.5	14.8
6. schwa/zero	14	5.2	0.0	14.5	0	-	-	-
7. zero	80	3.1	0.0	11.1	79	2.0	0.0	8.9
8. unintelligible	58	11.2	0.0	21.1	63	4.1	0.0	15.5
Total	686	39.8	44.7	25.6	685	39.5	43.9	26.0

Table 1: Duration (in ms.) of the eight categories for Flemish and Dutch listeners (frequency, mean, median, standard deviation)

Next the length of ‘long’ and ‘short’ vowels is compared in a contrast analysis. As far as the scores of the Dutch listeners are concerned, both categories have a significantly different duration ($F(1, 679) = 46.61, p < 0.01$). The Flemish listeners, however, do not show a significant difference in length between ‘long’ and ‘short’ vowels ($F(1, 678) = 0.22, p = 0.64$).

Finally, the stimuli with the longest duration were examined. For that purpose, the complete set of stimuli was split up in its quartiles (Table 2). We will select the quartile with the longest duration (56.4 to 106.7 ms.) and check how these stimuli were categorized by the Flemish and the Dutch listeners.

Quantiles	Duration (ms.)	
100.0%	maximum	106.7
75.0%	quartile	56.4
50.0%	median	43.1
25.0%	quartile	23.5
0.0%	minimum	0.0

Table 2: The complete set of stimuli ($n = 809$), split up in quartiles

Table 3 shows that two thirds of the vowels with a duration between 56.4 and 106.7 ms. were called ‘long’ by the Dutch listeners, whereas the Flemish

listeners called 83.7% of these vowels ‘short’.⁷ It is also clear from Table 3 that – at least for this subset – the competition is really between the labels ‘long’ (for the Dutch listeners), ‘long/short’ (for the Flemish listeners) and ‘short’ (for both the Dutch and the Flemish listeners). The categories 4 to 8, presented in Table 3 as one category ‘other’, were selected only occasionally.

	Flemish listeners		Dutch listeners	
	n	%	n	%
1. long	6	3.4%	120	66.7%
2. long/short	19	10.7%	2	1.1%
3. short	149	83.7%	56	31.1%
4-8. other	4	2.2%	2	1.1%
Total	178		180	

Table 3: Categorization of the vowels with the longest duration (56.4 until 106.7 ms.)

4. Discussion

A first interesting observation is that the vowel duration associated with the eight label categories is significantly different (Figure 2, Table 1). This suggests that both the Flemish and the Dutch listeners took vowel duration into account in categorizing the unstressed vowels. What makes this finding fascinating is that the listeners were not instructed at all to pay attention to vowel duration, which means that they must have picked up the durational cues automatically and/or unconsciously. For all eight categories the mean duration is fairly comparable to the median duration, both for the Flemish and the Dutch listeners. The only exception is the category ‘unintelligible’ of the Flemish listeners, where the mean duration is substantially higher than the median duration (11.2 vs. 0.0 ms.).

A closer look at the data reveals a significant durational difference between the categories ‘long’ and ‘short’ for the Dutch listeners. In other words, the Dutch listeners seem to detect and use durational cues for differentiating between ‘long’ and ‘short’ vowels. The results of the categorization task together with the results of the duration measurements suggest that the Dutch listeners have a clear *phoneme boundary* between ‘long’ and ‘short’ vowels. Vowel duration seems to be one of the parameters determining the location of this boundary. From a phonological point of view this is quite surprising, since in Dutch phonology the categories ‘long’ and ‘short’ are traditionally defined in terms of vowel quality and/or distribution, not in terms of vowel duration (e.g. Booij 1995, Moulton 1962).

⁷ Of course, at this stage, we focused on the stimuli where the listeners agreed on (“consensus”) again.

For the Flemish listeners, the duration of ‘long’ and ‘short’ vowels is not significantly different. Neither the categorization task nor the duration measurements give information on the exact location of the phoneme boundary between the two categories. The fact that Flemish listeners do not really differentiate between ‘long’ and ‘short’ unstressed vowels does not imply that they are not able to detect the same fine differences the Dutch listeners hear. It means that Flemish listeners apparently do not attach linguistic value to the same durational cues as the Dutch listeners (Lehiste 1970). The Flemish listeners clearly prefer the category ‘short’, irrespective of the vowels’ duration. Even when they hear vowels belonging to the quartile with the longest duration, they still call them ‘short’ (Table 3).

It could be argued that the Flemish listeners prefer the category ‘short’ because this is the most frequent (or even the only) variant in *everyday Flemish pronunciation* of unstressed vowels. This would imply that the option ‘long’ was in fact very unfamiliar to the Flemish listeners, and, consequently, was chosen only occasionally (11 times). Indeed, the standard deviation for the category ‘long’ is remarkably high, which suggests (a.o.) that the Flemish labelers did not have a precise idea about how long a phonologically ‘long’ vowel should last. Another indication for the hesitation of the Flemish listeners is the – in comparison to the Dutch listeners – fairly high score for the category ‘long/short’.

However, this explanation is not unproblematic. First of all, only little is known about the actual durational and qualitative properties of unstressed vowels in everyday Flemish speech. Kloots (2008) showed that the Flemish teachers produced more ‘short’ vowels in unstressed syllables than their Dutch counterparts, but her results are also based on a categorization task, not on acoustic measurements. Furthermore, if the extremely low frequency of the label ‘long’ for the Flemish labelers was to be related to the (semi-)absence of ‘long’ vowels in everyday Flemish pronunciation, logically speaking, this explanation should also hold for other categories. Kloots (2008), however, also showed that Flemish listeners heard far more strongly reduced forms (e.g. deletions) in Dutch speech than in Flemish speech. In other words, the Flemish listeners are actually able to recognize categories in Dutch-Dutch that they do not hear frequently in their own national variety.

Another important factor in this discussion is *stress*. In this contribution we focused on the duration of unstressed vowels. Unstressed vowels typically have a shorter duration than their stressed counterparts (e.g. Lehiste 1970, Koopmans-van Beinum 1980, Rietveld et al. 2004). This means that, globally speaking, all vowels in our categorization task have a fairly short duration, and consequently, it is not surprising that many of these vowels are classified as ‘short’ both by the

Flemish and the Dutch listeners, since this is the phonological category that only contains vowels with a short duration.

The Dutch listeners, however, also classified many of these fairly short vowels as 'long'. From a quantitative point of view, this could mean that, for the Dutch listeners, the duration of some of the unstressed vowels was actually too long to categorize them as 'short'. However, it could also mean that for the Dutch listeners duration was not the (only) deciding factor. Maybe the Dutch listeners also took into account and/or gave different weight to other acoustic factors than duration, e.g. vowel quality, intensity or average pitch level. A first exploration of our data revealed, for example, that the 'long' vowels of the Dutch listeners also have a significant higher intensity than the 'short' vowels. This was not the case for the Flemish listeners. The exact location of the phoneme boundary between the categories 'long' and 'short' for the Flemish listeners could not be determined on the basis of our stimuli. Maybe the Flemish listeners only differentiate between 'long' and 'short' when they are categorizing stressed vowels.

Finally it could be asked to what extent the results of the categorization task are influenced by the *Brabantic dialect background* of the listeners (see section 1). Maybe listeners with a Brabantic dialect background are used to hearing and/or producing shorter or – on the contrary – longer vowels in everyday speech than listeners from another region. Unfortunately, until now only a few acoustic studies have systematically examined regional differences in Dutch vowel duration (Verhoeven & Van Bael 2002, Adank et al. 2004 and 2007). These studies cannot be directly linked to our categorization task, since they are based on stressed vowels, elicited in read speech and in a fixed consonantal context, whereas we have studied unstressed vowels originating from spontaneous speech.

In a follow-up study stimuli should be created of which (at least) vowel quality and duration are systematically varied (cf. Janson 1981). Next, these stimuli should be categorized by the same Flemish and Dutch listeners. Only in this way can we acquire a clearer understanding of the discrepancy between Flemish and Dutch listeners and the different location of their phoneme boundaries. It would also be interesting to repeat the listening experiment with listeners from other regions and compare the results with those of the Brabantic listeners.

5. Conclusion

The present study revealed some new insights into durational aspects of vowel categorization. Kloots et al. (2006) found that Flemish listeners categorized unstressed /a/'s and /o/'s quite consistently as 'short', whereas their Dutch colleagues clearly differentiated between (phonologically) 'long' and 'short' vowels. This follow-up study showed that the 'long'-short distinction of the Dutch listeners goes hand in hand with a significant difference in vowel duration: 'long' vowels have a longer duration than their 'short' counterparts. The mean duration of the vowels, categorized as 'long' and 'short' by the Flemish listeners was not significantly different. These findings confirm our assumption that (only) for the Dutch listeners is there a real phoneme boundary between 'long' and 'short' vowels. Vowel duration seems to be one of the parameters determining the location of this boundary. In order to find the exact location of the phoneme boundary of the Flemish listeners and to compare it with its Dutch counterpart, a new experiment is needed. For this experiment stimuli should be created in which vowel duration, quality and intensity are gradually varied.

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