INTRINSIC VOWEL PITCH IN DUTCH AND ARABIC

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ABSTRACT

This paper examines intrinsic vowel pitch (IF0) in Moroccan Standard Arabic and Belgian Standard Dutch in order to investigate the hypothesis that IF0 may depend on the size of the vowel inventory. The results of a production task with 11 Moroccan native speakers of Standard Arabic and 10 Belgian native speakers of Dutch reveal that IF0 in Arabic is significantly smaller (1.28 ST) than in Dutch (2.78 ST). These results are suggestive of a possible influence on IF0 of the size of the vowel inventory in a language. The effect of speaker sex on IF0 was not significant, while the front-back distinction in the articulation of vowels was significant in Belgian Dutch.

Keywords: intrinsic vowel pitch, prosody, Dutch, Arabic.

1. INTRODUCTION

Intrinsic vowel F0 or vowel pitch (henceforth IF0) refers to the tendency of high vowels such as /i/ and /u/ to have a higher fundamental frequency than low vowels such as /a/ and /ɑ/. [1] have given a comprehensive survey of IF0 research. Their survey includes languages from a typologically representative range of pitch functions (stress, contour and register tone, and pitch accent) and supported the general conclusion that IF0 is a universal, phonetically based phenomenon, as opposed to a feature used to enhance vowel contrasts (cf [2], [3], [4] and [5]). This finding was supported by the absence of any statistically significant relationship between the size of the vowel inventory of the languages concerned and IF0. Nevertheless, it is noted that the reported figures in [1] show an interesting trend in that languages with smaller vowel inventories have a considerably smaller IF0 than languages with larger vowel inventories. Expressed in semi-tones, the reported IF0 values for small, medium, 12-vowel and large inventories was 1.17, 1.33, 1.70 and 1.64 semi-tones respectively and in the absence of statistical significance of these figures, [1] concede that there is a need for a better controlled dataset to ensure that the statistics do not hide a small effect. This study aims to investigate such possible effect by comparing IF0 in Moroccan Standard Arabic and Belgian Standard Dutch, two languages which differ considerably in the size of their vowel inventories.

2. MATERIALS AND METHODS

In order to examine this aspect of IF0, production data on the vowels /i/, /u/ and /a/ were collected in Moroccan Standard Arabic and Belgian Standard Dutch. Standard Arabic has a vowel system consisting of 3 distinctive monophthongal vowel qualities /i/, /u/ and /a/. Each of these vowels has a long and a short variant. Belgian Standard Dutch distinguishes between 12 qualitatively different monophthongs [6]. The particular variety of Standard Dutch of the Belgian participants (Antwerp region) had the additional characteristic that /i/, /u/ and /a/ are typically pronounced long [7]. As a result of this, it is possible to compare IF0 in the long vowels of a system with a small number of vowels (Arabic) with IF0 in a system with a fairly large number of vowels (Dutch).

2.1. Materials

The datacollection consisted of a reading task the materials of which were obtained by inserting the long vowels /i/, /u/ and /a/ in monosyllabic (nonsense) words with a CVC structure: this yielded phonologically and morphologically well-formed words in both Arabic and Dutch. The consonants of these words were selected on the basis of phonological and morphological information about Modern Standard Arabic and Moroccan Arabic in [8] and [9]. The main criterion was that these consonants had to occur as phonemes in both Arabic and Dutch and that their phonetic realisation had to be very similar in both languages. On the basis of this, 10 consonantal contexts were selected, i.e. [b_n], [m_s], [f_t], [d_k], [n_s], [s_f], [z_t], [l_m], [k_f] and [h_k]. In each language, the three vowels were inserted between the consonants yielding a total of 30 nonsense words which entirely conformed to the

phonological and morphological restrictions of both languages.

For Dutch, these words were inserted in the first slot of the carrier phrase [ɪn __ staːt ən __] (Lit: In __ stands a __). This places the target word in [+FOCUS, -FINAL] position so that it is likely to be realised with a clear sentence accent. The second slot contained an orthographic transcription of the vowel contained in the stimulus word. In the reading list, each stimulus occurred twice, resulting in a total of 60 stimuli (i.e. 3 vowels x 10 consonantal contexts x 2 repititions).

For Arabic, the target words were inserted in the first slot of an Arabic translation of the Dutch carrier phrase [fi: __ __]. Also in Arabic, the [+FOCUS, -FINAL] position of the target word in the carrier phrase is conducive for sentence stress. The target word's vowel was repeated in the second slot of the carrier phrase. Although vowels in Arabic texts are not usually transcribed orthographically, the vowel length markers are, and this was regarded sufficient to avoid potential problems with the correct recognition of some of the nonsense words. The 60 stimuli in the Arabic reading list occurred in the same sequential order as the ones in the Dutch list in order to avoid potential order effects.

2.2. Speakers

Ten speakers of Belgian Dutch and 11 speakers of Moroccan Standard Arabic participated voluntarily in the reading task. The Dutch group consisted of 5 male and 5 female native speakers from the region of Antwerp in the northern part of Belgium: their average age was 22 years. Only one speaker in this group reported to have an elementary knowledge of Arabic.

The Moroccan group consisted of 6 male and 5 female speakers from various regions in the country (Tetouan, Tanger, Oujda, Fes, Rabat, Al Hoceima, Temsamen). Their average age was 27 years. All speakers were registered for an elementary Dutch course, but from conversations with these participants it was clear that their knowledge of Dutch was minimal to such an extent that French had to be used as the language of communication.

2.3. Recording procedure

The speakers were asked to read the sentences as naturally as possible and they were allowed to repeat a sentence if they were not satisfied with their pronunciation. The recordings were made in quiet surroundings with no disturbing background noise. The recording equipment consisted of a TASCAM DAT recorder and an AKG head-mounted microphone (CLL 444).

2.4. Analysis procedures

In order to measure the F0 of the vowels, each vowel was manually selected in PRAAT [10] on the basis of a broadband spectrogram which was time-aligned with the sound wave. Subsequently, F0, F1 and F2 of each vowel were measured as the average value in the vowel's middle third portion. The F0 analysis used PRAAT's standard autocorrelation algorithm optimised for intonation analysis. The formants were extracted by means of PRAAT's standard LPC-based method. The analysis conditions were set to be appropriate to male or female voices. The selection of the middle third portion of the vowel and the acoustic analyses were carried out automatically by means of a script.

After obtaining the F0 measurements, the IF0 values were calculated by converting the F0 measurements for /i/ and /a/ (front dimension) in corresponding target words into a semitone distance value. The same was done for the F0 measurements for /u/ and /a/ (back dimension). As a result, IF0 in this paper is defined operationally as the pitch distance in semi-tones between high and low vowels in corresponding target words and these semi-tone values were used for statistical analysis in the next section. This approach is slightly different from other studies on intrinsic vowel pitch, which generally analyse the obtained F0 values for the high and low vowels in order to investigate a statistical effect of vowel height on F0. Our method was preferred since it enables a normalisation for gender/individual anatomical differences between speakers. Occasional negative IF0 values arising from this procedure were excluded from the statistical analysis.

3. RESULTS

In this experiment, a total of 1,260 observations were obtained, i.e. 60 stimuli x 21 informants. 600 observations pertained to Belgian Standard Dutch, while 660 observations related to Moroccan Arabic.

The obtained IF0 estimates in semitones were analysed by means of a three-way repeated

measures ANOVA with 'language' (2) and 'sex' (2) as between-subject variables, and 'backness' (2) as a within-subjects variable. The analysis showed a significant effect of the speakers' language background ($F(1, 351) = 66{,}197$ $p < 0.0001$). This effect is such that IF0 in Moroccan Standard Arabic (1.28 ST) is substantially smaller than in Belgian Dutch (2.78 ST).

Besides this main variable of interest, we also looked at the effect of the front-back distinction on IF0 in the experimental vowels. This effect was not significant ($F(1,351) = 2{,}294$, $p = 0.131$) although IF0 in the back dimension is somewhat bigger (2.12 ST) than in the front dimension (1.94 ST). It should also be pointed out that there is a significant interaction between 'language' and 'backness' ($F(1, 351) = 7{,}960$, $p = 0.005$). This interaction is such that in Moroccan Arabic IF0 is slightly bigger in the front dimension (Front = 1.36 ST, Back = 1.20 ST), while IF0 in Dutch is biggest in the back dimension (Front = 2.52 ST, Back = 3.03 ST).A contrast analysis shows that only the difference in Dutch is significant ($F(1, 702) = 4.92$, $p = 0.026$).

Finally, the analysis shows that the 'sex' of the speakers in the experiment did not have a significant effect on IF0 ($F(1, 351) = 0.009$, $p = 0.926$). IF0 for male speakers was 2.04 ST, while the female speakers had a mean IF0 of 2.02 ST.

Besides the IF0 analysis, it is of interest to examine the formant values of the vowels in the two languages. Since we wanted to get information about possible pronunciation differences between the vowels in the two languages, it was decided not to normalise the formant values by any numerical or perceptual transformations. The resulting scatterplot is illustrated in figure 1, which represents a visual representation of the formant values of the vowels included in the IF0 analysis.

In figure 1 it can be observed that the mean formant values for corresponding vowels do differ slightly in the two languages in that the vowel space for Moroccan Standard Arabic is somewhat smaller than that of Belgian Dutch.

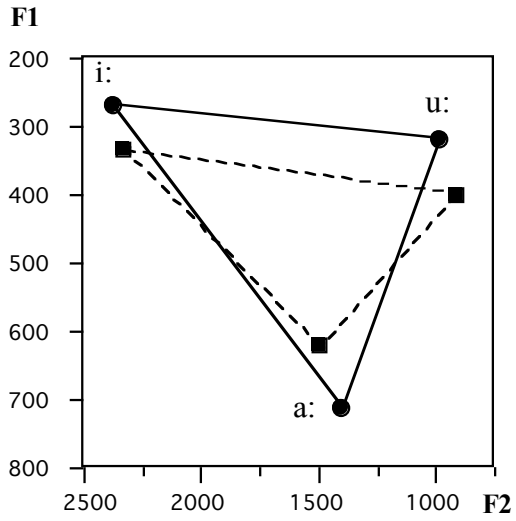

Figure 1: Acoustic vowel space in Moroccan Arabic (dashed line) and Belgian Standard Dutch (solid line). The averages of the Dutch vowels are based on 200 observations, those of Arabic on 220 measurements.

4. DISCUSSION

This experiment aimed to investigate whether there are differences in IF0 as a function of vowel inventory size. For this purpose IF0 was derived from F0 measurements in /i/, /u/ and /a/ in Moroccan Standard Arabic and Belgian Standard Dutch: the former has a vowel system with 3 qualitatively different long vowels, while the latter has a system with 12 monophthongs differing in quality.

It was found that intrinsic vowel pitch in Arabic differs significantly from Belgian Dutch. The effect is such that IF0 in Arabic (1.28 ST) is substantially smaller than in Belgian Dutch (2.78 ST). This effect is present in both male and female speakers and in both the front and back dimensions of the vowel space. This seems to suggest that there is a relationship between the size of the vowel inventory and IF0: bigger inventories yield bigger IF0 values. This effect is consistent with [1]. Although they did not find significant differences in IF0 for vowel inventories of different sizes, the reported values in [1] suggest that larger inventories have larger IF0: the reported values are 1.17, 1.33, 1.70 and 1.64 ST for small, medium, 12-vowel and large inventories. It can be noted that the IF0 value for Arabic found in this investigation matches Whalen & Levitt's value for small vowel systems rather well. Our value for the Belgian Dutch 12-vowel system is considerably bigger than the 1.70 ST associated with the 12-vowel systems in the Whalen & Levitt collection of languages.

This relationship between vowel inventory size and IF0 at first sight seems to suggest that these

IF0 differences may be related to deliberate enhancement of vowel qualities in crowded vowel spaces, where there may be a greater need to perceptually distinguish vowel qualities on the basis of other acoustic characteristics than quality alone. However, from the spectrographic analysis in figure 1, it is clear that there are also spectral differences between corresponding vowels in the two languages: the acoustic vowel space of Belgian Dutch was found to involve a somewhat bigger distance between high and low vowels than in Arabic. These spectral differences suggest that there are likely to be articulatory differences between corresponding vowels in both systems which may have caused the IF0 differences. Since Belgian Standard Dutch has 12 vowels, the high and low vowels are possibly articulated at more peripheral positions to maximize the space available for the articulation of the vowels at intermediary degrees of opening. These more peripheral articulations are likely to translate in more tongue pull on the larynx in the high vowels and less tongue pull in the low vowels leading to the greater IF0 values for Belgian Dutch. The phonetic realisation of vowels in a smaller inventory does not require such extreme peripheral articulations of the high and low vowels since there is no competition of other vowels at intermediary degrees of opening. This creates a smaller tongue pull effect in high and low vowels leading to smaller IF0 values. In this line of reasoning, we would like to suggest that the relationship between vowel inventory size and IF0 is the indirect result of more or less extreme articulatory positions of the corner vowels, rather than deliberate perceptual enhancement.

The second new and important finding of this investigation relates to the effect of sex on IF0. Whalen & Levitt (1995) found slightly bigger IF0 for female speakers on a Hz-scale; on the semitone scale the effect is reversed with the difference being bigger for male speakers. The results of this study also found substantial differences between men and women on a Hz-scale and this applies to both languages (AR-M = 10 Hz, AR-F = 15 Hz, BD-M = 21 Hz, BD-F = 31 Hz). In both languages, these differences disappear entirely on the semitone scale: AR-M = 1.26 ST, AR-F = 1.30 ST; BD-M = 2.81 ST, BD-F = 2.74 ST. This strongly suggests that effects of speaker sex are more apparent than real and the observed differences on the Hz-scale may be have to be attributed to register differences between male and female speakers.

The third finding of this study relates to IF0 differences between the front and back dimensions of the vowel space. The results indicate that there is a significant effect of the front-back dimension in Belgian Dutch, not in Moroccan Arabic. In Belgian Dutch the effect is such that IF0 is significantly bigger in the back vowels (3.03 ST) than in the front vowels (2.52 ST). This is contradictory to the findings in Whalen & Levitt (1995) who found no IF0 differences between the front and back dimension. At present it is not quite clear how this difference between the two languages has to be accounted for.

5. CONCLUSION

The most important result of this investigation is the effect of vowel inventory size on IF0 which is hypothesized to result from articulatory differences between the two languages studied. The second new finding indicates that the difference between male and female speakers does not correlate significantly with IF0. Finally, it was found that IF0 may be different in the front and back dimensions of vowel articulation.

6. REFERENCES

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