

Speech Rhythm Variation in Arabic Dialects

Salem Ghazali¹, Rym Hamdi^{1,2}, Melissa Barkat²

¹Institut Supérieur des langues, Université 7 Novembre à Carthage, Tunisia

²Laboratoire Dynamique du Langage, Institut des Sciences de l'Homme, Lyon, France

salem.ghazali@irsit.rnrt.tn, rymhamdi@yahoo.fr, Melissa.Barkat@ish-lyon.cnrs.fr

Abstract

Speech rhythm in the different Arabic dialects investigated has been consistently described as stress-timed. At the same time, there is preliminary evidence from perceptual experiments that listeners use speech rhythm cues to distinguish speakers from North Africa from those of the Middle East. In an attempt to elucidate the apparent contradiction, an acoustic investigation of the proportion of vocalic intervals and the standard deviation of consonantal intervals in six dialects (Morocco, Algeria, Tunisia, Egypt, Syria and Jordan) was carried out using procedures put forth by Ramus & al [1]. The results show that complex syllable and reduced vowels in the Western dialects, and longer vowels in the Eastern dialects seem to be the main factors responsible for differences in rhythmic structures. The paper also raises questions about the discrete or continuous natures of rhythm types.

1. Introduction

Arabic dialects may be characterized as representing a continuum along which mutual intelligibility breaks down progressively as the geographical distance between speakers increases. Communication between literate Arabs is normally achieved through the use of Middle or Standard Arabic, two language levels extensively documented in the literature on Arabic socio-linguistics. It is also well known to scholars of Arabic that this continuum is somewhat bipolar with the Middle East representing the Eastern Dialects and North Africa hosting the Western Dialects. Although this division is an oversimplification of Arabic dialectology, it is widely accepted by the linguistic community and may be supported by linguistic behavior. Barkat [2] reported that, during a listening task, her subjects who were linguistically naïve native speakers of Arabic from various regions in the Arab world were able to successfully identify speakers as belonging to North Africa or the Middle East in 97% of the time. On the same task, native speakers of French with no knowledge of Arabic were able to discriminate between the two regions in 56% of the time only. The results, however, were reported to be statistically significant ($p > 0.05$).

2. The role of rhythm as a discrimination factor

When asked to list the criteria that had helped them make their choices, most subjects mentioned that North African Arabic sounded faster and jerky or more halting than Eastern Arabic an impression that, if translated into linguistics phonetics, would be correlated with speech rhythm.

To investigate the matter further, Barkat [2] set up another experiment where the stimuli consisted of only F0 and amplitude with all the segmental material deleted. Correct identification dropped considerably (58% for native speakers of Arabic and 49% for French subjects). The comparatively poor results in this second experiment, however, do not imply that rhythm is not a reliable cue in discriminating between Arabic dialects, namely because the only acoustic stimuli left for subjects to rely on in this experiment were F0 and amplitude. Segmental material that preserves syllabic structure has been deleted. In fact, Ramus and Mehler [3] provided experimental evidence supporting the effective role of rhythm in discriminating between languages. They set up experiments where English and Japanese sentences were resynthesized and transformed in various ways to control the variables of syllabic rhythm and F0. They reported that by keeping F0 flat, and replacing all the original consonants by [s]'s and all the vowels by [a]'s thus reserving syllabic structure, their French adult subjects obtained the highest scores in discriminating between English and Japanese. They concluded that syllabic rhythm is a necessary and sufficient cue for discrimination between languages in their experiment.

In the literature on Arabic speech rhythm, all the dialects investigated have been consistently categorized as 'stress-timed' in opposition to 'syllable-timed' or 'mora-timed' languages [4] [5] [6] [7] [8]. Evidence for these classifications comes essentially from perceptual experiments. According to Roach [9], measurements obtained from the acoustic signal could not provide evidence for classifying languages (including Arabic) as stress-timed, as opposed to syllable-timed, if stress-timing meant isochrony of inter-stress intervals. Dauer [10] came to similar conclusions and argued that the perception of different types of rhythm has to do mainly with differences in syllable structure, vowel reduction and types of stress. Ramus & al. [1] argued that perceived rhythm classes corresponding to the phonological properties put forth by Dauer [10] [11] can be accounted for by instrumental measurements of the acoustic signal as we will explain later with respect to Arabic speech rhythm. Now, if different languages may be perceived as belonging to different rhythm classes, and if Arabic is always categorized as a stress-timed language, what cues in the acoustic signal made the subjects in Barkat's experiment [2] feel that Western Arabic sounded faster and jerky or more halting than Arabic in the Middle East? In other words, can a language or a dialect be more or less stress-timed than another? In an attempt to seek answers to this question, an experiment was set up to investigate the production of rhythm in six Arabic dialects.

3. Method

3.1. Subjects

The subjects were 4 Moroccans , 2 Algerians and 2 Tunisian speakers representing Western Arabic, and 2 Jordanians, 3 Syrians and 1 Egyptian representing the Middle East. They were students in the city of Lyon, but were all native speakers of their dialects

3.2. Data

Each subject listened sentence by sentence to the story "*the north wind and the sun*" in French and translated each sentence spontaneously into his dialects. The recording procedures are described in [2]. The language corpus used in this paper consists of 140 Arabic sentences (10 sentences per subject) with an average duration of 2.5 seconds for each sentence.

3.3. Analysis procedures

Following the experimental procedures proposed in Ramus & al. [1], Hamdi [12] used the Multi Speech© signal processing and editing software to identify and classify segments as vowels or consonants. She computed : (i) the duration of each sentences, (ii) the duration of each string of consecutive vowels (vocalic intervals), and (iii) the duration of each string of consecutive consonants (consonantal intervals). For example, the following sentence is comprised of 10 vocalic and 10 consonantal intervals.:

mbɛʔdha bɛ:təriħ tʕsʕu:tʕ bkul quwətha
CCVCCCV CCVVCVC CCVVC CCVC CVCVCC
And then the wind began to blow with all its force

The next step consisted in computing the proportion of vocalic and consonantal intervals (V% and C% respectively) in each sentence, and the standard deviation of vocalic and consonantal intervals within each sentences (ΔV and ΔC respectively). Details of how these variables are computed are explained in [3].

3.4. Results

Table 1 : Computed values for %V and ΔC

Western area	%V	ΔC	Eastern area	%V	ΔC
Morocco	32.38	8.52	Egypt	36.98	3.89
Algeria	33.84	6.75	Jordan	41.09	4.76
Tunisia	34.97	5.25	Syria	43.66	4.54

Table 1 shows the average proportions of vocalic intervals (%V) and the average standard deviation of consonantal intervals (ΔC) for the subjects in each of the six dialects investigated.

These results show that while the proportion of vocalic intervals represents less than 50% of the total duration of a sentence in all the dialects , it is more important in the Eastern dialects than the Western ones. In fact, there is a gradual increase of %V as one moves from West to East. Conversely, ΔC decreases from West to East. Figure 1 illustrates the negative correlation between %V and ΔC and dialect location ($r = - 0.75$) as one moves from West to East ΔC decreases and %V increases. Using t-test for the difference between pairs of dialects, we found that the significance level is directly proportional to the distance between two countries. For example, the results, for both %V and ΔC , are not significant when Syria is compared to Jordan or when we compare Morocco to Algeria that is , when two dialects are spoken in two countries that belong to the same region. The values for %V and ΔC are, however, highly significant for pairs of dialects located in the opposite ends of the continuum such as Syrian and Moroccan ($p > 0.001$). Note also that both Tunisia and Egypt which are located near the center of the continuum show significant differences only when compared to Morocco, a fact that we will try to account for later. Figure 2 is an illustration of the average values of the proportion of vocalic intervals and the standard deviation of the consonantal intervals when the three dialects of each region are grouped together. It clearly shows that %V is higher in the dialects of the Middle East than in the dialect of North Africa ($p < 0.0001$), while the opposite results obtain for ΔC .

Figure 3 is a three-way comparison : Morocco and Algeria representing the far end of the western pole, Syria and Jordan the eastern end, and Tunisia and Egypt an intermediate zone. This comparison confirms the gradual decrease of %V from East to West with Tunisia and Egypt exhibiting intermediate values. It also shows that with respect to ΔC Tunisia and Egypt are closer to the dialects of the Middle East than to North Africa.

4. Discussion

of shorter vowels. All investigations of Arabic vowel space [2] have underlined the fact that in North African dialects, phonologically long and Lower proportions of vocalic intervals reflect the presence short vowels have shorter duration than the corresponding vowels in the dialects of the Middle East. The standard deviation of consonantal intervals is correlated with syllabic diversity and complexity [1]. North African Arabic is well known for processes of short vowel deletion in open syllable resulting in various consonants clusters and types of syllables with complex onsets and codas. The complex syllables coupled with reduced vowels , especially in the Moroccan dialects result in the impression of the jerky and halting speech reported by listeners. Differences in vowel duration and syllabic complexity seem to be the main factors responsible for differences in stress patterns and rhythmic structure. Although in both Western and Eastern Arabic dialects stress placement is conditioned to a large extent by the opposition of light and heavy syllable, stress patterns differ in the two regions and may also differ from one dialect to another. For example, in the North African dialects stress falls on the last syllable when it is heavy otherwise the penultimate is stressed. In the Easter dialects, stress

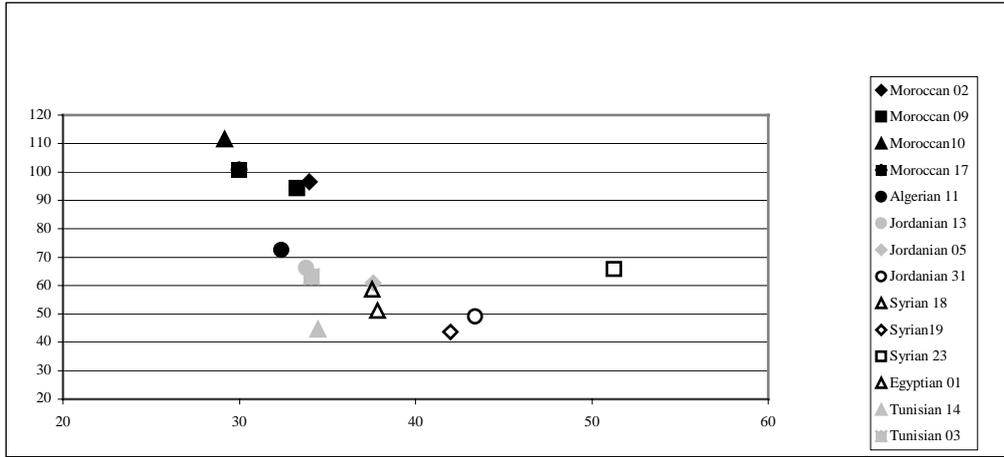


Figure 1: Distribution of the dialects along the %V and ΔC dimensions

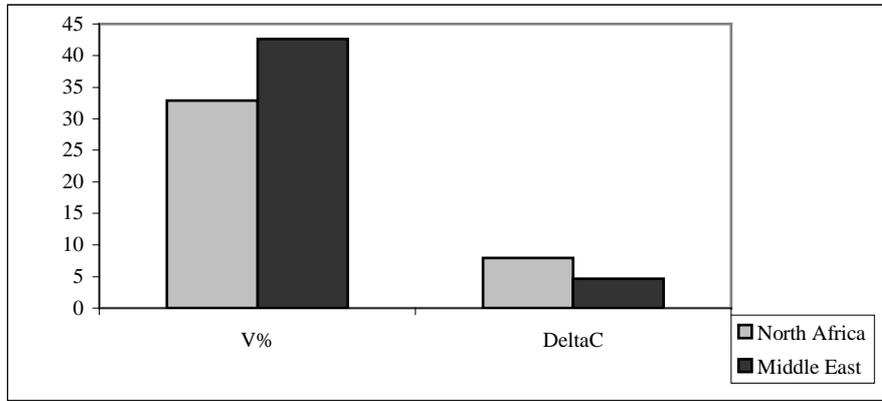


Figure 2 : Comparison of %V and Delta C in NA and the ME

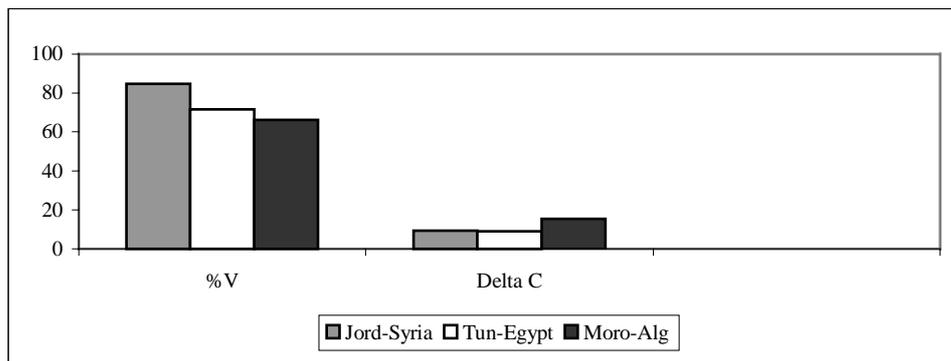


Figure 3 : Comparison of %V and Delta C in 3 groups of dialects (Algeria + Morocco; Tunisia + Egypt and Jordan + Syria).

may move to the ante-penultimate syllable in forms where the three final syllables are light (CVCVCV(C)). These forms are not found in North African dialects which do not allow short vowels in open syllable as stated above.

In Ramus & al [1], languages with the highest ΔC and the lowest %V such as English were those traditionally known as stress-timed. In our study, the dialects that exhibit high ΔC and low %V that is, the dialects that are characterized by the presence of complex syllables and short and reduced vowels are those spoken in North Africa, especially in Morocco and Algeria. Since Eastern dialects such as those of Iraq [6] and Jordan [7] have also been classified as stress-timed despite the fact that they have longer vowels and simpler syllables than Western dialects, we may need to allow for a great deal of variation within the class of stress-timing. To maintain a discrete category 'stress-timing' as distinct from some other timing, there should exist one or more key factors the presence of which constantly induces the perception of stress-timing. Such a conditioning factor could be the tendency in all Arabic dialects for long or heavy syllables to attract stress, despite the differences in stress placement discussed earlier. Since syllabic weight, in these dialect is a cline, we may get the impression of different subclasses of rhythm. Note also how dialects geographically located between the two poles are also intermediate with respect to phonetic facts (Figure 1). Barkat [2] reported that most of the discrimination errors made by her subjects were the result of not being able to correctly classify Tunisian speakers. In fact, Tunisian speakers have a %V similar to North Africa but a ΔC closer to the Middle East. In other words, their vowels are slightly longer and less reduced than those of Moroccans and Algerians, but significantly shorter than Syrian and Jordanian; they don't, however, exhibit the same syllabic complexity as the other North African subjects.

When using natural speech during a discrimination task, native speakers of Arabic may also have available lexical and morpho-syntactic cues to reduce perplexity. A useful perceptual task may be to ask non native speakers of Arabic to classify speech data from different Arabic dialects along with speech data from different other languages known to have different types of stress-timing (English, French, Japanese etc.). Such an experiment being currently carried out by Hamdi [13] may meaningfully reveal whether all Arabic dialects continue to cluster around stress-timed languages, or whether they will be distributed over other rhythm categories as well.

Acknowledgements

F. Ramus, F. Pellegrino and I. Vasilescu have each helped at one moment or another during the preparation of this work, we are grateful to all of them.

5. References

[1] Ramus, F.; Nespors, M.; Mehler, J., 1999. Correlates of linguistic rhythm in the speech signal. (Available from URL: <http://www.ehess.fr/lscp/persons/ramus/pub.htm>.)
 [2] Barkat, M., 2000. Determination of Reliable Acoustic Cues for the Automatic Identification of Arabic Dialects, Doctoral thesis, University of Lyon 2, (written in French).

[3] Ramus, F.; Melher, J., 1999. Language identification with suprasegmental cues. A study based on speech resynthesis. *Journal of the Acoustical Society of America*, 105(1), 512-521.
 [4] Abercrombie, D., 1967. Elements of General Phonetics, Edinburgh University Press.
 [5] Miller, M., 1984. On the perception of rhythm, *Journal of Phonetics*, 12, 75-83.
 [6] Benguerel, A., 1999. Stress-timing vs syllable-timing vs mora-timing: The perception of speech rhythm by native speakers of different languages. *VARIA, Etudes & Travaux n°3*.
 [7] Tajima, K.; Zawaydeh, B.; Kitabara, M., 1999. A comparative study of speech rhythm in Arabic, English and Japanese, *Proceedings of the XIV ICPHS*, San Francisco, U.S.A.
 [8] Cheikhrouhou, M. Tunisian Arabic and English speech rhythm: A comparative analysis. Doctoral thesis in preparation at the University of Tunis .
 [9] Roach, P., 1982. On the distinction between 'stress-timed' and 'syllable-timed' languages. In *Linguistic controversies*, D. Crystal Ed, London: Edward Arnold. 73-79.
 [10] Dauer, R.M., 1983. Stress-timing and syllable-timing reanalysed, *Journal of Phonetics* 51-69
 [11] Dauer, R.M., 1987. Phonetic and phonological components of language rhythm, *Proceedings of the XIth ICPHS*, Tallinn, Estonia, Vol.5, 447-450.
 [12] Hamdi, R., 2001. An Acoustic investigation of Rhythm in the Arabic dialects. M.A. thesis (written in Arabic), Institut Supérieur des Langues de Tunis.
 [13] The identification of Arabic dialects using prosodic cues, Doctoral dissertation (in preparation). Institut Supérieur des langues de Tunis and University of Lyon 2.