

ACOUSTIC ANALYSIS OF TWO LONG EMPHATIC VOWELS IN ORAL AND NASAL CONTEXT: CASE OF ALGERIAN DIALECT

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Abstract- The aim of this study was to explore the acoustic properties of two emphatic vowels of Algerian dialect produced in oral and nasal context. Recordings were made of four Algerian subjects producing the long vowels /æ:, u:/ in emphatic and non-emphatic /CVC/ syllables both in oral and nasal context. The acoustic analysis was based on an investigation of vowel duration and the first two formant frequencies. Using Praat, vowel duration was automatically measured from the onset of the vowel to the offset. F1 and F2 were extracted at the target vowel midpoint using LPC analysis with the Burg algorithm. The results have shown that emphasis increase vowel duration both in oral and nasal context. However, increase of vowel duration is significant for vowels in nasal context. F1 is raised and F2 is lowered for emphatic vowels both in oral and nasal context. The lowering of F2 was significant for vowels in nasal context.

Keywords- Algerian dialect, Emphatic, Oral, Nasal, Vowel duration, Formant frequencies F1, F2.

I. INTRODUCTION

Algerian dialect, also called 'Darija' is the language spoken in Algeria. Its main vocabulary is made up of Arabic language; however, it has been phonologically modified (1) mainly due to the influence of French. Similar to Arabic, Algerian dialect also has four emphatic coronal obstruents /t^s, d^s, s^s, ð^s/ and their non-emphatic or plain counterparts /t, d, s, ð/. Emphatic consonants are characterized by a primary constriction in the alveolar region and a secondary constriction in the vocal tract posterior region (2). Most of them are pharyngealized, some of them, however, are labialized (3). Few previous studies (e.g. 2, 4) have been interested in analyzing acoustic properties of vowels adjacent to emphatic consonants. According to (5, 2) acoustic characteristics of emphatic vowels differ from one vowel to another depending on vowel quality. Previous research indicated that vowels adjacent to emphatic consonants have lower F2 (2, 6, 7, 8, 9, 10, 3). (11) observed that the lowering of F2 was greater for the long low back vowel /a:/ than that for the long high vowels /i:/ and /u:/.

While some studies (e.g. 12) reported no cues for the effect of emphatic consonants on F1, some others (2, 11) found that vowels' F1 is higher in emphatic context. It was also reported that the effect of emphatic plosives on surrounding vowels is greater as compared to that of emphatic fricatives (2). Another acoustic study by (3) has shown that emphatic consonantal context has no significant effect on vowel duration in any position, suggesting that vowel duration has no reliable cue for emphasis. As for the effect of emphasis on gender, it was found that the degree of lowering of F2 was significantly greater for females as compared to that for males.

The effect of emphasis on adjacent vowels was also assumed to be related to the position of the emphatic consonant. According to (2), the effect of emphatics

embedded in word-final position is greater on vowels than that of those embedded in initial-word position.

Emphatic vowels may also be influenced by nasalization when they are adjacent to nasal consonants. Nasalized vowels are realized with lowered velum to allow some airstream escaping through nasal cavity (13). It is also assumed that vowel nasalization is associated with longer durations (14) and a reduction in the spectral prominence of F1 (15). The current study presents the first attempt to analyze acoustic properties of Algerian dialect vowels in emphatic vs. non-emphatic environment. It is based on examination of the two long emphatic vowels /æ:, u:/ in oral and nasal context produced by Algerian subjects. Acoustic measurements explored the analysis of vowel duration and the first two formant frequencies (F1, F2) as they are assumed to be the most important cues to vowel identification (16).

II. METHODS

1.1. Subjects

Four Algerian participants (2 males and 2 females) aged 25-27 were recruited. All were born and raised in East region of Algeria. All were native speakers of Algerian dialect with no history of speech or hearing disorders.

1.2. Stimuli

Two emphatic consonants (1 plosive, 1 fricative) of Algerian dialect /t^s, s^s/ and their non-emphatic counterparts /t, s/ in word pairs were recorded. The total number of target words is 8. For controlling the effect of context, the target pairs of words were embedded in the phrase [gu:l_____ ktar mən məɾa] ("Say_____ once more"). Target words included the target vowels /æ:, u:/. Syllable frames used in the stimuli were /tVb/ and /sVm/ for oral and nasal emphatics, respectively. Each stimulus was repeated two times.

1.3. Procedures and Measurements

The speech data were recorded in a quiet room using digital audio tape at a sampling rate of 44.1 kHz with 16-bit quantization. All measurements were made using the Praat signal-processing software (17). Recorded data was resampled to 22.05 kHz. Vowels were segmented and duration was automatically extracted. F1 and F2 were measured at the midpoint of the target vowel using LPC based-method with the Burg algorithm. Formant tracking conditions for five formants were set to a range of 0-5000 Hz for males and 0-5500 Hz for females within a 25-ms-long Gaussian-like window. A series of ANOVAs and posthoc tests were conducted to examine the main effects of Emphasis, Vowel quality and Emphasis by Vowel quality interactions on vowel duration and the vowel first two formant frequencies both in oral and nasal context.

III. RESULTS AND DISCUSSION

1.4. Vowel duration

In both oral and nasal environments, vowel duration was found to be longer in emphatic context than that in non-emphatic context (Fig.1). A two-way Repeated Measures ANOVA with Emphasis (2) and Vowel quality (2) as independent variables and vowel duration as the dependent variable was conducted for each pair of vowel (emphatic vs. non-emphatic) in oral and nasal environments. For vowels in oral context, results indicated neither a significant main effect of Emphasis [$F(1, 12) = .68, p = .68$] or Vowel quality [$F(1, 12) = 2.18, p = .17$] nor a significant Emphasis by Vowel quality interaction [$F(1, 12) = .02, p = .9$]. As for vowels in nasal context, however, a main effect of Emphasis [$F(1, 12) = 17.52, p = .001$] and subsequent posthoc test indicated that difference in duration between emphatic and non-emphatic context was significant for the long close vowel /u:/ [$t(3) = 3.16, p = .02$]. Results have also shown that there was a significant Vowel quality by Emphasis interaction [$F(1, 12) = 5.05, p = .04$].

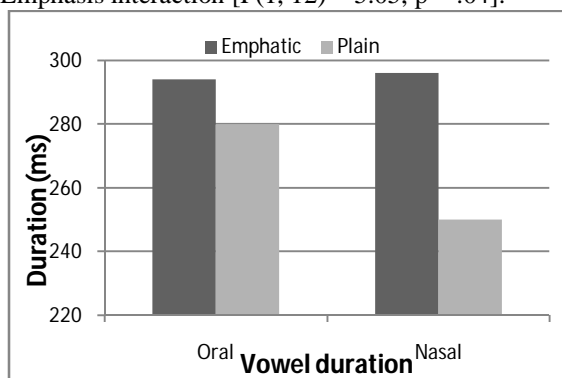


Fig.1. Duration of vowels in in emphatic or non-emphatic environment produced in oral and nasal contexts

1.5. Formant frequencies

Effect of emphasis on vowel F1 is clear. F1 was found to be higher for emphatic vowels both in oral

and nasal context (Fig. 2). Two-way Repeated Measures ANOVA with Emphasis (2) and Vowel quality (2) as independent variables and F1 as the dependent variable was run for each vowel in emphatic/plain context in oral/nasal consonantal environment. For vowels in oral context, ANOVA indicated neither a significant main effect of Emphasis [$F(1, 12) = 1.93, p = .19$] or Vowel quality [$F(1, 12) = 4.48, p = .06$] nor a significant Emphasis by Vowel quality interaction [$F(1, 12) = .27, p = .62$]. Regarding vowels in nasal context, however, ANOVA yielded a significant effect of Vowel quality on F1 [$F(1, 12) = 6.53, p = .03$]. Subsequent posthoc test showed that F1 for the long vowels /æ:/ and /u:/ was significantly different in emphatic context [$t(3) = 3.33, p < .05$].

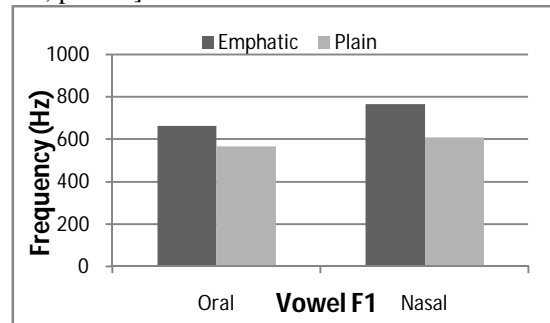


Fig.2. F1 frequency for vowels in emphatic/plain context produced in oral and nasal contexts

Regarding F2, it was found to be lower for emphatic vowels both in oral and nasal context (Fig. 3). Two-way Repeated Measures ANOVA with Emphasis (2) and Vowel quality (2) as independent variables and F2 as the dependent variable was conducted for each vowel preceding emphatic or plain consonant in oral and nasal context. For target vowels in oral context, results indicated a main effect of Vowel quality [$F(1, 12) = 26.04, p < .001$]. Posthoc test indicated that F2 for the long vowels /æ:/ and /u:/ was significantly different both in emphatic and non-emphatic consonantal context ($p < .05$). As for vowels in nasal context, ANOVA yielded a significant main effect of Vowel quality [$F(1, 12) = 26.99, p < .001$], a main effect of Emphasis [$F(1, 12) = 6.64, p = .03$], and a main effect of Emphasis by Vowel quality interaction [$F(1, 12) = 8.35, p = .01$]. Subsequent posthoc test indicated that main effect of emphasis was significant for the long vowel /æ:/ [$t(3) = -8.27, p = .002$].

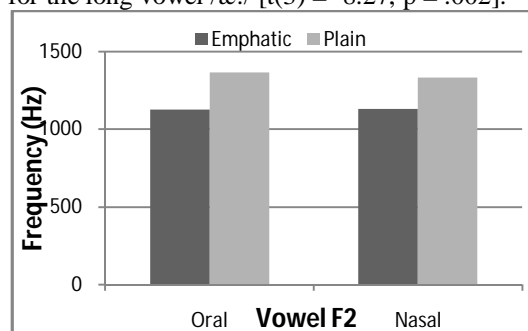


Fig.3. F2 frequency for vowels in emphatic/plain context produced in oral and nasal contexts

CONCLUSIONS

This study explored an acoustic analysis of two Algerian vowels /æ:, u:/ adjacent to emphatic vs. plain consonants both in oral and nasal context. In general, the effect of emphatic consonants on adjacent vowels is associated with an increase in vowel duration and F1 and a lowering of F2, indicating that these vowels are distinguished by acoustic effects which are different from those of vowels produced in non-emphatic context. Findings related to formant structure could be attributed to coarticulatory effects suggesting that vowels adjacent to emphatic consonants are produced slightly lower and the tongue is relatively moved further back as compared to those produced in non-emphatic consonantal context. These findings are in agreement with previous research (2).

ANOVA results have indicated that vowels in oral context showed no significant effect of emphasis on neither vowel duration nor F1 and F2 formant frequencies. Regarding vowels in nasal context, however, the effect of emphasis was significant both on vowel duration and vowel F2. Future research will extend the scope of this study to other syllable structures and provides a detailed account of acoustic characteristics of emphatic vowels of Algerian dialect.

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