



## Dysprosody in aphasia: An acoustic analysis evidence from Palestinian Arabic

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### Abstract

The present study was aimed to present an acoustic analysis of Palestinian prosody based on data obtained from four Palestinian speaking- persons with Broca's aphasia and normal speakers. A number of acoustic measures were examined in this study including tone modulation, F0 range, phrase-final lengthening, word duration and syllable duration. The results indicated that Broca's aphasics were unable to implement phrase-final lengthening compared to the control participants, which suggests underlying deficits in speech planning and timing. Furthermore, Broca's aphasics showed higher F0 range compared to the control subjects. However, they demonstrated relatively spared rising and falling intonation patterns. The findings of the study are in consensus with previous studies on timing and prosodic patterns in persons with Broca's aphasia, in which speech timing deficits and abnormal durational patterns are the significant characteristic in speech of Broca's aphasia. The results of the study contribute to the neurolinguistic research across different languages, specifically where Palestinian Arabic is much less investigated compared to other Arabic dialects and languages.

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*Keywords:* Dysprosody in Broca's aphasia; Palestinian Arabic; Acoustic analysis

### 1. Introduction

Prosody, the melody of speech, is considered as a main aspect of communication. Several studies indicated that prosody serves as a facilitator for different aspects of information processing and communicative functions including emotional (affective), pragmatic, and linguistic aspects (Baum et al., 2001). Functionally, the literature distinguishes between two main types of prosody: linguistic prosody and emotional prosody. The emotional prosody conveys emotional states, such as happiness, sadness and anger. For example, in terms of variations in fundamental frequency (F0), researchers found that expressions of happiness are generally characterized by higher and more variable F0 (Viscovich et al., 2003). In contrast, the linguistic prosody conveys linguistic functions such as interrogatives, statements, and imperatives. It has been found, for example, that statements in different languages are distinguished with low F0 peaks, whereas imperatives and interrogatives have higher F0 (Bauer, 1987).

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Several studies also have revealed that prosody may play an important role in assessing the listener detect the boundaries within and between sentences (Blasko & Hall, 1998; Cutler et al., 1997). Since the listeners often depend on prosodic elements to predict and interpret a speaker's communicative intent and attitude, prosody often be called the “emotional component of speech and language” (Viscovich et al., 2003, p. 760).

Prosody has three main physical parameters: fundamental frequency (F0), duration, and amplitude. These physical components are perceived by the listener as pitch, speech rate, and loudness. Many acoustic studies found that variations in (F0), duration and intensity (amplitude) (Gussenhoven & Carlos, 2004, Nespor et al. 1986). The fundamental frequency refers to the number of periodic movements in the vocal folds per second. A number of durational features are involved in the prosodic features of the language system, such as syllable and word duration, phrase final lengthening, pausing, rate, and changing voice quality (Van Lancker, & Daum, 2000; Hird & Kirsner, 2002). Consequently, due to the fact that the prosodic elements may affect more than a phonetic segment, they are considered suprasegmental in nature (Kent & Rosenbek, 1982).

## 2. Neurolinguistic Background on Prosody and Aphasia

Aphasia is a language disorder caused by damage to anterior regions of the brain, particularly Broca's area (Brookshire, 2003; Bastiaanse, & Van Zonneveld, 2004). It may affect different modalities of language function, such as speaking, writing and, reading. It also affects different levels and components of the language system, including phonology, lexicon, syntax, and, semantics. These components are affected on the word, syllable, and, sound levels based upon the type of language disturbance. Speech of agrammatic speakers with Broca's aphasia is characterized by the omission and substitution of grammatical morphemes (Goodglass, 1976). However, several studies have shown that not all grammatical morphemes are equally affected and agrammatism, therefore, cannot be considered as a pure morphosyntactic deficit. For example, various studies revealed that in speech of English- speaking Broca's aphasics, the *-ing* affix is omitted much less often than past-tense *-ed* or the 3rd singular present-tense (Druks & Carroll, 2005).

Previous studies have reported abnormal durational patterns among Broca's aphasics. Goodglass and Kaplan (1972) found the speech of this clinical population to be laboured, slowed, and dysprosodic. Additionally, it has also been found that Broca's aphasics display impaired melodic modulation and temporal deficits. Ryalls (1982) evidenced that F0 variation in speech of Broca's aphasics is restricted in range for sentence-level stimuli.

Few other studies have suggested that Broca's aphasics usually tend to shorten the obligatory utterance-final lengthening (Danly, de Villiers & Cooper, 1979). Ryalls (1986) found that the word and sentence level were considerably longer for Broca's aphasics than for normal subjects. Kent and Rosenbek (1982) reported from abnormal rhythm and rate among speech of Broca's aphasics. In contrast, results from Danly and Shapiro (1982) indicated that Broca's aphasics demonstrate relative preservation of the F0 variations, but absence of sentence-final lengthening.

Similarly, other studies also reported timing deficits among Broca's aphasics (Baum & Boyczuk, 1999; Shah, Baum, & Dwivedi, 2006). In this account, Baum and Boyczuk (1999) found that Broca's aphasics usually exhibit timing deficits in speech units, particularly in monosyllabic words. In their acoustic study on Italian prosody as produced by a set of Broca's aphasics, Marotta et al. (2008) also reported from speech timing deficits and abnormal lengthening of all syllables.

Seddoh (2008) suggested that in syntactically conditioned speech timing tasks, the agrammatic speakers demonstrated temporal impairments, specifically abnormally long durations in all segmental

measures. In fact, several studies have related the high fundamental frequency F0 average of Broca's aphasics to greater psychological stress (Heesch, et al., 1988). Similar trend is also exhibited by neurotypical speakers, where they increase their F0 with increase in psychological stress (Geller and Apple, 1977). Thus, in light of the previous discussion we assume that utterances produced by Broca's aphasics may demonstrate high F0 averages, compared to the control speakers and hence this study was carried out to test this assumption.

In fact, several studies have examined morpho-syntactic deficits in Arabic, but with less focus on the prosodic patterns of the agrammatic speakers, including Palestinian Arabic (Friedmann, 2001), Algerian Arabic (Mimouni, & Jarema, 1997), Moroccan Arabic (Diouny, 2010) and Jordanian Arabic (Albustanji, 2013). For example, Al Albustanji (2013) examined the production of morpho-syntactic features in agrammatic Jordanian-Arabic (JA) speaking. The findings revealed that the speakers of JA with agrammatism are showing a dissociation between specific morpho-syntactic features.

Prosody is one aspect which varies across the languages and dialects. There has been very limited attempts in Palestinian Arabic language to investigate the prosodic deficits in person with Broca's aphasia. It is expected that the study will fill up some of the gaps in understanding how the prosodic deficits vary across language which in turn may provide corroborative basis for the existing research. It is also felt that the findings may throw some light on the better assessment and planning strategies to rehabilitate persons with aphasia showing obvious prosodic deficits.

### **3. Method**

#### *3.1. Participants*

The goal of the present study was to explore intonational and temporal patterns among Palestinian agrammatic subjects. Four male subjects aged between 49 and 66 from the same region residence participated in the current study who served as the experimental group. All of them had been diagnosed with Broca's aphasia based on adaptation of the BDAE and the Bilingual aphasia Test; Jordanian Arabic version (Paradis, 1987). The sites of lesions were determined by neurologists.

All the participants were predominantly right-handed. They had single left hemisphere lesion for at least six months prior to testing. Hearing was within normal limits with no evidence of dysarthria or visual impairments. All participants demonstrated the classical picture of telegraphic speech features, specifically, effortful, non-fluent, and dysprosodic speech, with well-preserved understating abilities. Four native speakers with no language or speech impairments served as the control group. They were right-handed and roughly matched for age and education to the experimental group.

#### *3.2. Speech samples and acoustic analysis procedure*

For this study, the spontaneous speech samples of four Broca's aphasics (experimental group) and four neurotypical controls were elicited. The participants were asked about their hobbies, profession, daily activities, former jobs, and family etc. The spontaneous speech samples of the aphasic subjects were recorded during rehabilitative sessions of speech therapy at Bethlehem Rehabilitation Centre, and those of neurotypical speakers were recorded in a quite well-isolated room at a training centre at Hebron. The speech sample was recorded using a high-quality microphone positioned around 2.5 centimetres from the participants' mouth. The structured part of the study was focused on eliciting the WH-questions in a repetition task. Agrammatic participants were asked to repeat simple 5 Wh-questions as shown in the below example:

Experimenter: Ali drank water.

Ali shirib maj. esh shirib Ali.

Target: what Ali drank?

Each recording session was completed in approximately within 25 minutes. The utterances were recorded directly to a PC computer. In case of recording error and inaccurate articulation, the subjects were asked to repeat the test items and the responses were re-recorded. The acoustic analysis of the speech sample was carried out using the software PRAAT (Boersma & Weenink, 2008) and Phono-Lab (Metoui, 1995). Based on Marotta et.al (2008:84) study, which sought to examine the maintenance of prosodic structures in Italian aphasic speakers by using several acoustic measures, the following parameters were used for the current analysis-•pitch range and pitch values (Hz) at the beginning (onset) and at the end (offset) of the breath-group; and melodic shape of the final syllable, classified according to the following categories: rising, falling, rising-falling, falling-rising, flat.

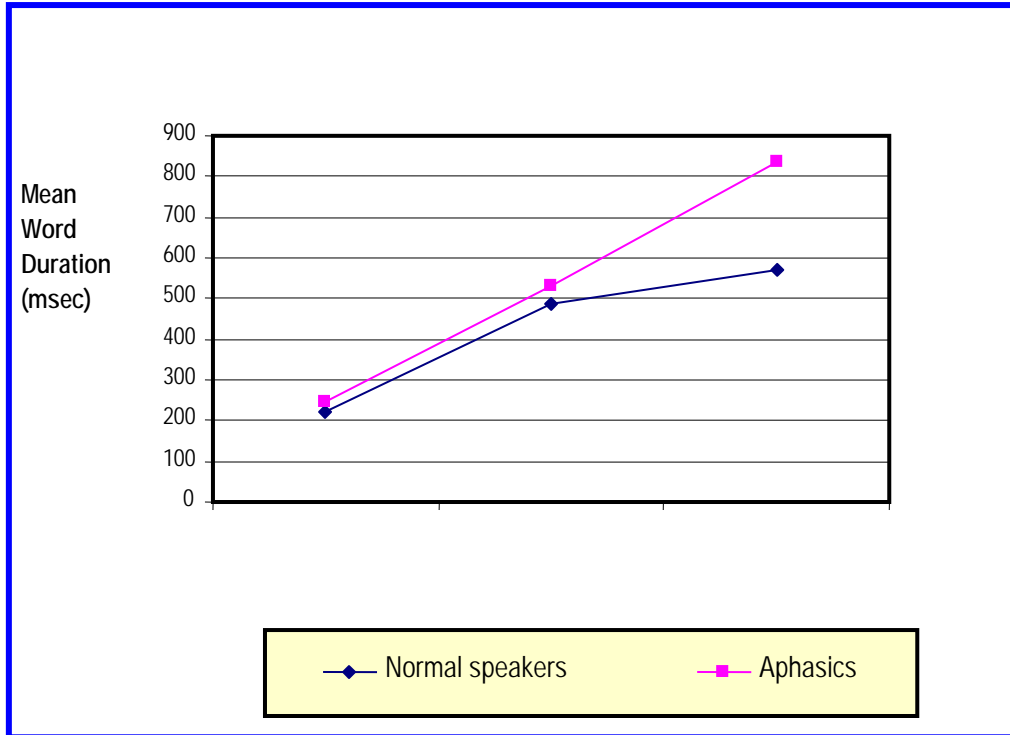
#### **4. Results and Discussion**

Different profiles of prosodic and timing patterns were observed in the two groups of the present study. The following results and discussion are addressed along four domains:

- Duration measures
- Rate
- Melodic shape of the utterance
- Pitch range and values

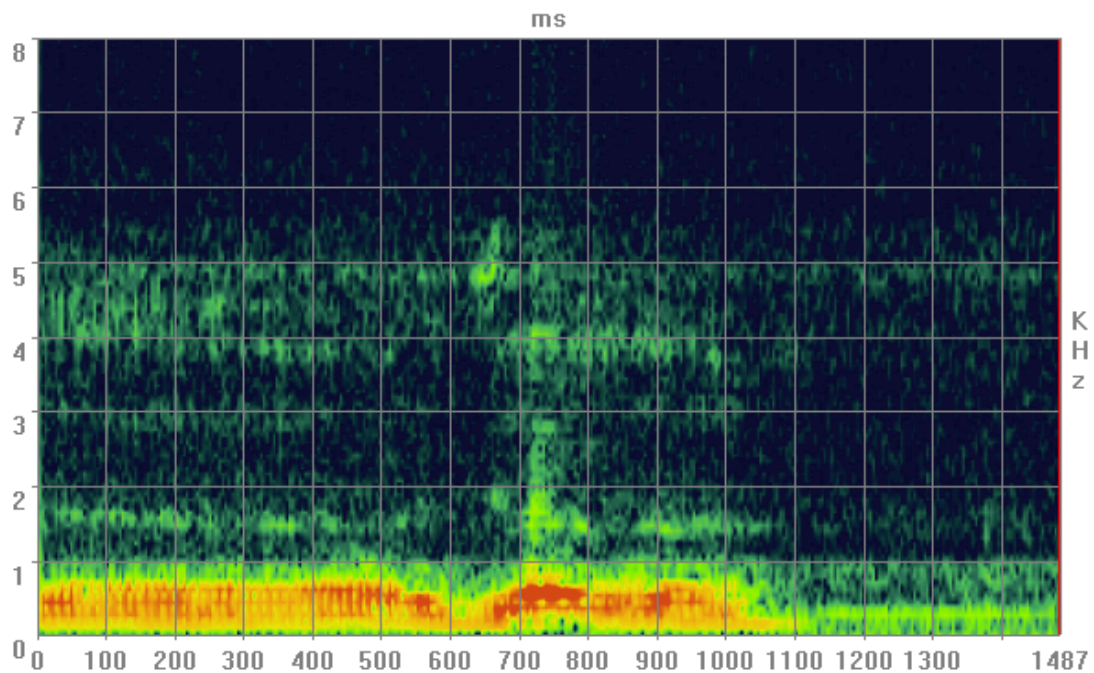
The acoustic analysis revealed that persons with Broca's aphasia exhibited presence of dysprosodic structures when compared to the sample produced by control subjects. The dysprosodic deficits were quite evident in persons with Broca's aphasia. Due to the obvious prosodic deficits, the overall quality of speech was severely effected as a results the intelligibility of speech was restricted in persons with aphasia. Furthermore, they also exhibited abnormal lengthening of the word and utterance duration, which was not typical to those found among the normal speakers. The increased abnormal lengthening and increased duration resulted in abnormal slow rate of speech; this signifies that if the timing is not maintained, the quality and quantity of speech gets disrupted. Further, this puts constrain on both the speaker and listener. As a result the listener might pay more attention on the manner of speech rather than the content of speech, which in turn hampers the effective communication. Thus, this in turn reflects that the speech chain gets disrupted, results in overt speech deficits in persons with aphasia.

However, one needs to be cautious in interpreting these results, that these deficits signify that such prosodic deficits are secondary in nature. This occurs as a result of obvious paralysis or paresis on the left side of body following stroke. As shown below in figure 1, Broca's aphasics demonstrated a significant increase in word duration as the number of syllables increased. In contrast, the patterns of the healthy speakers exhibited that by increasing the number of syllables, the word duration decreased, especially in the trisyllabic words. These findings further illustrates that the as the number of syllable and their complexity increases persons with aphasia starts showing over prosodic deficits. These findings signify that persons with aphasia may not be able to program their articular as the number of syllables increase. Such poor programming can be direct consequence of neurological insult which in turn influences the overall quality of speech in persons with Broca's aphasia.



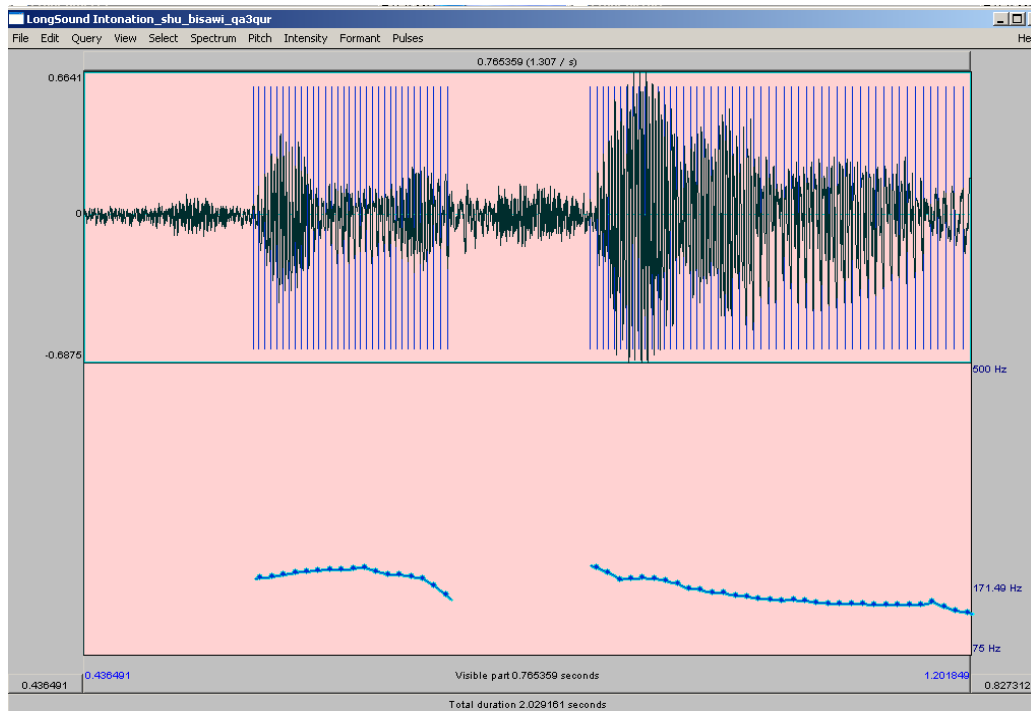
**Figure 1:** Mean duration values in milliseconds for Mono, Di- and Tri-syllabic words produced by the aphasic subjects and the control group.

Furthermore, timing deficits causes a decrease in speech rate that is related to the number of syllables of the utterance. The slow speech pattern may also be attributed to the frequent pauses that characterize their speech. Furthermore it can also indicate that the accessibility of the linguistic is slowed down in persons with aphasia .Figure 2 clearly shows unusual pauses by one of the aphasic subjects.



**Figure 2:** Spectrogram showing unusual pauses as produced by an aphasic subject

Interestingly, results of the study revealed that Broca's aphasics could produce final falling pitch for a WH-question, which was similar to the patterns produced by the control subjects, as can be seen in figure 3. The findings also demonstrated that the energy distribution observed during the production of WH-questions by Broca's aphasics began from a higher value when compared the control subjects. Moreover, in contrast to the normal subjects, the patterns found in the Broca's aphasics were low in amplitude at the end of the utterance. The findings highlight that energy is more distributed to WH questions, where there is possibility that semanticity, frequency of stimuli has played an important role. Further production of final failing pitch may indicate that by the time linguistic stimuli is released persons with aphasia are able to produce better output. This shows that persons with aphasia show intent to articulate the syllables more clearly.



**Figure 3:** Waveform display, spectrogram, representing final falling pitch for a WH-question sentence repeated by an aphasic subject.

It should, however, be noticed that Broca's aphasics displayed higher F0 values in contrast to the normal speakers, as can be shown in Table 1.

**Table 1:** Differences in F0 averages between Broca's aphasics and normal speakers

Broca's Aphasics	Normal speakers	Differences
165	120	45

With respect to the F0 declination, the acoustic data revealed that Broca's aphasics retain the ability to demonstrate F0 declination, which can be defined as the tendency for fundamental frequency (F0) to gradually drift downward in the course of an utterance (Ladd, 1984; Lieberman, 1967).

Functionally, declination considered as a structuring device, since a reset in the slope of declination often conveys information about the boundaries of different linguistic units.

Furthermore, it is clear from the data that Broca's aphasics tended to produce sentences characterized by long pauses. This shows that persons with aphasia show intent to produce quality verbal output. This is due the fact that these persons are aware about of their problem and shows strong willingness to improve their overall quality of speech. Furthermore, the acoustic analysis showed that the normal speakers produced the declarative sentences with falling intonation and the interrogative utterance with rising intonation. Interestingly, the aphasic subjects were able to maintain this acoustic –prosodic rule, by exhibiting rising intonation for interrogative sentences and falling intonation for the declarative ones.

## 5. Conclusion

This paper presents the main acoustic features of Palestinian prosody based on data obtained from four Palestinian- speaking Broca's aphasics and normal speakers. A number of acoustic measures have been examined in this study, including tone modulation, F0 range, phrase-final lengthening, and word duration and syllable duration. Though it was a preliminary attempt, but the results have been quite clear and provides corroborative evidence to the existing research. The acoustic analysis indicated that Broca's aphasics show abnormal prosodic patterns, due to excessive syllable and segmental lengthening, frequent hesitations, slow speaking rate, and pauses. However, the results revealed that Broca's aphasics have the ability to signal the intonational contrast at least in short sentences. The findings of the present study indicate that Broca's aphasics were unable to implement phrase-final lengthening compared to the control subjects, indicating motor speech planning and timing deficits.

Furthermore, the results display that aspects of speech prosody in individuals with Broca's aphasia are not all broken, for example, the ability to distinguish between declarative and interrogative sentences. Similar to previous research, the data also shows that that Broca's aphasics have an overall average increase of F0 compared to the normal speakers (Danly, & Shapiro, 1982).

Overall, these results are consistent with previous studies on speech timing in aphasia which claim that Broca's aphasics demonstrate deficits in some prosodic aspects and their impaired melody of speech is related to timing deficits rather than to intonational abnormalities (Ghosh et al., 2008, Baum et al. 1999). Generally, this acoustic investigation might contribute to the neurolinguistic research across different languages in the effort to better understand the nature and underlying causes of speech and language disorders, specifically in Palestinian Arabic, which is less investigated compared to other Arabic dialects and languages. Furthermore, the persistent and vehement armed conflict in the region and knowing more about this aphasia could help rehabilitate Palestinians better, especially since Arabic is a Semitic language with particular social/emotional cues that hinge on cadence and prosody, arguably much more so than lingua-franca like English where the emphasis is mostly semantic.

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## Ahenksiz konuşma: Filistin Arapçasından akustik analiz örneği

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### Öz

Bu çalışma Broca afazisi olan ve normal Filistin dili konuşan dört kişiden toplanan veri üzerinden Filistin dilinin bürününün akustik incelenmesini sunmayı amaçlamaktadır. Bu çalışmada ton modülasyon, F0 aralığı, ifade sonu uzatma, kelime süresi ve hece süresini kapsayan çeşitli akustik ölçüler incelenmiştir. Sonuçlar, Broca afazili kişilerin kontrol grubuna göre ifade sonu uzatmalarını gerçekleştiremediklerini göstermiştir. Bu da konuşma planlaması ve zamanlamasında altta yatan zorlukları ortaya koymaktadır. Ayrıca kontrol grubuna göre Broca afazili kişiler yüksek F0 aralığı göstermiştir. Buna rağmen, kısmen daha düzgün yüksek ve düşük entonasyon modelleri sergilemişlerdir. Bu çalışmanın sonuçları, konuşma zamanlama eksikliklerinin ve anormal süresel modellerin Broca afazili kişilerin konuşmalarının önemli bir özelliği olduğu Broca afazili kişilerde zamanlama ve bürünsel modeller açısından önceki çalışmalarla bağlantılıdır. Bu çalışmanın sonuçları diğer dillerde özellikle diğer Arapça lehçelerine ve dillerine kıyasla daha az araştırılan Filistin Arapçasında yapılan nörolingüistik araştırmalarına katkı sağlamaktadır.

*Anahtar Sözcükler:* Ahenksiz konuşma; Filistin Arapçası; akustik analiz

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