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STUDYING THE RELATIONSHIP BETWEEN DISSONANCE OF ARABIC LETTERS AND THE DISTANCE OF THEIR OUTLETS

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ABSTRACT

Spoken texts have varying levels of eloquence. One main feature of eloquent spoken text is the absence of dissonance between its adjacent letters. A number of theories were proposed to reason why a given pair of adjacent pronounced Arabic letters show dissonance. One of these theories refers it to the closeness or remoteness of their mouth outlets. In this paper, the relationship between the dissonance of letters and the distances between their outlets is computationally studied. Our approach is based on finding the outlets distances for adjacent letters in a text of perfect eloquence. Quran was chosen for this study. This is because Quran is known to be the only Arabic text with perfect eloquence and hence shows no letter dissonance. The frequencies of different outlet distances for every adjacent pair of the spoken letters were calculated. Although found varying, these frequencies did not show significant variation. This means that outlet distances is not the reason for dissonance of adjacent letters. Otherwise, we should see very low frequencies for adjacent letters with very far or very close outlet distances. In other words, the letter dissonance between two adjacent letters does not necessarily happen because of their outlets being too close nor too far.

Keywords: *Natural Language Processing, Letter Dissonance, Letter Outlets, Quran*

1. INTRODUCTION

It is known that different spoken texts have varying levels of eloquence. One factor that determines the eloquence of spoken text is the absence of adjacent dissonant letters [1]. This is because adjacent dissonant letters are heavier and more difficult to pronounce and to hear. Take for example the words (هعخغ) with the transliteration (ha-h-kh-a-h) and (مستشزرات) with transliteration (mus-tash-zi-rat). A number of theories were proposed to reason why a given pair of adjacent Arabic letters show dissonance [2,3]. Some scholars stated that there is no specific reason or rule. It is just a matter of taste and being used to the words that are often used in eloquent speeches. Others stated that the reason for dissonance is the characteristics of the adjacent letters. Examples of these characteristics are whispering and loudness, softness and toughness, openness and closeness. Others referred letter dissonance for a pair of adjacent letters to the distance between their outlets by being very close or very far. What is meant by a *letter outlet* is the location in mouth from where this letter is pronounced.

In this paper, a statistical study is conducted to verify if there is a relationship between adjacent letters dissonance and the distance between their outlets. The frequencies of outlet distances between adjacent pronounced letters will be found for a text with perfect eloquence (Holy Quran). Then, these frequencies will be analyzed to explore if there is a relationship between outlet distances and dissonance between adjacent letters.

Looking into literature, a lot of work was directed towards studying the linguistics features of the Holy Quran. Researchers in [4] have studied parts of the Quran and found that its phonetic harmony and repeating vowels and consonants had a deep effect in conveying meanings to its readers. In [5], the phonemic harmony of Surat Al-Zalzalah from Quran showed unique style and rhythm that can never be challenged. In [6], it was shown that phonetic harmony and word selection in Quran had a great effect in facilitating its memorization by heart. Research in [7] showed how letter diphthong (i.e. edgham-إدغام) and replacement (i.e. ibdal- إبدال) in Quran eliminates potential dissonance for adjacent letters. It was mentioned in [8] that most of the old Arabic language scholars had the tendency to believe that the letter dissonance is

reduced if the letters are from distant outlets. One main result of this study was that adjacent letter dissonance cannot be referred to the very far/close distance between their outlets. However, this result was proven by presenting some examples of a number of words with adjacent letters with very close/far outlets and yet they didn't show dissonance. This study was vocal, with no generic computational proof. On the other hand, our study is computational. It is built on using a text with no letter dissonance, to validate a widely known theory that theorizes the reason of this phenomenon. To the best of the knowledge of the author, no similar computational study for the relationship between letter dissonance and their outlets was cited.

Since letter dissonance is related to spoken text and not written text, and because the written text does not exactly match the pronounced version of it, a translation of the written text is needed to generate the corresponding vector of actually pronounced letters. The outlet distance for every adjacent pair in this vector is calculated and the frequencies of different outlets distances are recorded. These frequencies are then studied to see whether there is a relationship between the outlet distances and the absence of letter dissonance in Quran. This work is based on the fact that the Quran spoken text has no letter dissonance.

This paper is structured as follows: in section 2, the outlets of Arabic letters are introduced. In Section 3, the algorithm to build the pronounced letters vector from Quranic text is given. In section 4, the algorithm that calculates the frequencies of outlet distances is presented and finally the results are discussed. The paper ends with a conclusion and a number of references.

2. ARABIC LANGUAGE LETTERS OUTLETS

The outlets of the Arabic letters are shown in Table-1. This table shows for each outlet its rank and the letters that are pronounced from that outlet. Outlets are ranked based on their location, starting from the interior, through throat, tongue and ending with the lips. This ranking is taken as is from specialized Arabic language books. In this paper, the outlet distance will be calculated based on these ranks. That is, the outlet distance for a pair of adjacent letters will be the absolute value of the difference between the ranks of their outlets. For example, take the adjacent pair of letters in the word (في). It is composed of two letters (ف) whose outlet rank is 15 and the (ي) which is a tide letter whose outlet rank is 0. The outlet distance for this pair of letters will be 15 minus 0 which is 15. The distance is calculated by the absolute value of the difference of their outlet ranks. This means that the the same pair with the two letters inverted (يف) will also have an outlet distance equals 15.

Table 1: Arabic Letters Outlets.

Rank	Letter Outlet	Letters
1	interior (الجوف)	Tide letters (حروف المد)
2	far throat (أقصى الحلق)	هـ ، أ
3	middle throat (وسط الحلق)	ع ، ح
4	near Throat (أدنى الحلق)	غ ، خ
5	far tongue_qaf (أقصى اللسان_ق)	ق
6	far tongue_kaf (أقصى اللسان_ك)	ك
7	middle tongue (وسط اللسان)	ج، ش ، ي
8	tongue sides_dhad (حافتا اللسان_ض)	ض
9	tongue sides_lam (حافتا اللسان_ل)	ل
10	tongue head_noon (طرف اللسان_ن)	ن
11	tongue head_ra (طرف اللسان_ر)	ر
12	tongue head_tta_da_ta (طرف اللسان_ط_د_ت)	ط ، د ، ت
13	tongue head_seen_sad_zai (طرف اللسان_س_ص_ز)	س، ص، ز
14	Tongue head_zha_tha_tha (طرف اللسان_ظ_ذ_ث)	ظ، ذ، ث
15	Lips_fa (الشفتان_ف)	ف
16	Lips_ba_meem_waw (الشفتان_ب_م_و)	ب، م، و

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3. TRANSLATING WRITTEN TEXT TO A VECTOR OF PRONOUNCED LETTERS

Calculating outlet distances cannot be done directly from the written text for many reasons: (1) dissonance is a feature that occurs between pronounced letters, (2) there are many letters that are written in text but are not pronounced (e.g. Hamzat-wasl), (3) some written letters are actually pronounced as two or three letters. For example, a written letter with *shadda* (e.g. ذَّ) is actually pronounced as two letters: an idle version (ذْ), followed by non-idle version (ذَ), (4) the pronunciation of the Holy Quran letters slightly differs from those of the standard Arabic. Because of these reasons, an additional step is required for an accurate calculation of outlet distances between adjacent pairs of letters. A translation is required to convert the written Quranic text into a vector of the corresponding pronounced letters, as when this Quranic text is read. This vector is built by GENERATE-PRONOUNCED-LETTERS algorithm that is shown in figure 1.

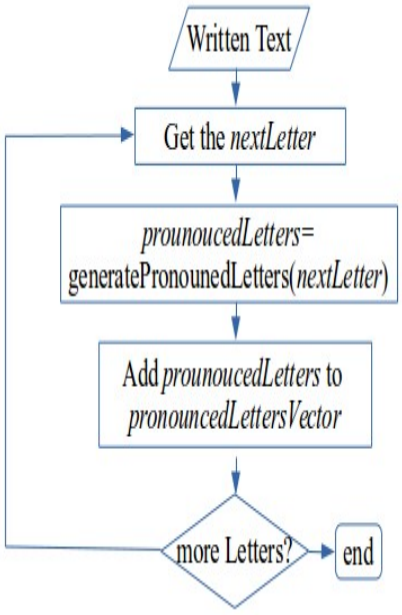

Figure 1: Generate-Pronounced-Letters

In this algorithm the letters from the Quranic text are taken one by one and passed through a sequence of rules through which the corresponding pronounced letters are identified and then appended to the *pronouncedLettersVector*. The list of these rules is long and language specific. So, to save space, a number of examples are shown in Table 2 to give a sense of these rules.

Table 2: Examples of Generating Pronounced Letters From Written Text.

Word	Pronounced Letters
الٓمٓ	ا ـ لِ ـ فْ ـ لَ ـ ا ـ مْ ـ مِ ـ يـ ـ مْ
ذَٰلِكَ الْكِتَٰبُ	ذَ ـ ا ـ لِ ـ كَ ـ لْ ـ كِ ـ تَ ـ ا ـ بُ
هُدًى لِّلْمُتَّقِينَ	هُ ـ دَ ـ لْ ـ لِ ـ لْ ـ مُ ـ تْ ـ تَ ـ قِ ـ يْ ـ نَ
وَمِنَ النَّاسِ	وَ ـ مِ ـ نَ ـ نْ ـ نَ ـ ا ـ سِ
صُمٌّۢ بُكْمٌ	صُ ـ مْ ـ مُ ـ مْ ـ بُ ـ كْ ـ مُ ـ نْ

4. CALCULATING FREQUENCIES OF OUTLET DISTANCES

Once the *pronoucedLettersVector* is constructed, the frequencies of the outlet distances between adjacent letters in this vector are calculated through FIND-OUTLET-DISTANCE-FREQ algorithm (figure 2). In this algorithm, every adjacent pair of letters in the *pronouncedLettersVector* is taken. The first pair will be composed of the first and second letters, the next pair will be the second and the third letters in this vector and so on. For every pair, the outlet distance of these two letters is calculated and the corresponding entry in the outlet distance frequency array is incremented. For example, for the pair of adjacent letters (فـي), the outlet distance of these two letters is 15, so *OutletDistanceFreq[15]* will be incremented.

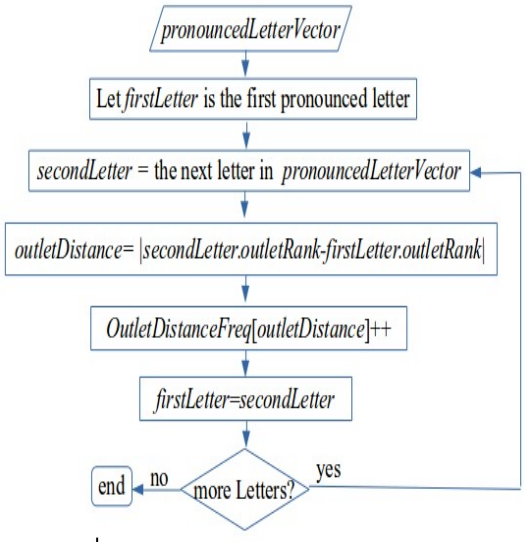

Figure 2: Find-Outlet-Distance-Freq

5. EXPERIMENTAL STUDY

Algorithms were implemented using Java. The number of written letters of Quran is 320015 and the *pronouncedLettersVector* is of length 338537 letters. The frequencies of outlet distances for adjacent letters are shown in figure 3. For example, the frequency of adjacent pair of pronounced letters that belong to the same outlet (i.e. outlet distance is 0) is 41061.

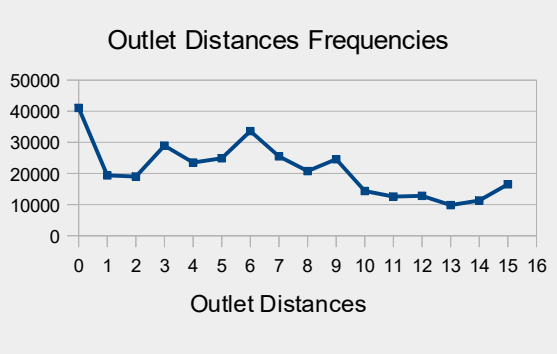

Figure 3: Frequencies Of Outlet Distances

The main assumption upon which these results are based is that these frequencies are found for a text with no letter dissonance. The first observation from this graph is that although distances of different outlets have varying frequencies, it can be seen that there is no significant difference between these distances. It can be easily seen that the frequencies of adjacent letters with very close outlets does not differ much from frequencies of adjacent letters with very far outlets. This weakens the argument saying that text with letters that are very close/far in outlets means high letter dissonance. Otherwise, we should see very low frequencies for very short/far distances. This is because Quran has no letter dissonance. However there is a slightly higher frequencies for adjacent letters with short and middle outlet distances than far outlet distances.

The second observation is that there is a noticeable high frequency for pairs of adjacent letters that are from the same outlet (i.e. outlet distance is 0). This allows us to say that, to some degree, that adjacent letters that are from the same outlets is a feature of text with low letter dissonance.

6. CONCLUSIONS

The main question that is answered by this research is: Is the dissonance between adjacent letters related to the closeness (or remoteness) of their outlets? This question was answered computationally by calculating the distances between outlets of adjacent letters in a text with no letter dissonance. The frequencies of these distances are then calculated. It was found that these frequencies does not significantly vary. This takes us to the main result of this study which is that there seems to be a weak relationship between the dissonance of adjacent letters and the distance between their outlets. So, we cannot say that having adjacent letters that are very close or very far in their outlets is the only nor the main reason for their dissonance. Although this research seems to be very language specific, it showed an example where computation may be utilized to explore features of natural languages. This work suggests - as a future work – computationally exploring other factors that were assumed to be the reason of letter dissonance, and studying how these factors integrate together in causing letter dissonance.

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