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Arabic Diagnostic Rhyme Test using minimal pairs

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Abstract

In this paper, we try to adapt to Arabic the diagnostic rhyme test (DRT) developed by Voiers for English and adapted to French by Peckels & Rossi. DRT is specific to each language and is essential to subjective assessments of coders and synthesizers. Six Arabic pertinent dimensions are used which are acuteness, compactness, tenseness, stridence, nasality and flatness. 72 monosyllabic meaningful pairs of words called minimal pairs have been developed. The apprehensibility of every attribute is tested in each of six vowel contexts. Every feature has been repeated six times and has been paired twice with every vowel.

1 Introduction

Most of speech processing systems (SPS) such as automatic speech recognition (ASR) systems, coders and synthesizers, have been devised in laboratories dealing with English, French or other European languages. Today, adequate linguistic material and various databases for assessments as well as various algorithms for speech processing, are easily obtained for these languages. Unfortunately, in the case of Arabic, speech processing presents more difficulty, because of the limitation of such useful tools.

To this end, and since some years already, we had begun to fill this emptiness, while contributing to finalize of such tools. We mention for example, the structural work on Arabian phonetically balanced sentences analogous to those of Combesure [1] for the French language that we presented in Boudraa [2].

In the same way, statistical studies and a hierarchy of the acoustic features of the Arabic permitted us to develop a set of phonetic and phonological rules that help to better approach the problems of based knowledge recognition systems when achieved in this language [3].

In continuity to these works, we propose in this paper an adaptation to the Arabic language, of a test of diagnostic using minimal pairs. The test called DRT (diagnosis rhyme test) was initially proposed by Voiers [4] for the English language. Then, the test has been adapted to other languages. Among the known adaptations, we mention the one carried out by Peckels & Rossi [5] to the French language and that helps since, to conceive synthesizers and coders treating with this language.

2 Diagnostic rhyme test using minimal pairs

The goal of this test is to verify whether the initial consonants of the monosyllabic words presented to a listener are well considered by the listener or if they are taken for other consonants. In fact, speaker-recordings are presented to a listener who must choose among an opposition presented on a computer screen and representing a minimal pair. Thus, to test the voiced feature, voiced consonants are opposed to unvoiced ones. In case of the compact feature, compact consonants are opposed to diffuse ones; etc. This test is useful in several applications of the speech processing. The test permits to evaluate the quality of a vocoder or a synthesizer while establishing a

diagnostic contrary to most other known methods of assessment that permit to give only a global cleanness of quality. DRT also serves to physicians who take care of hearing and phonation problems. Otherwise, this test can be easily conducted because it doesn't make intervene necessarily of the specialized listeners, contrary to the logatome test for example. In addition, a DRT needs only a short time: a test session is of about twenty minutes.

3 Arabic distinctive features

To construct a DRT using minimal pairs in Arabic, it is necessary to analyze the structure of this language carefully. To this end, two main orientations can be considered. The two orientations are the Prague school represented by Jakobson, the father of linguistics (Jakobson, Fant & Hall, [6]) and the American school firstly represented by Miller and Nicely [7] then by Chomsky and Halle [8]. In the two studies, the problem of classification of the sounds of the most languages existing nowadays is clarified. These two different models of classification influence all currently works. Thus, Jakobson noted that the sounds of any language can be decomposed in a set of distinctive features (opposites). Jakobson asserts that binary representation of any language doesn't exceed twelve features. The set of features leans on acoustic and articulatory domains. A simplified version of this representation was adopted by Voiers and consists of the following features:

voiced / unvoiced	b/p
nasal / oral	m/b
interrupted / non interrupted	t/s
strident / mellow	s/θ
grave / acute	p/t
compact / diffuse	k/t
vocalic / non-vocalic	j/ʒ

According to the American school orientations, another classification can be considered. For example, the three features: "grave", "compact" and "diffuse" can be replaced by "anterior", "coronal", "high", "low" and "posterior". In fact, Chomsky and Halle described the articulatory interrelationship of every feature and illustrated them while mentioning examples of their occurrence in different languages. However, the features defined by these authors are not binary. Thus, we believe testing a feature, whereas in reality we are testing several ones. Therefore we can say that Jakobson' features are more convenient for the construction of our diagnostic rhyme test, as it was considered by Voiers for English and by Peckels and Rossi

for French. Consequently, we have used a simplified version of the taxonomic matrix proposed by Jakobson in [9] for the Arabic language.

compact / diffuse (CM)
 grave / acute (AC)
 tense / lax (TN)
 interrupted / non interrupted (IT)
 strident / mellow (ST)

4. The taxonomic matrix of the Arabic

According to the works of Jakobson [9], Roman [10] and Al-Ani [11], the Arabian consonants can be represented by nine distinct features, which are:

vocalic / non vocalic (VC)
 continuant / abrupt (CT)
 flat / plain (FL)
 nasal / oral (NZ)

In fact, we considered a simplified version of the Arab taxonomic matrix given by Jakobson in [9]. Let's recall that Voiers [4] as well as Peckels & Rossi [5] have also considered these kinds of matrices when constructing their DRT, respectively for the English and the French languages. Our simplified phonetic matrix is presented in the table 1:

Arabic Consonants		Features								
		AC	IT	CT	CM	TN	ST	VC	NZ	FL
n	ن	+	+	+	-	-	-	+	+	-
l	ل	+	+	+	-	-	-	+	-	-
r	ر	+	+	-	+	-	-	+	-	-
ʒ	ج	+	+	-	+	+	-	-	-	-
tʃ	ط	+	+	-	-	-	+	-	-	+
t	ت	+	+	-	-	-	+	-	-	-
dʃ	ض	+	+	-	-	-	-	-	-	+
d	د	+	+	-	-	-	-	-	-	-
ʃ	ش	+	-	+	+	+	+	-	-	-
y	ي	+	-	+	+	-	-	+	-	-
sʃ	ص	+	-	+	-	+	+	-	-	+
s	س	+	-	+	-	+	+	-	-	-
θ	ث	+	-	+	-	-	+	-	-	-
z	ز	+	-	+	-	+	-	-	-	-
zʃ	ظ	+	-	+	-	-	-	-	-	+
ð	ذ	+	-	+	-	-	-	-	-	-
m	م	-	+	+	-	-	-	+	+	-
k	ك	-	+	-	+	-	+	-	-	-
q	ق	-	+	-	+	-	-	-	-	-
ʔ	ء	-	+	-	-	-	+	-	-	-
b	ب	-	+	-	-	-	-	-	-	-
χ	خ	-	-	+	+	+	+	-	-	-
ħ	ح	-	-	+	+	-	+	-	-	-
ʕ	ع	-	-	+	+	+	-	-	-	-
ʕ	ع	-	-	+	+	-	-	-	-	-
f	ف	-	-	+	-	+	+	-	-	-
h	ه	-	-	+	-	-	+	-	-	-
w	و	-	-	+	-	-	-	+	-	-

Table 1: Phonetic matrix of Arabic.

5 List of the minimal pairs of the constructed Arabic DRT

The linguistic material of the constructed DRT consists in a corpus of 72 pairs of monosyllabic words named "minimal pairs". Thus, an opposition is considered minimal if the words of every pair oppose only by one feature considered in the first consonant. In the list of the pairs presented in table 2, we can observe that six measurements have been kept. It is about the features: grave / acute, tense / lax, compact / diffuse, strident / mat, nasal / oral and flat / plain. Besides, all the chosen words have a sense in standard Arabic. In the constructed DRT corpus, every feature is repeated six times. For example, acute feature appears in the six oppositions s/f, d/b, m/n, q/h, ð/x and ?/t. Otherwise, all Arabian vocalic contexts have been considered.

6 Test methodology using Arabic DRT

Note that DRT is more convenient to assess the quality of a coder or a synthesizer than a normal speech communication. Neither the context nor the position of the word will help the listener to discriminate the phonemes.

In this work, we have extended to Arabic the test methodology used by Voiers for English and adapted by Peckels and Rossi for French. Indeed, an Arab speaker

pronounces isolated monosyllabic meaningful words as /fil/, /sīl/, /ās/, /kās/, /lis/, /nis/... and an Arab listener endeavours to recognize them correctly. In addition, every feature has been repeated six times and has been paired twice with every vowel. Moreover, recordings of the test materials have been conducted by two speakers: one male and one female, and then presented randomly and with an optimal rate of one word per 1.4 seconds [12] to test-groups of eight to ten listeners. In each step, two words are presented to the screen and the listener must indicate which one of the two words has been heard. Recall that every pair differs only by one feature considered in the first position. A computer program allows treating the answers and then an automatic diagnostic is realized.

For example, /fi:l/ (elephant) is presented simultaneously with /si:l/ (flow). The commutation between the two words is realized while changing the acute consonant /s/ by the grave one /f/. These two consonants have the same features except the opposition acute /grave.

Note that the DRT is more properly described in terms of a set of principles for item construction and selection than in terms of a specific corpus of test materials (as argued by Voiers).

7 Exploitation of the results

The results of the test can be exploited of different ways according to our interest. Generally, an importance is given to the global result obtained on the retained features.

Features	Vowels					
	/i/	/i:/	/a/	/a:/	/u/	/u:/
AC	سِلْ \ قِلْ fil / sil دِعْ \ بِعْ biε / diε	نَيْلْ \ مَيْلْ mi:l / ni:l شَيْلْ \ خَيْلْ χi:l / ši:l	دَرْ \ بَرْ bar / dar تَمْ \ هَمْ ham / θam	تَاةْ \ آةْ a:h / ta:h تَابْ \ أَبْ a:b / ta:b	نُخْ \ مُخْ muχ / nuχ تُرْ \ هُرْ hur / θur	سور \ فور fu:r / su:r شور \ خور χu:r / šu:r
TN	زِرْ \ سِرْ sir / zir ضِفْ \ طِفْ t ^ʔ if / d ^ʔ if	قَيْسْ \ كَيْلْ ki:l / qi:l دَيْنْ \ تَيْنْ ti:n / di:n	دَرْ \ تَرْ θar / dar عَلْ \ حَلْ ħal / ʕal	غَابْ \ خَابْ χa:b / ʕa:b بَارْ \ آرْ a:r / ba:r	قُلْ \ كُلْ kul / qul دُبْ \ ثُبْ ðub / dub	خُورْ \ غُورْ χu:r / ʕu:r عُومْ \ حُومْ ħu:m / ʕu:m
CM	خِمْ \ فِمْ fim / χim كِنْ \ إِنْ ʔin / kin	حِينْ \ وِينْ wi:n / ħi:n شِيمْ \ سِيمْ si:m / ši:m	سَدْ \ شَدْ sad / šad قَلْ \ بَلْ bal / qal	كاسْ \ آسْ a:s / ka:s كادْ \ آدْ a:d / ka:d	حُمْ \ هُمْ hum / ħum فُدْ \ بُدْ bud / qud	شُوقْ \ سُوقْ su:q / šu:q خُولْ \ فُولْ fu:l / χu:l
ST	عِبْ \ غِبْ εib / ʕib سِقْ \ تِقْ θiq / siq	زَيْلْ \ نَيْلْ ði:l / zi:l فَيْلْ \ هَيْلْ hi:l / fi:l	زَمْ \ دَمْ dam / zam سَرْ \ تَرْ θar / sar	غَالْ \ عَالْ ʕa:l / ʕa:l خَارْ \ حَارْ ħa:r / χa:r	سُلْ \ ثُلْ θul / sul خُدْ \ حُدْ ħud / χud	فُوجْ \ هُوجْ hu:ʒ / fu:ʒ غُوصْ \ حُوصْ ʕu:s ^ʔ / χu:s ^ʔ
NZ	لِقْ \ نِقْ liq / niq لِسْ \ نِسْ lis / nis	نَيْلْ \ لَيْلْ li:l / ni:l نَيْفْ \ لَيْفْ li:f / ni:f	نَدْ \ لَدْ lad / nad نَبْ \ لَبْ lab / nab	نَابْ \ لَابْ la:b / na:b نَاخْ \ لَاخْ la:ħ / na:ħ	لُدْ \ نُدْ lud / nud لُبْ \ نُبْ lub / nub	لُومْ \ نُومْ lu:m / nu:m لُوعْ \ نُوعْ lu:ʕ / nu:ʕ
BM	طِقْ \ ثِقْ θiq / t ^ʔ iq ظَلْ \ ذَلْ ðil / z ^ʔ il	ضَيْفْ \ دَيْفْ di:f / d ^ʔ i:f صَيْفْ \ سَيْفْ si:f / s ^ʔ i:f	صَخْ \ دَخْ daʕ / d ^ʔ aʕ ظَلْ \ ذَلْ ðal / z ^ʔ al	طَابْ \ تَابْ ta:b / t ^ʔ a:b طافْ \ تافْ ta:f / t ^ʔ a:f	صُمْ \ سُمْ sum / s ^ʔ um ضُرْ \ دُرْ dur / d ^ʔ ur	صُومْ \ سُومْ su:m / s ^ʔ u:m صُوفْ \ سُوفْ su:f / s ^ʔ u:f

Table 2: Corpus of the Arabic DRT

However, in some applications we can be more interested in the results of a particular feature.

In many cases, we compute the score S (in %) of the correct answers, expressed by [13]:

$$S = 100(R-W)/T$$

Where R represents the number of the observed correct answers in a total of T possible answers while W are the erroneous ones.

8 Conclusion

In this paper, we present an Arabic DRT essential to assess the quality of a vocoder or a speech synthesizer when using Arabic. We tried to fill a void encountered by the absence of such a tool in Arabian language. We construct a corpus of 72 pairs of monosyllabic words where the two words of every pair differentiate themselves only by the first consonant (placed in the beginning of the word). We think that the positions "middle" and "end" of the word can bring other information, but as the interest is carried here on the consonants, they keep all their features in all positions. The initial context has been considered for reasons of simplicity and clearness of the corpus. That was the case in the works of Voiers, Peckels and Rossi. We hope that the researchers in Arabic will find in this paper a solution of their assessment problems.

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