NATURE OF UTTERANCE OF ARABIC SOUNDS

[/t̲/, /d̲/, /s̲/, /ð̲/, /χ/, /ʁ/, /ħ/, /ʕ/]

Essay

Submitted in the Partial Fulfillment for the Master Degree in Phoniatrics

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2010

طبيعة الأصــوات العربيــة
ط, ض, ص, ظ, خ , غ ,ح , ع

رسالة توطئة للحصول على الماجستير فى
امراض التخاطب

مقدمة من

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جامعة عين شمس

2010

Acknowledgement

First and foremost thanks to ***Allah*** *the most beneficent and merciful.*

I wish to express my great appreciation to ***Prof. Dr. Nahla Abd El-Aziz Youssef Rifaie*** *Professor of Phoniatrics – Ain Shams University for her great support, guidance and encouragement.*

I wish to express my deepest gratitude to ***Ass. Prof. Dr. Amal Sayed Mahmoud Saber*** *Assistant Professor of Phoniatrics–Ain Shams University for her supervision and close valuable guidance all through this work.*

Words are not enough to thank ***Ass. Prof. Dr. Jilan Fouad Nassar*** *Assistant Professor of Phoniatrics –Ain Shams University for her valuable participation in our work by kindly performing the visual evoked potential and the nerve conduction studies of the patients and control.*

Finally, I wish to express great appreciation and gratitude to ***my mother, father, husband and my children*** *for their support.*

Ranya Abd El-Aziz

Introduction

Sound is the perception of the movement of air particles which causes a displacement of the ear-drum. The air particles are extremely small about 400 billion per cubic inch and when set in motion create patterns of sound waves. Certain concepts in acoustics (frequency, amplitude, waveform analysis and resonance) provide the bases for an understanding of the structure of these sound-waves ***(Fry, 1979).***

A phoneme is the smallest unit of sound that corresponds to an element of human speech that can indicate differences in meaning between words or sentences. Phonemes are often classified into two major groups: vowels and consonants. In terms of their phonetic realization, vowels contain no major airflow restriction in the vocal tract; consonants involve a significant restriction of airflow and are therefore weaker in amplitude and often noisier than vowels ***(Rabiner and Juang, 1993; Deller et al., 1993).*** Arabic has 36 phonemes consisting of three short vowels (/i/, /a/, /u/), three long vowels (/i: /, /a: /, /u: / which are the counterparts of the short vowels), and 28 consonants ***(Alghamdi, 2004).***

Phonetics (the scientific study of speech production) embraces not only the constituents and patterns of sound-waves (ACOUSTIC PHONETICS) but also the means by which the sound-waves are generated within the human vocal tract (ARTICULATORY PHONETICS**)** ***(Allen, 1981).*** And also for most phonetic purposes, it is sufficient to be able to say that the vocal folds are either:

(i) Apart in which case the sound is said to be VOICELESS.

(ii) Close together and vibrating against each other then the sound is VOICED

Different categories of consonant are established on the basis of:

(i) The actual relationship between the articulators and thus the way in which the air passes through certain parts of the vocal tract, the (MANNER OF ARTICULATION)

(ii) Where in the vocal tract there is approximation, narrowing or obstruction the (PLACE or POINTOF ARTICULATION) ***(Allen, 1953).***

Unique consonants in Arabic:

In Arabic, some unique consonants exist that cannot be found in other languages. For example, there are four emphatic consonants in Arabic: two plosives, / **d**/-/ض /and

/ṯ /- /ط/and two fricatives, /Ṣ /-/ص/and / ð̲ /-/ظ/ ***(Selouania and Caelen, 1998; Al-Muhtaseb et al., 2000 and Ouni et al., 2005).*** /**d̲**/ is a voiced empatic stop with an alveo-dental point of articulation. As this phone is not found in other languages Arabic is commonly called ‘‘The Dhaad language”, where Dhaad is the name of the spoken Arabic letter that carries the, / **d̲**/ phoneme. **/ṯ /**is an unvoiced emphatic stop with an alveo-dental point of articulation. / **Ṣ**/ is an unvoiced emphatic fricative with an alveo-dental point of articulation. Finally, **/ ð̲/** is a voiced empatic fricative with an inter-dental point of articulation ***(Alkhouli, 1990).*** Also there are two pharyngeal phonemes in Arabic **/ /ʕ/-/ع/** and /**ħ**/-/ح/ ***(Alkhouli, 1990; Alghamdi, 2004 ;),*** uvular **/ ʁ /-/غ/, /x/ -/ خ/**and /q/-/ق/so Arabic phonemes contain two distinctive classes that are named pharyngeal and emphatic phonemes. These two classes are primarily found in Semitic languages like Hebrew and Arabic ***(Alkhouli, 1990; Elshafei, 1991).*** Delattre in 1971 found pharyngeal features in other languages like German, and Spanish.

Classification is done according to three descriptive parameters to describe the Arabic consonantal speech

sounds. **/ħ/, / ʕ /, /χ/, / ʁ /, /d̲/, /t̲/, /s̲/, /ð̲/** which represent the letters **/ح /,/ع//خ/ ,/غ/ , /ض/ ,/ ط/ ,/ص/ /,ظ**

1- Voiced or voiceless.

2- Place of articulation.

3- Manner of articulation.

1) Voiced or voiceless:

Sounds which are produced with this vocal fold vibration are said to be voiced sounds, as in **/ ʁ /, / ʕ /, /ð̲/, /d̲/** which represent the letters **/غ/. /ع/, /ظ/, /ض/** whereas sounds produced without such vibration are said to be voiceless sounds as in **/ħ/, / χ/ /t̲/,** /q/, **/ s̲ /** which represent the letters

/ح/- /خ/ - /ط/- /ق- /ص/ (***Browman et al., 1992).***

2) Place of articulation: *(El ghamdi, 2001)*

a-Interdental sounds:

Sounds in which there is constriction between the tip of the tongue and the upper teeth as in sound **/ð̲/** which represent the sound **/ظ**

b- Alveo-dental sounds:

Sounds in which there is constriction between the blade of the tongue and dental, alveolar regions as in sounds **//d̲//-/ض/, / t̲ /-/ط/ / s̲ /-/ص/.**

c- Uvular sounds:

Sounds in which there is constriction between the back of the tongue and uvular region as in sounds / ʁ /-/غ/, /**x**/ -/خ/, /q/-/ق/.

d- Pharyngeal sounds:

Sounds in which there is constriction between the root of the tongue and pharyngeal region as in sounds / ʕ / -/ع/ and /**ħ**/-/ح/.

3) Manners of articulation*: (Ladefoged, 2005).*

a-Stop: **(**Complete closure of the articulators involved so that the Air stream cannot escape through the mouth**.)**

Oral stops: / **d** /-/ض/, / **t** /-/ط/ /q/-/ق/.

If in addition to the articulatory closure in the mouth, the soft palate is raised so that the nasal tract is blocked off, then the air stream will be completely obstructed. Pressure in the mouth will build up and an oral stop will be formed. When the articulators come apart, the air stream will be released in a small burst of sound.

b-Fricative:

/ ð /, / s /, /χ/, ʁ/ / , /ħ/, / ʕ / which represent the sounds **/ظ /ص /, /خ /, /غ/, /ح/, /ع/** Close approximation of two articulators so that the air streams partially escape through the mouth).

Arabic sounds can also be classified according to the manner of articulation into emphatic and back. The emphatic consonants **/t/, /d/, /s/, /ð/** are produced with retraction of the root of the tongue toward the posterior pharyngeal wall **(*Amayreh and Dyson, 2000).*** While the back consonants are velar **/χ/, / ʁ/ , /q/** or pharyngeal **/ħ/, /** ʕ/) Omar**, 1973**).

			Bilabial	Labio-dental	Inter-dental	Alveo-dental	Alveolar	Palatal	Velar	Uvular	Pharyngeal	Glottal
Stop	Voiced	Emphatic				ض /D/						
		Non- Emphatic	ب /b/			د /d/		ج /j/				
	Unvoiced	Emphatic				ط /T/						
		Non- Emphatic				ت /t/			ك /k/	ق /q/		ء /Q/
Fricative	Voiced	Emphatic			ظ /Z/							
		Non- Emphatic			ذ /TH/	ز /z/				غ /G/	ع /C/	
	Unvoiced	Emphatic				ص /S/						
		Non- Emphatic		ف /f/	ث /th/	س /s/		ش /sh/		خ /x/	ح /H/	ه /h/
Nasal	Voiced	Non- Emphatic	م /m/				ن /n/					
Liquid	Voiced	Non- Emphatic					ل ر /l/r/					
		Emphatic					ل /l/					
Semivowels	Voiced	Non- Emphatic	و /w/					ى /y/				

Table 1: standard Arabic consonants Adapted from (Alotaibi, 2008)

Acoustic phonetics:

Acoustically sounds may vary in pitch, loudness, and quality. The pitch of a sound with a periodic wave form (i.e. a voiced sound) is determined by its fundamental frequency or rate of repetition of the cycles of air pressure ***(Jacobson et al., 1963).***

The quality of a sound is determined by the smaller variations in air pressure which are superimposed on major variations that recur at the fundamental frequency. Every

time the vocal folds open and close there is a pulse of air from the lungs. These pulses act like sharp taps on the air in the vocal tract, so the vibrations begin in a way which is determined by its size and shape. Voiced consonants are more like vowels in that they can be characterized by the resonant frequencies (the formants) of their vocal tract shapes. They differ from vowels in that during the release of a stop and whole of a semivowel the vocal tract shapes are changing comparatively rapid.

These transitional movements in consonants can be specified acoustically in terms of the movements of the formant frequencies. Voiceless sounds do not have a periodic wave form with a well defined fundamental frequency. The shape of vocal tract determines the transfer function of the vocal tract response to an excitation signal. This transfer function is usually composed of a number of resonances, known as formants, and occasionally of anti-resonances too ***(Maeda, 1990)***.

Speech is produced by exciting the resonances and anti-resonances of the vocal tract alter. The excitation either comes from the vibration of the vocal folds during voiced speech, at the fundamental frequency, F0, or from turbulent noise created at a constriction somewhere in the vocal tract in the case of unvoiced speech. In some sounds

both types of excitation may be present at the same time. Nevertheless some sensation of pitch accompany the variations in air pressure caused by the turbulent air flow which accrues during a voiceless, Fricatives, or in the release relation between the phase of a voiceless stops ***(Jurafsky et al., 2007).***

Studying the production mechanisms and acoustics properties of speech wave form of Arabic consonants would help in developing a more detailed quantitative acoustic theory of speech production ***(Shadle, 1986).***

Aim of the Work

To illustrate the special characters of the Arabic sounds **[/t̲/, /d̲/, /s̲/, /ð̲/, /χ/, / ʁ /, /ħ/, / ʕ /]** that are unique to Arabic language in order to put basic information for Arabic and non Arabic speakers, since it was rarely mentioned in the literature before.

Basic Vocal Tract Anatomy

In this section, we take a look at the active articulatory organs and describe the main muscles that underlie their actions. Only the articulatory organs that are directly implicated in the articulation of the sounds of interest are discussed here. This is why, for example, the lips are ignored in the following review.

The Tongue:

This flexible mass of muscle fiber is arguably the most notable articulatory organ. The tongue is divided into four parts: the tip, the blade, the dorsum, and the root. The rear and radical portions of the tongue are fixed to the velum, the pharynx, the epiglottis, and the hyoid bone ***(Gritzmann et al., 1988)*.**

The lingual movements are executed by two sets of muscles: the intrinsic muscles of the tongue, which originate from inside the tongue itself, and the extrinsic muscles of the tongue, which arise from neighboring structures and terminate at various points in the tongue.

Intrinsic muscles of the tongue:

The intrinsic muscles of the tongue are the superior longitudinal muscle, the inferior longitudinal muscle, the

transverse muscle, and the vertical muscle. The superior longitudinal muscle is a sheet of muscle tissue that extends throughout the length of the tongue just below its upper surface. When contracted, it shortens the tongue or lifts the tip and neighboring sides upwards giving the tongue a concave shape. Contracting one side of this muscle alone causes the tongue to turn to that side.

The inferior longitudinal muscle is a paired muscle that arises from the root of the tongue and extends all the way to its tip. It courses along the lower surface of the tongue following two side paths separated along the middle by the genioglossus muscle. Contracting this muscle shortens the tongue or lowers its tip. Like the superior longitudinal muscle, contraction of one side of this muscle causes the tongue to turn to that side.

The transverse muscle is a paired muscle whose fibers radiate from the median fiber wall of the tongue and stretch laterally to terminate at the side edges of the tongue. Contraction of this muscle narrows the tongue and lengthens it.

The vertical muscle is also a paired muscle whose fibers extend vertically from just below the upper surface of the tongue flowing downward towards the base of the tongue. Along the way, these fibers intertwine with those of