

Brief Insight About Speech Perception And Classification Of Speech Sound In Arabic Dialects

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Abstract

Background: Speech is simply an acoustic signal that carries linguistic information. Sound is the basic requirement for speech production, initiated by a simple disturbance of air molecules in the vocal passage is provided by movement of certain body organs such as chest muscles, vocal cords, lips, teeth, tongue, palates etc. finally producing spoken language. Speech signal is a multidimensional acoustic wave, which provides information about the words or message being spoken expressing speaker ideas, feelings and emotions to the listener reflecting speaker identity, physical and mental health, race, age, sex, education level, religious orientation and overall individual background. The Variation in speech production might be explained by several factors including inter-speakers and intra-speaker variations. The inter-speakers variation includes idiosyncratic and social-indexical differences as well as differences in vocal tract size as a result of age and sex differences. Therefore, two different speakers may articulate the same intended sound with different acoustic patterns and different sounds with the same acoustic patterns. Speech sounds may be classified under two major categories: vowels and consonants. The 28 consonants in MSA ,3 short vowels (/a/, /u/, /i/), 3 longer vowels (/a:/, /u:/, /i:/), and two diphthongs(/ai/, /au/).

Keywords: Speech perception, Arabic dialects

INTRODUCTION

Speech is simply an acoustic signal that carries linguistic information. It is a term used to express the complex motor activity of the vocal tract in the production of spoken language (1).

Speech is the vocal aspect of communication made by human beings. Human beings are able to express their ideas, feelings and emotions to the listener through speech generated using vocal articulators (2).

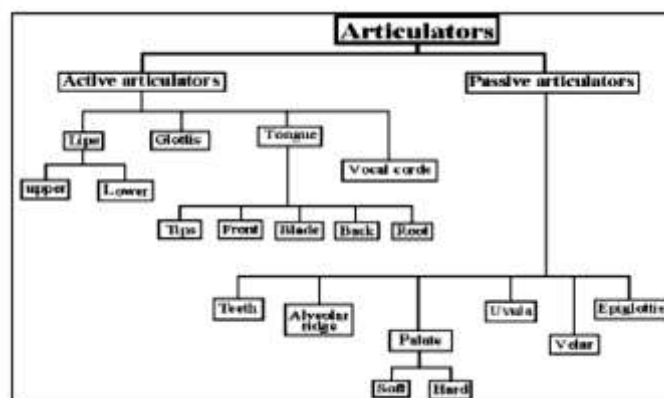
Speech signal is a multidimensional acoustic wave, which provides information about the words or message being spoken, speaker identity, language spoken, physical and mental health, race, age, sex, education level, religious orientation and background of an individual (3)

Sound is the basic requirement for speech production, initiated by a simple disturbance of air molecules in the vocal passage is provided by movement of certain body organs such as chest muscles, vocal cords, lips, teeth, tongue, palates etc. This disturbance in the form of waves travels to the ear of the listener, who interprets the wave as sound (4).

Anatomy of speech production

The sound vibrate in a complex periodic fashion, the vocal folds generate a harmonic series, consisting of a fundamental frequency and many whole number multiple of that fundamental frequency (harmonics). The fundamental frequency is the number of glottal openings/closing per second (5).

Articulation is a process resulting in the production of speech sounds. It consists of a series of movements by a set of organs of speech called the articulators (as seen in figure 1.) that move during the process of articulation are called active articulators. Organs of speech which remain relatively motionless are called passive articulators. The points at which the articulator are moving towards or coming in to contact with certain other organ are the place of articulation. The type or the nature of movement made by the articulator is called the manner of articulation (5).



(5)

The seven articulators described below are the main ones used in speech. Firstly, the larynx could also be described as an articulator - a very complex and independent one. Secondly, the jaws are sometimes called articulators; certainly the lower jaw is moved a lot in speaking. But the jaws are not articulators in the same way as the others, because they cannot themselves make contact with other articulators. Finally, although there is practically nothing that we can do with the nose and the nasal cavity, they are a very important part of our equipment for making sounds (what is sometimes called our vocal apparatus), particularly nasal consonants such as m, n, we cannot really describe the nose and the nasal cavity as articulators in the same sense as (i) to (vii) below:

The pharynx is a tube which begins just above the larynx. It is about 7 cm long in women and about 8 cm in men, and at its top end it is divided into two, one part being the back of the mouth and the other being the beginning of the way through the nasal cavity.

ii) The velum or soft palate is seen in the diagram in a position that allows air to pass through the nose and through the mouth. In speech it is raised so that air cannot escape through the nose. The other important thing about the velum is that it is one of the articulators that can be touched by the tongue. When the sounds k and g are made the tongue is in contact with the lower side of the velum, and these are called velar consonants.

iii) The hard palate is often called the "roof of the mouth".

iv) The alveolar ridge is between the top front teeth and the hard palate. Its surface is really much rougher than it feels, and is covered with little ridges. Sounds made with the tongue touching here (such as t and d) are called alveolar.

v) The tongue is important articulator and it can be moved into many different places and different shapes. It is usual to divide the tongue into different parts, though there are no clear dividing lines within the tongue. Fig. 2 shows the tongue on a larger scale with these parts shown: tip, blade, front, back and root.

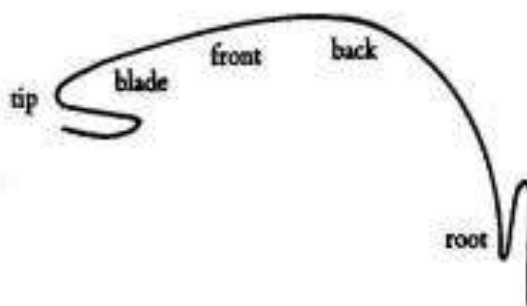


Figure (2): Sub-divisions of the tongue (6)

vii) The lips are important in speech. They can be pressed together (when the sounds p, b are produced), brought into contact with the teeth (as in f, v), or rounded to produce the lip-shape for vowels like u. Sounds in which the lips are in contact with each other are called bilabial, while those with lip-to-teeth contact are called labiodental. (6)

Mechanism of phonation

The larynx is naturally a part of respiratory system. It has to be wide open during inspiration for the very valuable, oxygen rich air, to rush into the trachea, bronchi then the air in their lumen and the gases in the blood brought to the walls of the air sacs (vesicles) the small blood vessels. Thus the functions of the larynx are respiration, protection and phonation (7).

Voice is a sound wave produced at its source in the glottis of the larynx by vibration of vocal folds, these vibrations occur as a response to an aerodynamic phenomenon, where the expiratory flow of air is interrupted by the beats of the mucosal lining of glottic wave of vocal folds.

The glottic wave is a movement of the mucous membrane covering the vocal folds. It is an undulating movement, in both the vertical and horizontal planes, excited by the high speed flow of expiratory air through the glottis (8)

During phonation there is approximation of 2 vocal folds in the midline closing the glottis. At the same time there is a purposive

expiratory effort against this closed glottis .when the 2 vocal folds are adducted, that is meeting in the middle line of the glottis, the outgoing air is facing resistance at this closed glottis leading to increase in the pressure under this glottis (sub –glottic pressure). The increase subglottic pressure will at certain point overcome the resistant of adducted vocal folds, forcing their edges slightly apart (9).

The air rushing with high pressure and at a good speed through this small gap between the vocal folds edges will create a negative pressure, a sucking force, on the parting edges bringing them back to the initial closed position, the closure of vocal folds is aided by the elastic recoil of deformed, everted tissues at the edge of vocal folds, when the vocal folds return to the closed position, the sub glottis pressure rises again and the cycle is repeated (9).

- A. Voiced sound: the vocal cords vibrations occur along most of the length of the glottis, and the frequency is determined by the tension in the vocal folds. All vowels and diphthongs together with some consonants like b, d, g, m, n, v, l, j, r produces voice sounds .(10)
- B. Unvoiced sound: is characterized by the absence of its phonation. The vocal folds remain separated and the glottis is held open at all times. The opening lets the airflow passes through without creating any vibrations, but still accelerates the air by being narrower than the trachea Unvoiced sounds include plosive and fricative consonants like p, t, f, s, h etc.
- C. Whisper: is created by keeping an opening between the arytenoids while the vocal folds are kept together. This changes the properties of voiced sounds, but leaves the unvoiced sounds unaffected
- D. Creaking: these are low frequency sounds, produced when the glottis is closed, but also has settings in the vocal folds that only allow a short fragment of them to vibrate.
- E. Falsetto: is similar to voiced sounds in which vibrations occur along the whole length of the vocal folds, but attains characteristically high frequencies by shaping the vocal folds so that they get a thin edge.
- F. Murmur - is combination of sounds without full closure of the glottis. (11)

During phonation, each cycle of vocal fold vibration is caused both by the sub glottal air pressure that built up to separate the folds (12).

Phonetics is the study of the production and perception of speech sounds. It is the study of the speech sounds that occur in all languages and gives the physical description of sounds in languages. Phonation refers to the function of the larynx and the different uses of vocal fold vibrations in speech production. It is a process by which molecules of air are set into vibration, through vibrating vocal cords (13).

Phonetics differs from language to another; Acoustic phonetics deals with the physical production and transmission of speech sound. auditory phonetics deals with the perception of speech sound, and articulatory phonetics deals with the production of speech sound(13)

Acoustic phonetics

Vowel production

The vocal tract in vowel production is generally open with little constriction. The vowels are relatively low frequency but with a high sound energy, intensity. The vowels have also a sound wave with more or less regular periodicity (10).

The outcome of the effect of the filter on the source is to increase the amplitude (intensity) of some overtones (partials) at certain frequency bands and reduce the intensity of some overtones at other frequency bands. The peaks of increased amplitude are called "formants".

The formants are very important in the making and the identification of the various vowels. The filters can be tuned in many different manners depending on the size, the shape, and the degree of tension in the walls of these resonators, namely pharynx, mouth and nose. This tuning shall give rise to multiple outcomes of resonations and formants (10).

The end result of the resonance effect of the supra-laryngeal filters on the laryngeal source is the modification of the latter's characteristics producing sets of speech sounds called vowels.

These vowels are recognized by their relative by positions of the amplitude peaks, formant 1(F1) and formant 2 (F2) on frequency spectrum. The value in the frequency of F1 and F2 which are specific for each vowel-depends on the variation in the position of the tongue in the mouth cavity, whether forward or backward.

The variations in tongue position may be also in the vertical level, being high or low in mouth cavity .Another very important factor is the degree and shape of lip rounding which also include the position of lower jaw. (10).It is important to notice that vowels may be produced singly or in a combination of usually two. These are diphthongs.

General acoustic features of vowels

In vowel production the vocal tract is generally open with little constriction. The vowels are relatively low frequency but with a high sound energy, intensity. The vowels have also a sound wave with more or less regular periodicity (10).

Constant production

As the expiratory air flows out in the vocal tract further modification may lead to the production of additional sounds that are Used in speech production .if the flow of this air is left free, there shall be no sound heard. Expiration is normally a silent process, But if the vocal tract is constricted at any site from the larynx below to the lips above, the expiratory air flow shall produce various types of sounds depending on the site and degree of constriction of the vocal tract. These sounds are the consonants an important element of speech sounds (10).

The constriction in the vocal tract that causes the flow of air to produce the consonant sounds is made possible by the approximation of 2 anatomical parts of the vocal tract ,The articulators. One articulator is fixed while the other moves toward it to cause the constriction /narrowing of vocal tract.

The sites of constriction/ narrowing are :

- Between the lips ; bilabial.
- between the lower lip and the upper teeth ;labio-dental.
- between the tip of the tongue and teeth of both jaws ; interdental.
- between the tip of tongue and the back of upper teeth ; epico-dental.
- between the tip of tongue and the back of upper gums ; epico-alveolar.
- Between the dorsum of tongue and the hard palate; dorso-palatal.
- Between the dorsum of tongue and the soft palate; dorso-velar.
- Between the back of tongue and uvula; dorso-uvular.
- Between the epiglottis and the back wall of the pharynx
epiglottopharyngeal.
- Between vocal folds-whether open or closed, glottal.
- Between the edges of the tongue blade and the inner aspects of the inner aspects of the lateral gums; lateral glides.

The type of narrowing at these sites is very important in deciding the consonant produced. The narrowing may be incomplete and continuous giving rise to a hissing relatively long sound due to the friction of the rushing air in the narrowed space under pressure .in this way *fricative* sounds are produced.(10)

The narrowing may on the other hand be complete and temporary causing the air rushing out to be held behind it accumulating energy that when the narrowing is released may cause a type of short explosion in this way the plosive sounds are produced. (10)

The consonant may be modified further by the contrasts of being voiced, that is the vocal fold vibrating while produced the consonant or unvoiced when the vocal folds are still.

Opening of Velo-pharyngeal valve if the opened the consonant shall be nasalized produced nasal consonants, when Velo-pharyngeal valve is closed as in most of speech sounds, the produced consonant is oral (10).

The consonant sounds may be classified to at least 6 points of contrast these are:

2. The passive articulator.
3. The type of narrowing friction or explosive (fricatives and plosive).
4. The presence or absence of vocal folds 'vibration voiced or unvoiced.
5. The status of the velo-pharyngeal valve-open or closed ,nasal or oral.
6. Source and type of air flow responsible for the production of all of the consonant.

When 2 consonant are joined an affricate is produce. Consonant can stand singly or in combination of consonants .this is referred as consonant cluster.

The consonant are in the physical acoustic terms, a 'noise' this means the sound waves of consonants are repeated in a haphazard way .this noise is usually a mixed one 'white noise'

The consonant are usually of higher frequency than vowels but have a lower acoustic energy. vowels are made of regularly repeated waves of varying shape like music (10).

The syllable, supra-segmental phonetics

The element units of speech sounds (segments) namely vowels and consonants, these units should be joined in a chain following an order ,specific for each language.

For example a consonant (C) and a vowel (V) . This is a CV syllable,

The syllables are further joined in a chain that varies in length, intensity and frequency variants this 'musical' aspect of the sound system of speech is highly specific for each language (10).

Variability in speech production

The Variation in speech production might be explained by several factors. These include between-speakers and intra-speakers variation (14).The between-speakers variation includes idiosyncratic and social-indexical differences as well as differences in vocal tract size as a result of age and sex differences. Therefore, two different speakers may articulate the same intended sound with different acoustic patterns and different sounds with the same acoustic patterns (15). On other hand Intra-speaker variation may result from contextual factors such as speaking rate and phonetic context. When vowels are contiguous to consonants in normal speech these vowels are affected by the properties of these consonants. This is known as coarticulation (16).

There are several factors produce speech variation within and cross speakers which are gender, age, dialect and social class in addition to phonetic context. (17).

There are many different between Arabic dialects and modern standard Arabic (MSA)

Classical Arabic (the language of the Qur'an), Modern Standard Arabic (also known as MSA, a simplified form of classical Arabic, used in formal media and international politics), Spoken Arabic dialects (what you use to talk to almost anyone, all the time)

Arabic dialects form two major groups: **Maghrebi (Western) Arabic** and **Mashriqi (Eastern) Arabic**. **Maghrebi Arabic** is spoken in Libya and other countries in North Africa (other than Egypt) Tunisia, Morocco and Algeria, Mauritania and Western Sahara.

Mashriqi Arabic is spoken everywhere else. It's also better broken up into smaller sub-groups:

- **Egyptian Arabic** (Egypt, Sudan).
- **Levantine Arabic** (Syria, Lebanon, Jordan, and Palestine)
- **Peninsular Gulf Arabic** (Iraq, Kuwait, Oman, and Saudi Arabia)
- **Peninsular Arabic** (West Saudi Arabia, including Mecca and Medina, plus a few other regional countries (18)

Phonological Variations among Arabic Dialects And Modern Standard Arabic (MSA):

Most of the phonemes in MSA are retained in Arabic dialects. However, there are some phonological features that can systematically differentiate between each of the Arabic dialect and MSA (19).

The major phonemic differences between MSA and other Arabic dialects (i.e., MSA /θ/, /ð/, /ðˤ/, /dˤ/, and /q/) are from low probability phonemes in spoken language. However, it should be noted that such tests might only be valid in the Middle East, as the Maghrebi dialect (Libya) found in north western African countries is very diverse and substantially different from other regional dialects (20)

The common phonologically variations between Arabic dialect and MSA include the following:

- 1) The MSA consonant /q/ is commonly preserved in Maghrebi dialects (Libya), and replaced with a glottal stop /ʔ/ in Egyptian dialects, For example, 'road' appears as /Tariq/ MSA and Maghrebi (Libya) dialects, /Tariʔ/ in (Egyptian dialects).
- 2) The MSA alveolar affricate /j/ is realized as /g/ in Egyptian (EGY), and /j/ in Meghrebi dialect (libya), For example, jamil/ (MSA, Maghrebi dialects (libya), and /gamil/ (EGY) dialects.
- 3) The MSA consonant /θ/ is pronounced as /t/ in Meghrebi dialect (Libya) and /t/ or /s/ in EGY dialect for example, 'three' is pronounced /θalaθa/ in MSA versus /talata/ in both Meghrabi (Libya) and(EGY) dialects or /s/ for another example ('revolution') is pronounced as /θawra/ in MSA versus /sawra/ in EGY dialect .
- 4) The MSA consonant/ð/ is pronounced as /d/ or /z/ in EGY and /d/ in Meghrebi (Libya) for example, 'this' is pronounced /haða/ in MSA versus /hada/ in Meghrebi dialect (Libya) and (EGY) dialect /d/ as /hada/ or /z/ for example 'broadcasting' is pronounced as /ʔiða:ʕa/ versus /ʔiza:ʕa/ in EGY dialect.
- 5) The MSA consonants /D/ (emphatic d) and /Dˤ/ (emphatic / ð /) are both normalized to /D/ in EGY and Meghrebi dialect (Libya) For example 'he continued to hit' is pronounced / Dˤalla yaDrubu / in MSA versus Dall yuDrub in EGY and Meghrebi dialect (Libya) , /Dˤ/ is pronounced /Z/ (emphatic z). For instance, 'police officer' is /DˤəbiT/ in MSA but /ZabiT/ in EGY.
- 6) The MSA emphatic phonemes /dˤ/ and /ðˤ/ are generally normalized to /dˤ/ in Egyptian and Meghrebi dialects, for example 'nail' is pronounced /ðˤufr/ in MSA versus /dˤufr/, Likewise 'bone'/ ʕaðˤm a/ in MSA versus ʕadˤm in EGY and Libya dialect .

(21)

Vowels

The three short vowels in MSA are generally preserved in Arabic dialects, except in Maghrebi dialects (libya) where the short vowels /a/ and /i/ are centralized to /ə/ For example, the MSA words /kita:b/ and /qalb/ are commonly pronounced as /kṭab/ and /qəlb/ in Meghrebi Arabic (Libya), respectively (20).

Classification of speech sound in Arabic dialects

Speech sounds may be classified under two major categories : vowels and consonants (21). The 28 consonants in MSA, 3 short vowels (/a/, /u/, /i/), 3 longer vowels (/aː/, /uː/, /iː/), and two diphthongs(/ai/, /au/).

1) Vowels

Figure 1: Arabic vocalic phonemic inventory. Vowels are represented in terms of *height* and *backness* of the position of the tongue. Phonemes in gray are non-MSA (dialectal).

	Front	Central	Back
High	i ī		u ū
Mid	e ē		o ō
Low		a ā	

2)Consonants Consonants may be identified according to the place , manner and voicing (21) .

Figure 2: Arabic consonantal phonemic inventory. Rows represent the different *manners of articulation*, while columns represent the different *places of articulation*. Pairs of phonemes are plain and emphatic variants. Phonemes in gray are non-MSA (dialectal).

		Labial	Labio-dental	Interdental	Dental	Alveolar	Palatal	Velar	Uvular	Pharyngeal	Glottal
Stop	voiceless				tT			k	q		'
	voiced	b			dD			g	Q		
Fricative	voiceless		f	θ	sS	ʃ		x		ħ	h
	voiced			ðD	zZ	ʒ		ɣ		ç	
Affricate	voiceless					tʃ					
	voiced					dʒ					
Glide		w					y				
Nasal		m				n					
Liquid					l	r					

Watson(2002)

Libyan dialect

Libyan dialect can be divided into two major dialect areas: the eastern centred in Benghazi and Bayda, and the western centred in Tripoli and Misrata. The Eastern variety extends beyond the borders to the east and share the same dialect with far Western Egypt.

Libyan Arabic consonant phonemes											
		Labial		Interdental		Dental/Alveolar		Palatal	Velar	Uvular	Pharyngeal
		plain	emphatic	plain	emphatic	Plain	emphatic				
<u>Nasal</u>		m	m ^ʕ			n					
<u>Stops</u>	<u>voiceless</u>					t	t ^ʕ		k	(q)	
	<u>voiced</u>	b				d	d ^ʕ		g		
<u>Fricative</u>	<u>voiceless</u>	f		θ		s	s ^ʕ	ʃ		ʒ	ħ
	<u>voiced</u>	(v)		ð	(ð ^ʕ)	z	z ^ʕ	ʒ		ʁ	ç
<u>Trill</u>						r	r ^ʕ				
<u>Approximant</u>						l	l ^ʕ	i	w		

In western dialects, the interdental fricatives /θ ð ð^ʕ/ have merged with the corresponding dental stops /t d d^ʕ/. Eastern dialects generally still distinguish the two sets, but there is a tendency to replace /d^ʕ/ with /ð^ʕ/. /ā/ is heard as [ɛ] in unstressed closed syllables. /a:/ is heard as [ɑ] before and after velar consonants and as [æ:] in free variation before non-velar consonants. /i/ phonetically occurs as a more central near-close sound [ɨ]. The e and o vowels exist only in long form with /e:/ replacing /ai/ and /o:/ replacing /au/

(21)

Libyan Arabic vowel phonemes			
	Front	Central	Back
<u>Close</u>	i:		u:
<u>Near-close</u>	ɪ		ʊ
<u>Mid</u>	e:		o:
<u>Open</u>	Ä	a:	

Egyptian dialect

Egyptian Arabic has a phonology that differ significantly from Libyan one ,and has its own inventory of consonants and vowels.

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