دراسة صوتية لتركيبة الصوامت في اللغة العربية الفصحى المعاصرة

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الملخص

تختلف اللغات حول العالم، كما ورد في دراسات سابقة، على تقسيم المقاطع الصوتية. فهناك لغات تسمح بالترتيب (ساكن– صوتي) بينما تسمح لغات أخرى بتنسيق آخر يتضمن أول المقطع وآخره. لقد تم تنظيم هذه المقاطع بتسلسل معين وفقاً لمبادئ متبعة عالمياً. ويتم التحكم بتنظيم هذه المقاطع الصوتية وفقاً لنظرية التسلسل الصوتي والتسلسل الهرمي المتبع في هذه النظرية الذي يرتب المقطع الصوتي من الأكثر قيمة تسلسلية إلى الأقل. وتكشف هذه الدراسة عن المدارك الحسية لمقياس قوة السمع من وجهة نظر نظرية التسلسل الصوتي. ويُستخدم مخطط الطيف الخاص بالأصوات للمساعدة على تسليط الضوء على أهمية الرابط بين هذه النظرية والصوت بحد ذاته في اللغة العربية الفصحى المعاصرة. من وجهة نظر صوتية، فإن الكثافة أو الشدة والموجات والرسوم البيانية الخاصة بالموجات تدعم هذه النظرية بشكل تام.

الكلمات المفتاحية: مقاطع صوتية، التسلسل الهرمي، نظرية التسلسل الصوتي، الكثافة

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An Acoustic Study of Consonant Combination in Modern Standard Arabic (MSA)

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Abstract

As discussed before by many linguists, languages of the world differ in their syllable phonotactics. Some languages only allow CV sequences; others allow more complex structures both in the margins and nuclei. Across languages, segments are organized into well-formed sequences according to universal principles of segment sequencing. The organization of segments within the syllable is assumed to be driven by the sonority principle, which is a property that works on ranking segments along a hierarchy from most sonorous to least sonorous. This study explores the perceptibility of MSA sonority profiling from the perspective of the Sonority Sequencing Principle (SSP). Sample spectrograms are also provided to help highlight the significance of the acoustic correlates in signifying the relative MSA sonority. Acoustically speaking, intensity and waveform charts support the SSP and sonority scaling.

Keywords: syllable phonotactics, hierarchy, MSA, Sonority Sequencing Principle (SSP), intensity.

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1- Introduction

Phonotactics studies the way a language structures its syllables and their distributional properties of phonemes. In this regard, [1] views phonotactics as "A term used in phonology to refer to the sequential arrangements of phonological units which occur in a language-what counts as phonologically well- formed word." Segments are organized into well-formed sequences according to universal principles of segment sequencing. The organization of segments within the syllable, and across syllables, is assumed to be driven by principles of sonority, a property that ranks segments along a hierarchy from most sonorous to least sonorous [2]. A consonant combination is defined as a group or sequence of consonants that appear together in a syllable without a vowel between them.

1-1 Modern Standard Arabic (MSA)

Arabic language belongs to the Semitic language family spoken by more than 200 million people around the world. It is the official language in all Arab countries as it is the language of the Holy Qur'an, and the official language for all Muslims to practice their religion. Modern Standard Arabic (MSA) is an adaptation from the Classical Arabic Language (CAL). MSA is utilized in mass media and official communications daily life such as in schools, academic institutions, trade, etc.

Modern Standard Arabic is the standard form of the Arabic contemporary era, and the written record of its modern culture [3]. Moreover, MSA is also regarded as an official language in the United Nations and the medium of instruction in most, if not all, Arab countries[4].

1-2 Consonant Cluster in MSA

Arabic language, like any other Semitic languages, is based on the concept of 'consonantal root system' [5]. Arabic words are derived

[1] CRYSTAL, D. 2003. **A Dictionary of Linguistics and Phonetics**. (5th ed.). Malden: Blackwell Publishing. p.352

[2] PRINCE, A. & SMOLENSKY, P. 2004. **Optimality Theory:** Constraint Interaction in Generative Grammar.

[3] AL SOSWAH, A. 2002. **Al'arabiyyah alfos'a almo'asira wa 'osooloha altorathiyyah**. Dar Ghareeb, Cairo.

[4] WATSON, J. C. ED. 2002. **The phonology and morphology of Arabic**. NY: Oxford University Press Inc.

[5] AWDE.N. & P SAMANO. 1986.The **Arabic Alphabet**. p.15

from a 'root' (usually a verb) usually comprising of three letters. By adding prefixes or suffixes to the root, the root gets alternation to create other new words [1]. Its vowels are indicated by diacritic marks to show whether the vowel sound is long or short one [2]. The consonant inventory is presented in Figure 1 below which is adapted from [3]. MSA syllable structure is similar to that of English in having a nucleus, onset, and an optional coda, but different in allowing no more than one consonant in the onset. Below is Table (1) that shows the possible consonant clusters in both English and Arabic Languages:

MSA	Bilabial	Labio-dentals	Dental	Alveolar	Post-alveolar	Palatal	Velar	Uvular	Pharyngeal	Glottal
Plosive	b			t t̲ d d̲			k	q		ʔ
Nasal	m			n						
Flap				r						
Fricative		f	θ ð ð̲	s s̲ z		ʃ		x ɣ	ħ ʕ	h
Affricate					dʒ					
Glides	w									
Liquid (lateral)				l						

/t̲/, /d̲/, /s̲/, and /ð̲/ represent emphatic sounds, and, according to the IPA guidelines, they can be also transcribed as / tˤ/, /dˤ/, /sˤ/ and / ðˤ/, respectively

Figure (1) Modern standard Arabic Consonant Inventory

Table (1) Consonant Cluster in MSA

	Initial	Medial	Final
English	C	C	C
	CC	CC	CC
	CCC	CCC	CCC
	-	CCCC	CCCC
Arabic	C	C	C
	-	CC	CC

As stated before by [4], MSA vowels and consonants can be classified as follows as shown in Tables (2 & 3) below:

[1] AWDE.N. & P SAMANO. 1986.(ibid)

[2] ROGERS, H. 2004**. A linguistic Approach**. International Journal of American Linguistics

[3] AMAYREH, M. 2003. **Completion of the consonant inventory of Arabic**. Journal of Speech, Language and Hearing Research 46, 517–529.

[4] ALI, H. 2009. **English and Arabic Sonorant's: A Contrastive Study**. Tikrit University Journal for Humanities.

Table (2) Modern Standard Arabic Vowels

		Front	Central	Back
High	Short	ɪ		u
	Long	i:		u:
low	Short		a	
	Long		a:	

Table (3) Modern Standard Arabic Consonants

Manner of Articulation	Bilabials	Labiodentals	Interdentals	Alveolars	Alveo-palatals	Velars	Uvulars	Pharyngeals	Glottals
Stops	L			t ṭ		k	q		?
	D	b		d					
Fricatives	L	f	θ	s ṣ	ś		x	ĥ	h
	D		ð	z			ġ	ç	
Affricates					J				
Nasals		m		n					
Laterals				l					
Trills				r					
Semivowels		w			y				

2- Sonority Sequencing Principle

Parker among linguists stated that clusters are restricted by a coherent phonetic system. This system is called the Sonority Sequencing Principle (SSP). The SSP theory requires each C in an initial consonant cluster to be higher in sonority than the preceding one and lower than the following one. Thus, the first C of an initial consonant cluster must be the lowest in sonority, and the final C is the highest in sonority. SSP requires a final cluster, which is called a coda cluster, to have the sonority decreasing, just the reverse of the initial cluster[1]

The consonants' sonority hierarchy is distributed by their manner of articulation as presented in Figure (2) below: [2]

[1] PARKER, St. 2002. **Qualifying the Sonority Hierarchy.** Ph.D. Dissertation. University of Massachusetts. Amherst

[2] CARLISLE, R. 2001. **Syllable structure universals and second language acquisition.** International Journal of English Studies 1, 1–19.

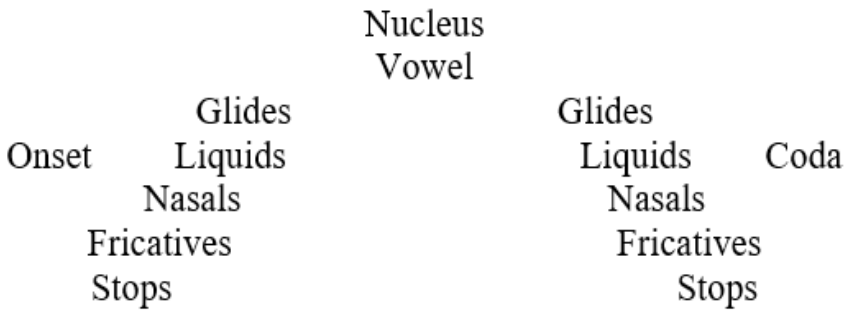

Figure (2) Consonants' Sonority Hierarchy

Analyzing the results of the present study based on the SSP theory would help to determine and examine how far the SSP theory applies to MSA consonant cluster. Moreover, referring to the SSP theory while analyzing the results can indicate how the MSA initial consonant cluster works due to the fixed scientific rules. Therefore, this study mainly relied on the SSP as the main theoretical framework of reference.

Complex onsets and codas are claimed to be governed by the Sonority Sequencing Principle (SSP), which suggests that sonority increases monotonically the closer one gets to the sonority peak (the nucleus), and decreases as one gets away from that peak[1].

Since sonority can be best defined in terms of intensity, in addition to airflow obstruction and voice as proposed by[2]and [3],preference in sonority research has been given to the sonority scales which are supported by intensity measurement, such as those put forward by [4], [5], [6] and [1]. Table (4) below shows the relative accuracy

[1] GOLDSMITH, J. 1990. **Auto segmental and metrical phonology**. Blackwell: Oxford.

[2] LADEFOGED, P. 1993. **A Course in Phonetics**. (3rd.ed.). New York: Harcourt Brace College Publishers.

[3] MORETON, E., FENG, G., & SMITH, J. 2008**. Syllabification, Sonority and Perception: New evidence from language game.** *Proceedings of CLS41* (1), 341–355.

[4]KIPARSKY, P. 2003. **Syllables and moras in Arabic. In C. Fery & R. de Vijver (eds), The syllable in optimality theory** (pp. 147-182). Germany: Cambridge University Press.

[5] HOGG, R. AND MCCULLY, C. 1987. **Metrical Phonology:** A Course Book. Cambridge. CUP. http://alllinguistic.com. Retrieved on 11/10/2015

[6] CLEMENTS, G.N. 1990. **" The Role of the Sonority Cycle in Core Syllabification"**. In Papers in Laboratory Phonology: between Grammar and

characterized by establishing sonority differences amongst different vowel classes (i.e. low, mid, high), and by breaking down obstruents into fricatives and stops, and these, in turn, into voiced and voiceless.

Table (4) Hogg and McCully's Sonority Scale (1987).

Sound	Sonority value	Sound	Sonority value	Sound	Sonority value
Low vowels	10	Flaps	7	Voiced fricative	4
Mid vowels	9	Laterals	6	Voiceless fricative	3
High vowels	8	Nasals	5	Voiced stops	2
				Voiceless stops	1

2-1 Sonority Hierarchy

According to [2] phonological sonority has concrete quantifiable physical correlates. By measuring five potential acoustic and aerodynamic correlates of sonority for English, which are, intensity, peak intraoral air pressure, first formant values, peak air flow, and total duration, [3] found that intensity is the most reliable acoustic correlate of sonority. It's also concluded by [4] that intensity is the most reliable correlate of phonological sonority while duration is the weakest correlate. This coincides with [5]'s definition of sonority which states that the sonority of a sound is its loudness relative to that of other sounds with the same length, stress, and pitch, which is based on intensity or the perceived loudness of a sound. Sonority hierarchy is a chart that states how sonorous certain classes of sounds are.

Obstruents have sonority ranking of (1), nasals of (2), liquids of (3), glides of (4), and vowels of (5). The sonority hierarchy looks like the following with the most sonorous sounds on the left:

Vowels > Glides > Liquids > Nasals > Fricatives > Affricates > Plosives

Glides include /j/ and /w/ as in '**y**ou' and '**w**ant'. Liquids include /l/ and /r/. Nasals include /m/ and /n/. Fricatives include /s/, /z/,

Physics of Speech", edited by John Kingston and Mary Beckman, pp. 283-333. Cambridge: CUP.

[1]PARKER, St. 2002. **Qualifying the Sonority Hierarchy.** Ph.D. Dissertation. University of Massachusetts. Amherst.

[2] ibid.

[3] ibid.

[4] ibid.

[5] LADEFOGED, P. 1993. **A Course in Phonetics**. (3rd.ed.). New York: Harcourt Brace College Publishers.

/f/ and /v/. Affricates include /tʃ/. Also voiced sounds are more sonorous than voiceless ones so, for example, the voiced fricative /z/ is more sonorous than its voiceless counterpart /s/. Below is a sample chart of the word snake /sneɪk/ that shows how sounds are ranked in the sonority hierarchy according to the Sonority Sequencing Principle (SSP).

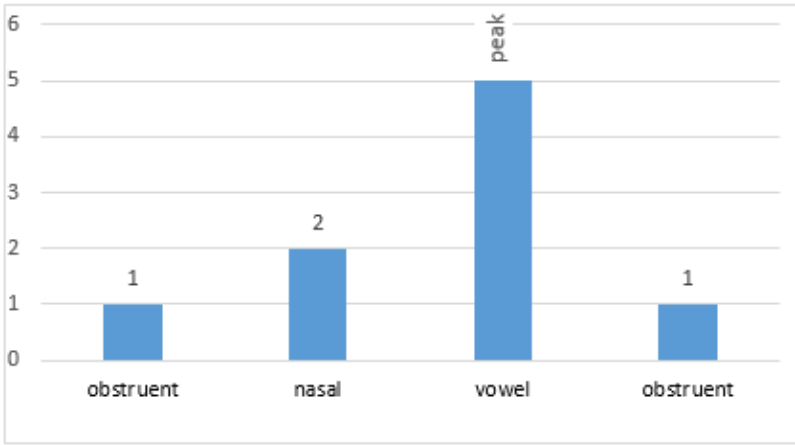

Figure (3) the sonority hierarchy of the word snake

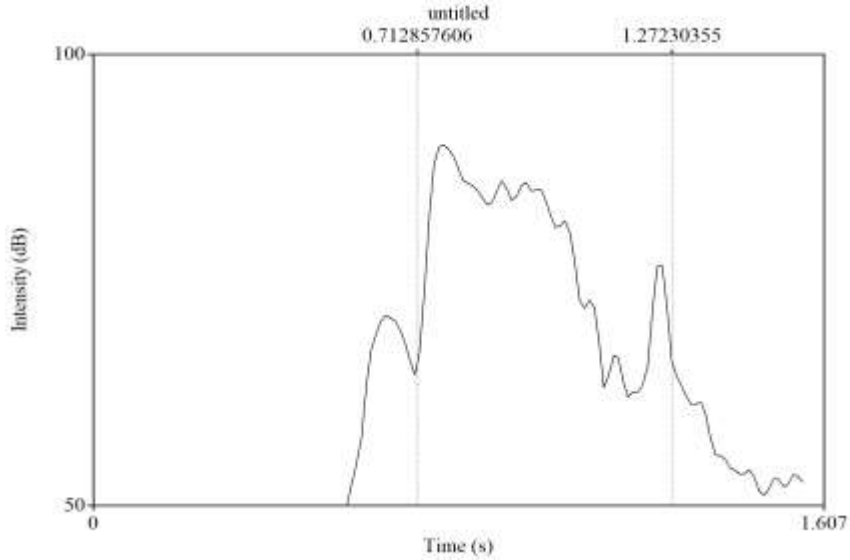

Figure (4). The intensity of the word snake as presented in PRAAT.

2-2 English and MSA Consonant Clusters

Standard English consonant clusters are two, three, or more consonants. Consonant clusters might occur at the beginning of a word

(initial position), or at the end of a word (final position). For example, in English: initial cluster/spl-/in/splɑ∫/ "splash"; final cluster /-st/ in /nest/. As stated by [1] English permits consonant clusters at the beginning and end of syllables . However, in MSA, consonant clusters can occur only at the end of syllables (final position). So, Arabic does not permit consonant clusters at the beginning of syllables.

stressed that initial consonant clusters in English can be made up of either two or three consonants[2] (as in "spring" and "steal") and final consonant clusters can be made up of either two, three, or four consonants as in "texts". MSA does not allow initial consonant clusters at all, only in the final position, but these clusters can be made up of two consonants. For example, /-lb/as in /qalb/ and /-bt /as in /sabt/**.** We can notice that the phonology of English permits consonant clusters up to three consonants to begin a syllable and up to four consonants to end a syllable. According to the SSP, any segment can occupy the syllable peak, but the ability of a given segment to function as a syllable peak is related to its rank on the sonority scale. Sonority "plateaus" happens when two adjacent consonants at the beginning or end of a word have the same sonority rank. Whereas, sonority "reversals" is when the sonority profile first rises, then drops again as we proceed from the edge of the word inward.

3- Statement of the Problem

Languages differ in their syllable division leading to have some problems in pronouncing some phonemes as in Standard English and MSA. This study will examine how these phonemes exist in each language in this study.

Every language has its own distribution of phonemes within the framework of syllables. The distribution of consonants in Standard English is either in the onset position or in the coda position or both. This study tries to shed light on the following points: 1) consonant phonotactics and the phonotactic constraints in MSA, 2) the most acoustic reliable correlate of the sonority sequencing principle.

4- Research Questions

This study aims at addressing the following questions:

[1] ROACH, P. 2004, **English Phonetics and Phonology** (7th ed), Cambridge: Cambridge University Press. pp,71-76

[2] BALASUBRAMANIAN, T. 2000. **A Textbook of English Phonetics for Indian Students,** Delhi: Replika Press PVT Ltd. p, 117

1. What is the acoustic correlate of sonority of consonant combination?
2. Do phonotactic rules affect the consonant combination in MSA?

5- Methodology

This study will investigate the phonotactic rules of consonant cluster or constraints in Modern Standard Arabic (MSA) in terms of phonology; in other words, how these rules behave phonologically. The intensity of a sound wave is measured in decibels (dB) and represents the power and loudness of the wave. Intensity is correlated with the amplitude of the wave, or how high above (compression) or below (rarefaction) the baseline the wave reaches in each cycle. Intensity in The Oxford Dictionary of English Grammar is defined as the amount of energy used in the production of a speech sound. Many MSA speakers often use the pausal form even in connected speech in order to avoid some inflectional complexities. Moreover, it is only in this form that one can identify the CC clusters of the CVCC syllable.

5-1 Procedure

After discussing the consonant combination in MSA, several words will be measured depending on intensity using PRAAT. Thus, the typical work flow is to collect data, transcribe, extract measurements via PRAAT[1]. The acoustic correlates of the sonority, which is intensity, of consonant combination in MSA will be examined , since it is the most reliable acoustic predictor of sonority.[2]

5-2 Measurements and Results

According to [3] the sonority of a sound is its loudness relative to that of other sounds with the same length, stress and pitch. As mentioned before, the SSP requires onsets to rise in sonority towards the nucleus and codas to fall from the nucleus[4]. According to the sonority hierarchy, in onsets, the consonant at the first position must be less sonorous than the other one in the second position. The more we move toward the vowel, the higher the sonority value will be. The Sonority Sequencing Principle requires that syllable onsets increase in sonority and codas decrease in sonority, and the sonority peak is

[1] BOERSMA & WEENINK,2021, version 6.1.38

[2] PARKER, ST. 2002. **Qualifying the Sonority Hierarchy**. Ph.D. Dissertation. University of Massachusetts. Amherst

[3] LADEFOGED, P. 1993. **A Course in Phonetics.** (3rd.ed.). New York: Harcourt Brace College

[4] KENSTOWICZ, M. 1994. **Sonority-Driven Stress**. Ms., MIT

supposed to be in the syllable nucleus. Below is the waveform and intensity measurement in dB of some tokens to show if they follow the SSP or not, as displayed in Figures (2), (3) and (4) below:

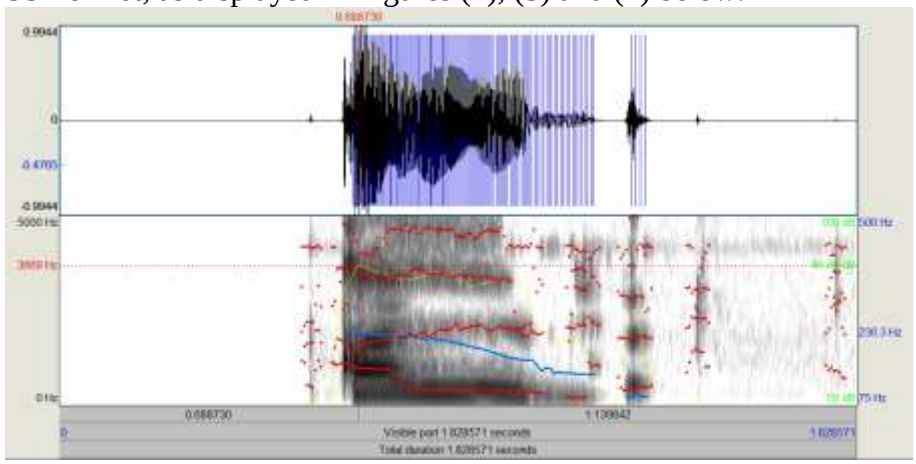

Figure (5) waveform of the word qalb */qalb/*

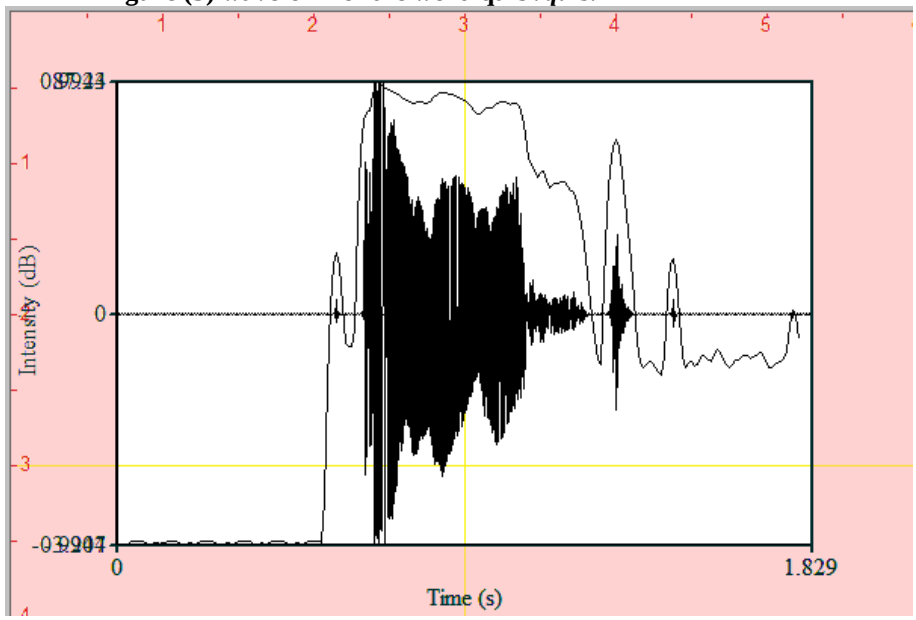

Figure (6) Intensity of the word qalb/qalb/

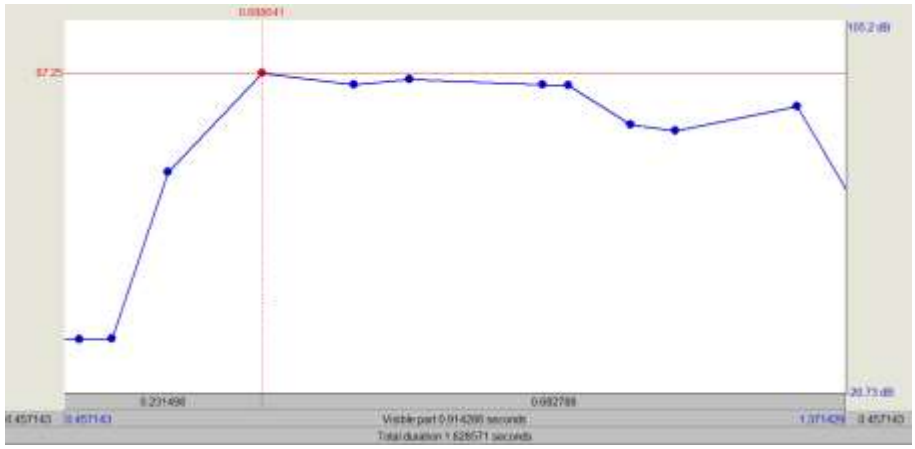

Figure (7) Intensity of the word qalb /qalb/ as in PRAAT

6- Discussion

As stated by [1] acoustic intensity is the appropriate measure corresponding to loudness. This intensity is proportional to the amplitude of the variations in air pressure. According to the intensity scale, vowels have the highest intensity. The lateral and nasals have slightly less intensity than vowels, voiced fricatives have very little intensity. Voiceless plosives show no intensity during closure[2]. Compared with English, MSA has very few permissible syllable structures because it is claimed that Arabic syllables cannot begin with a vowel. In the representation of the word /qalb/, the *fat-ha* is considered as a vowel when produced so we can notice that the sonority value rises at that point.

7- conclusion

As mentioned before, sonority is a scalar phonological feature which classifies all speech sounds into an autonomous hierarchy. The best correlate of sonority is intensity. Intensity (loudness) increases gradually on the onset, reaching it maximum value on the peak. Then, it drops down on the coda. Loudness increases as we move downward to the open position, and gradually decreases as we move upward to the close position. By applying this to the previous tokens in this study, we can find that they follow the sonority sequencing principle with its best acoustic correlate which is intensity. Since MSA does not allow

[1] LADEFOGED, P. 1993. **A Course in Phonetics**. (3rd.ed.). New York: Harcourt Brace College.

[2] PARKER, St. 2002. **Qualifying the Sonority Hierarchy.** Ph.D. Dissertation. University of Massachusetts. Amherst.

initial consonant cluster, we can say that the syllable structures of MSA allow coda position consonant cluster and as a result more sonority value in coda position than in initial.

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19. **Manğhijul Bahth al-Luġawiy**. Cairo: Maktabatulxanji.
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