FORMANT TUNING IN CRETAN RIZITIKO SINGING

S. Kalozakis[1], A. Georgaki[2] , G. Kouroupetroglou[3]

[1] National and Kapodistrian University of Athens/Music Department, Panepistimioupolis-Zografou, 157 84, Athens, Greece
Hellenic Mediterranean University/Department of Music Technology and Acoustics, 74133, Rethymnon, Greece

[2] National and Kapodistrian University of Athens/Music Department, Panepistimioupolis-Zografou, 157 84, Athens, Greece

[3] National and Kapodistrian University of Athens/Department of Informatics and Telecommunications, Panepistimioupolis- Ilisia, 157 84, Athens, Greece

Email addresses: kalozakis@hmu.gr[1], georgaki@music.uoa.gr[2], koupe@di.uoa.gr [3]

Abstract: **Recent research into different folk vocal styles has been conducted by examining the acoustic parameters of the singing voice [1] [2] [3] [4]. On the Greek island of Crete, the acoustical parameters of a song are "strongly" depended upon the origin of the singer, due to the peculiar pronunciation which each Cretan region adopts. The most known non-dance folk songs in Crete are "Rizitika" songs. (plural of "Rizitiko" song). Although Rizitiko has a distant chronological root (root in Greek means Riza which is etymologically related to Rizitiko) is a living culture, a dynamic legacy and heritage that is spread all over Crete and mainly at the western and central regions of the island.**

In this paper, we research thoroughly and present the formant characteristics of the Cretan Rizitiko singing style sung by sixteen (16) men. Specifically, we demonstrate (via illustrative panel) the formant tuning of two (2) singers whose origin belongs to different Cretan region. Also, we compare the vocal acoustical differences of formant frequencies between all participating singers for one singing diphone ("ki") and for one singing vowel ("a")

Keywords: **Rizitiko, Formant Tuning, Formant Frequency**

I. INTRODUCTION

Folk music is synonymous with traditional music. The island of Crete is a geographical part of Greece that still supports and embellishes its traditional identity [5]. Tradition, from the Latin verb tradire (to deliver) can be delivered (among other elements) through song, music and dance. These three are "strong" elements of the Cretan tradition [6]. The traditional music of a region can often be divided into dance and non- dance music. The most known non-dance folk songs in Crete are Rizitika (solemn slow songs, possibly of Byzantine origin) [7]. Rizitika songs are strong and a dynamic symbol of Cretan identity. There is a significant difference in pronunciation between the Prefectures of Crete, as each Cretan region adopts a characteristic pronunciation. This characteristic pronunciation becomes more noticeable with the use of velar consonants (such as k/x/g) which is followed by anterior vowel (i/e/ou) [8]. Particularly, the case of Diphones (consonant with a following vowel) meets the most characteristic element of the Cretan pronunciation that is not eliminated [9]. The question that arises is whether this characteristic pronunciation has an impact on the singer's voice. By this we mean, how this feature (pronunciation) is captured and imprinted during the performance of the modern Cretan singing voice, the existence (or not) of Formant Tuning along with the classification and distribution of formant frequencies by region under consideration.

II. METHODS

Sixteen (16) singers were recorded from four different regions. Specifically, these were three (3) Cretan regions Chania (or as pronounced Xania) Rethymnon and Heraklion. In these Cretan Counties the Rizitiko is found especially in the province of Xania [10]. The fourth region was Athens which is non-Cretan. The reason of recording two non-Cretan singers was to find how their singing (the acoustical and musical parameters) differentiates compared to Cretan singers and what is the "role" of the origin and how it functions to the "interpretation" of Rizitiko.
From Xania four (4) singers recorded as well as from the region of Heraklion. From Rethymnon six (6) singers recorded and from Athens two (2). All studio recordings were made in the same acoustic environment, in order

FUP Best Practice in Scholarly Publishing (DOI 10.36253/fup_best_practice)
Claudia Manfredi (edited by), *Models and Analysis of Vocal Emissions for Biomedical Applications : 12th International Workshop, December, 14-16, 2021*,
 published by Firenze University Press (www.fupress.com), ISSN 2704-5846 (online), ISBN 978-88-5518-449-6 (PDF), DOI 10.36253/978-88-5518-449-6

to achieve the correct comparison of the acoustic measurements that would follow. The equipment used was state of the art and it was identical to all recordings.

The equipment consisted of a condenser microphone with omnidirectional polar pattern (Earthworks Audio M30) with direct response across the frequency spectrum, keeping the same "working distance" (the distance between the singer and the microphone) which was thirteen centimeters (13 cm) for each session.
The microphone was connected to the low-noise preamplifier (Avalon M5 Pure Class A). Similar to previous studies [11] electrodes were placed to all singers during recordings. These were placed externally on the neck of the singers at the height of the thyroid cartilage to detect impedance changes of the vocal cords and were connected to the Electroglottograph Console (Kay Pentax Model 6103). The signal of the electroglottography (EGG) was stored as a "mono" signal to the digital recorder (Tascam X-48MKII hard-disk recorder). The digital recorder (using 44.1Khz sampling rate/16-bit resolution) was in connection with the mixing console (Audient ASP 8024) in order to have during playback the two signals (microphone and electroglottography). All recordings accomplished at the Studio of the Department of Music Technology and Acoustics, Rethymnon- Crete.

The whole recording process was identical for all participating singers. All singers were exclusively male. This was due to the fact that Rizitika songs always performed by male voices, in contrast to other vocal styles dominated by female voices [12]. The method included the following procedure:

Firstly, all singers (after they understood the procedure that would follow) filled in a questionnaire regarding their origin, where they grew up, age, musical studies, years of experience as performers and their discography, if they are smokers etc. After filling the questionnaire:

- It was found with the use of piano the singer's voice extend (registro) in order to be categorized the voice of all singers (tenor)
- Note selection of the Rizitiko by the singers
- All singers performed the same Rizitiko song "Se Psilo Vouno"
- The singers performed a major scale for all Greek vowels (a/e/i/o/ou) for both ascending and descending form (musical scale)
- After completing the recordings, the pre-selected Cretan characteristic singing diphones, all performed vowels, as well as the recitation of the lyrics of the performed Rizitiko song, isolated

in order to proceed data mining (using Praat software program).

Praat software program developed by Paul Boersma and David Weenick from the Institute of Phonetic Sciences of the University of Amsterdam.
Most of our measurements used in our analysis were acquired using the PRAAT software, as it is a valuable and flexible software tool in the field of phonetics and voice analysis [13]. This program can handle large audio files and extract measurements of the vocal parameters using its built- in function.

Mostly intensity, pitch and formant analysis were used in our measurements, as mentioned. More specifically, for the functions of pitch and formant analysis, PRAAT uses an algorithm that performs an acoustic periodicity detection trough a precise autocorrelation method and also, it can capture a value every 6.25 millisecond, giving the average value for the formant frequency we aim to find, respectively.

III. RESULTS

Formant frequencies initially differ depending on age and gender, as the anatomical features of the vocal tract (length) depend on the above two factors. That is why all singers had the same gender (male) and similar age range (32 to 43 years old).

Each of the preferred resonating frequencies of the vocal tract is known as a formant. In the vocal tract the five (5) lowest formant frequencies (usually referred to as F1 for the first, F2 for the second etc.) play a role in shaping the spectrum of the voice and the timbre of the voice (sound color).

Formant frequencies differ from the vowel that is pronounced each time, since the position and the shape of the tongue, the lips, the soft palate, the jaw, is on the substance, the articulatory movements of the face. The formant frequencies depend on the articulatory movements.

The position of the articulators affects only the first two formants (henceforth F1, F2) so the quality or recognizability of the vowel depends on the first two formants [14]. F1 is more susceptible to the changes of the jaw [14] [15]. Specifically, as long as the jaw opens, it increases the frequency of the first Formant and vice versa. F2 is more susceptible to the changes of the tongue [14]. When the tongue compresses the upper part of the vocal tract, it occurs a frequency increment of the second formant, or if we simplify it, F2 is mostly determined by the frontness/backness of the tongue body.

"Fig. 1, 2" show the average value of F1 and F2 for the vowel "A" and the diphone "KI" respectively. It appears

that singers whose origin is from Rethymnon, compared to other regions, use a smaller opened jaw position resulting to a low F1 value (below 500 hz at the diphone and well below 600 hz at the examined vowel). It can be easily ascertained that Rethymnon singers, have the lower F1 value for both vowel and diphone. Singers from Athens have obviously significantly higher F1 value for the vowel "A" something that is interpreted in a larger jaw opening compared to all Cretan singers. Vowel "A" is an "open" vowel and emphatically characterizes the opening of the jaw.

At "Fig. 1, 2" we can see as well that singers from Heraklion, Chania (or Xania) and Athens show interesting similarity to F1 value at diphone "KI". Comparing Cretan regions only, we see that Heraklion provided a higher F2 value at vowel "A" whilst, Chania at diphone "KI". The latter, is due to the fact perhaps that at the region of Chania this characteristic diphone [8] [9] ("ki") pronounced more "strongly" and has greater intensity.

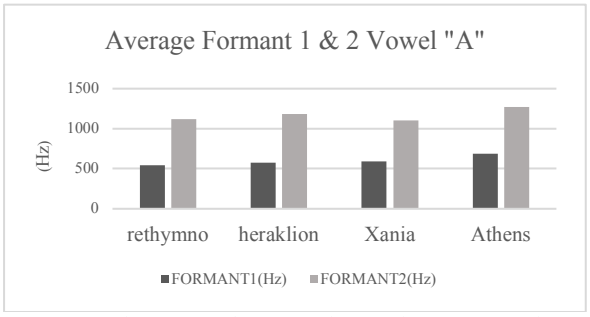

Fig. 1 Vowel "A". On the vertical axis: the average values of F1, F2 sorted by region with intense and pale color respectively. On the horizontal axis: the frequencies (hz)

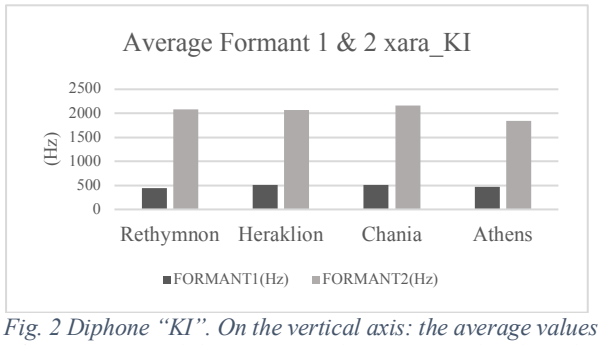

Fig. 2 Diphone "KI". On the vertical axis: the average values of F1, F2 sorted by region with intense and pale color respectively. On the horizontal axis: the frequencies (hz)

Having mined the values of the first two formants for all singers, our main objective was to investigate whether Rizitiko singers apply formant tuning. Formant tuning suggests that a singer increases Sound Pressure Level (SPL) without expense of vocal effort by adjusting his lower formant frequencies to coincide with partials (harmonic frequencies) in order to gain SPL. By doing this, a singer exposes his voice and can be heard with less vocal effort in large auditoria [15] [16] [17]. In many cases, singers can adjust the articulation of the vocal tract (formant tuning) in order to enhance and gain acoustic output [17]. Sometimes, singers tune their two lowest formant frequencies (F1, F2) to coincide harmonic partials in order to increase the audibility of the voice [18].

Earlier literature in formant tuning, considered that in order to be occurred formant tuning F1 and F2 must be tuned to a partial, either F1 is tuned to the fundamental frequency (f0) or F1 is tuned to the vicinity of a partial. In the latter, previous studies considered that vicinity between F1 or F2 is either over a semitone (100 cents) of a partial, or under (below) a semitone of a partial. [19] [13].

In the present study we consider formant tuning occurs if the F1 and F2 has maximum one semitone distance (above or below) a partial, or F1/F2 is tuned exactly at a partial. "Fig. 3, 4" represent a typical formant tuning phenomenon for two Cretan singers (from Rethymnon and Chania respectively) performing a major scale (ascending/descending form) singing vowel "A".

Rethymno singer at "Fig. 3" produces formant tuning since F1 (lower curve) is in most cases aligned with the third harmonic (H3). More specifically, at dominant, submediant and supertonic F1 is tuned exactly on H3. F2 (upper curve) formant tuning extends from H4 to H8.

F1 (lower curve) of the singer from Chania at "Fig. 4" is in almost complete alignment with the partials (harmonics). In fact, his F1 "follows" the performing note along the third harmonic (H3). At his F2 (upper curve) we observe evidence of formant tuning as well.

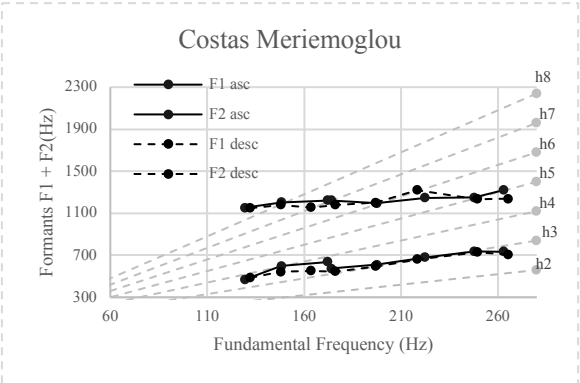

Fig. 3 Singer from Rethymno performing a major scale singing vowel "A". The continuous and dashed lines represent the ascending and descending form respectively. The oblique dashed lines are the partials (harmonics). Lower and Upper curve represent F1 and F2 respectively.

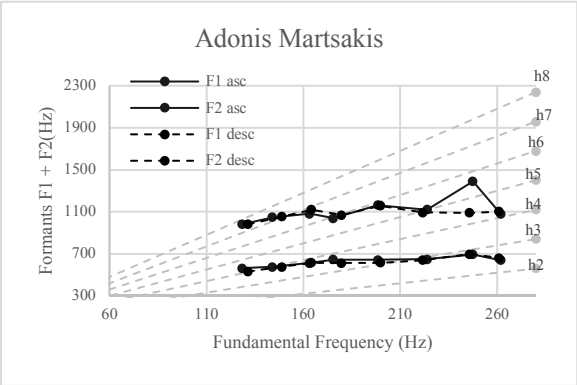

Fig. 4 Singer from Chania performing a major scale singing vowel "A". The continuous and dashed lines represent the ascending and descending form respectively. The oblique dashed lines are the partials (harmonics). Lower and Upper curve represent F1 and F2 respectively

IV. Discussion

In order to find evidences of formant tuning in modern Cretan singing and the classification and distribution of formant frequencies by Cretan region under consideration, we presented primarily our formant analysis and the results of our measurements. Despite the fact that this technique (formant tuning) more frequently appears among opera singers, none of the recorded Rizitiko singer has undergone operatic training. More vowels and diphones will be analyzed soon, to draw "solid" conclusions.

V. Conclusion

Our main goal was to find evidences of formant tuning in Cretan Rizitiko singing. The results revealed that formant tuning occurs in the modern Cretan singing voice, as in other non-operatic vocal styles [13] [20] [21]. All participating fourteen (14) Cretan singers, performed at vowel "A" the ascending/descending scale, with strong elements of formant tuning. In many cases of Cretan singers, F1 was tuned to H4, H3 and even at H2. At these harmonics, formant tuning becomes more noticeable as an increase of SPL is observed. Moreover, it has become clear from our measurements so far, that Rethymno singers use a smaller opened jaw position. The latter is reinforced by the fact, that Vowel "A" is an "open" vowel and emphatically characterizes the opening of the jaw.

REFERENCES

[1] [12] Nathalie Henrich, Mara Kiek, John Smith, Joe Wolfe. Resonance strategies used in Bulgarian women's singing style: a pilot study.
[2] H. Domitrovic. P. Boersma, C. Kovacic "Long – Term average spectra in professional folk music voices: a comparison of the KLAPA and DOZIVACKI styles." Institute of Phonetic Sciences, Proceedings 25 pp.53-64, 2003
[3] Ana P. Mendes, Aira F. Rodrigeus, and David M. Guerreiro. "Acoustic and Phonatory Characterization of the Fado Voice". Journal of Voice, Vol. 27, pp.655.e9-655e15, 2012
[4] J.J. Cabrera, J.M. Diaz-Banez, F.J. Escobar-Borrego, E. Gomez, F. Gomes, J. Mora. "Comparative Melodic Analysis of A Cappella Flamengo Cantes", Thessaloniki,Greece, Proceedings on Interdisciplinary Musicology, 2008
[5] [6] Hnaraki. M. "Cretan Music-Unravelling Ariadne's Thread", Athens, Kerkyra Publications, pp111-151, 2007
[7] D. Conklin, Chr. Anagnostopoulou "Comparative Pattern Analysis of Cretan Folk Songs" Journal of New Music Research, 40:2, 119-125, 2011
[8] [9] Ioanna Kappa "Phonological Features of the Cretan Dialect", University of Crete press, pp 53, 2014
[10] Hnaraki. M. "Cretan Music-Unravelling Ariadne's Thread", Athens, Kerkyra Publications, pp 97, 2007
[11] G. Kouroupetroglou, D. Delviniotis, G. Chrisoxoidis. "Standard Tagged Collection of Chanting Voices". Athens, Proceedings of International Musicological and Chanting Conference, 2006
[13] G. Chrisoxoidis, G. Kouroupetroglou."Formant Frequency Tuning in Professional Byzantine Chanters". Recent Advances in Electrical and Computer Engineering, 2014
[14] Sundberg Johan, "The Science of the singing Voice", University Press, Northern Illinois, 1987
[15] Joliveau. E, Smith. J, Wolfe. J "Vocal Tract Resonances in Singing: The Soprano Voice", Acoustical Society of America, 2004
[16] Summerfield. Q, Foster. J, Tyler. R "Influences of Formant Bandwidth and Auditory Frequency Selectivity on Identification of Place of Articulation in Stop Consonants", University of York, UK, 1984
[17] H. K. Shutte, D. G. Miller and J. G. Svec. "Measurements of Formant Frequencies and Bandwidths in Singing". Philadelphia, Journal of Voice, Vol. 9. No. 3. pp. 290-296, 1995
[18] G. Carlsson and J Sundberg. "Formant Frequency Tuning in Singing". New York, Journal of Voice, Vol 6. Pp. 256-260, 1992
[19] J. Sundberg, F. M. B. La and B. P. Gill." Formant Tuning Strategies in Professional Male Opera Singers". KTH Stockholm, Journal of Voice, Vol. 27. pp. 278-288, 2013
[20] H. Smith, K. Stevens, R. Tomlinson. "On an Unusual Mode of Chanting by Certain Tibetan Lamas". Journal of Acoustic Society of America, 41:1262-1264,1967
[21] J. Sundberg. "Vocal Tract Resonance in Singing ". New York: Raven Press, The NATS Journal, 1967.