Fourier Analyses of Certain Mystical Vowel Sound Intonations Using PRAAT Software

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Abstract

This unique study investigates the frequency spectrum of certain Rosicrucian vowel chants using PRAAT (Boersma 2001, 341-345) software and analysis. Certain Rosicrucian vowel sound intonations, which are shared by other traditions, were pre-recorded in a recording studio and analyzed. Given that many physiological, emotional, and psychic effects are experienced by both the intoner and the listener when these vowel sounds are produced, the frequency characteristics of such sounds may lead to correlations that reveal the cause of their health-producing effects. Studies of intensity vs. time and spectral characteristics related to the pitch and formant of the sound were also considered. It is anticipated that the results will provide a deeper understanding of the relationships between frequencies and their possible "resonant" effects on tissues.

Analyse harmonique de la série de Fourier de certaines intonations de son de voyelle mystique à l'aide du logiciel PRAAT

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Sommaire

Cette étude unique étudie le spectre de fréquence de certains chants de voyelles rosicruciens en utilisant le logiciel PRAAT (Boersma 2001, 341-345) et l'analyse. Certaines intonations de voyelles Rosicruciennes partagées par d'autres traditions ont été préenregistrées dans un studio d'enregistrement et analysées. Étant donné que de nombreux effets physiologiques, émotionnels et psychiques sont ressentis par le chanteur et l'auditeur lorsque ces sons vocaliques sont produits, les caractéristiques de fréquence de ces sons peuvent conduire à des corrélations qui révèlent la cause de leurs effets bénéfiques sur la santé. Des études de l'intensité en fonction du temps et des caractéristiques spectrales liées à la hauteur et au formant du son ont également considérées. On s'attend à ce que les résultats fournissent une compréhension plus profonde des relations entre les fréquences et de leurs possibles effets « résonnants » sur les tissus.

Análisis Fourier de la entonación de ciertos sonidos vocales místicos utilizando el sistema PRAAT

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Resumen

Este estudio único investiga el espectro de frecuencia de la entonación de ciertos sonidos vocales utilizando el sistema y análisis PRAAT (Boersma 2001, 331,345). Ciertas entonaciones de sonidos vocales rosacruces los cuales son compartidos por otras tradiciones, fueron grabados y analizados en un estudio de grabación. Debido a que muchos efectos fisiológicos, emocionales y psíquicos son experimentados por ambos, el entonador y el oyente durante la producción de estos sonidos vocales, las características de frecuencia de estos sonidos pueden llevarnos a una correlación que revela la causa de los efectos de salud que se producen. Estudios de intensidad en contra de tiempo y características del espectro relacionado con el tono y formato del sonido fueron también considerados. Se anticipa que los resultados proveerán una más profunda comprensión de la relación entre frecuencias y los posibles efectos de "resonancia" en los tejidos.

Análises de Fourier de Certas Entonações Sonoras de Vogais Místicas Usando o Software PRAAT

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Sumário

Este estudo sem igual investiga o espectro da frequência de certos Cantos Vocálicos Rosacruzes usando o software e análise PRAAT (Boersma 2001, 341-345). Certas entonações vocálicas Rosacruzes, que são também compartilhadas por outras tradições, foram analisadas e pré-gravadas em um estúdio de gravação. Sendo que muitos efeitos fisiológicos, emocionais e psíquicos são experimentados pelo entoador e pelo ouvinte quando esses sons vocálicos são produzidos, as características da frequência desses sons podem levar a correlações que revelam a causa de seus efeitos produtores de saúde. Estudos de intensidade vs. tempo e características espectrais relacionadas ao pitch e formante do som também foram considerados. Prevê-se que os resultados forneçam uma compreensão mais profunda das relações entre frequências e seus possíveis efeitos "ressonantes" nos tecidos humanos.

Fouriers Analyse hinsichtlich bestimmter Mystischen Vokalintonationen mit Hilfe der PRAAT Software

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Zusammenfassung

Diese einzigartige Studie befasst sich mit dem Frequenzspektrum bestimmter Rosenkreuzer Vokalgesänge, wobei PRAAT (Boersma 2001, 341-345) Software und Analysen verwendet wurden. Bestimmte Rosenkreuzer Vokalintonationen, die auch bei anderen Traditionen praktiziert werden, wurden vorab in einem Tonstudio aufgenommen und analysiert. Wenn man bedenkt, dass sowohl der Sänger als auch der Zuhörer während der Vokalintonation viele physiologische, emotionale und psychische Auswirkungen erleben, könnten die Frequenzeigenschaften dieser Töne dazu führen, die Zusammenhänge zu enthüllen, die Heilung bewirken. Hierzu wurden auch Untersuchungen der Intensität vs. Zeit und spektrale Eigenschaften in Bezug auf die Tonlage und den Formant des Klanges in Betracht genommen. Voraussichtlich werden die Resultate dazu beitragen, die Beziehungen zwischen Frequenzen und ihre möglichen resonante Wirkung auf das physische Gewebe besser zu verstehen.

Purpose

The purpose of this study is to analyze the frequency characteristics of certain Rosicrucian vowel intonations and then examine similarities and differences to elucidate possible reasons for their alleged therapeutic efficacy. This analysis will be the foundation for subsequent studies that investigate whether these frequencies can induce resonances in the various endocrine glands (i.e., the pineal gland, the thyroid gland, etc.). This will inform the scientific community whether such frequencies can be used to stimulate various glands to boost their hormonal production and bioelectric fields for health producing effects. An additional objective is to investigate whether, why, and how these intonations can activate the body's bioelectric field and induce higher states of consciousness and mystical experiences. This paper outlines the data gathering and analysis for the Rosicrucian vowel intonations. The research will be extended to other Rosicrucian intonations as well as to intonations and chants from other traditions.

Definition of Terms

Formant: The original definition describes a formant as the spectral peaks in a sound spectrum. Formant also refers to the resonance frequencies of a vocal tract in terms of its gain function. There is a third definition as a mathematical filter. "So, to some voice researchers, the formant refers to a peak in the spectrum (a property of the sound of the voice), to others it refers to a resonance of the vocal tract (a physical property of the tract), while to a third group it refers to the pole in a mathematical filter model (a property of a model)." (Wolfe, 1997) In the science of phonetics, one vowel can be disambiguated from others by the frequency pattern of its formants, particularly the first and second lowest formant frequencies (F1 and F2). (University of Southern California, Signal Analysis and Interpretation Laboratory, 2001)

Fourier Analysis: "The analysis of a complex waveform expressed as a series of sinusoidal functions, the frequencies of which form a harmonic series." (Weisstein 2018)

Fast Fourier Transform (FFT): A fast Fourier Transform is a computational algorithm that samples a signal over a time interval to determine the signal's frequency components.

A visual example of formants is shown below. Fig. 1 displays the intensity-vs.-time signals and the frequency spectra of the vowels "a, e, i, o, u" generated by a speech synthesizer in the PRAAT program. The top portion is a time-domain (intensity-vs.-time) graph of the generated vowel sounds, and the lower portion is a frequency domain (frequency-vs.-time) graph in which the red dot lines indicate the formants. A formant can be thought of as a harmonic of a note that is augmented by a resonance. (Jeans 1938) A formant can also be thought of absolute or relative maximum in a sound spectrum. (Standards Secretariat 1994) The identification of a formant value can thus be thought of as a time slice of the frequency spectrum of a sound. That value at a certain time is represented as a red dot on the frequency-vs.-time scale in the bottom part of Fig. 1. The grey area in the bottom of Fig. 1 is the spectrogram of the sound. With the y-axis representing the frequency in Hertz (Hz), the formants, ranging from lowest to highest frequencies, are referred to as F1, F2, F3, and F4. Usually F1 and F2 by themselves are enough to disambiguate vowels from each other. Note how the F1 and F2 (lowest two red dot lines) differ for each vowel.

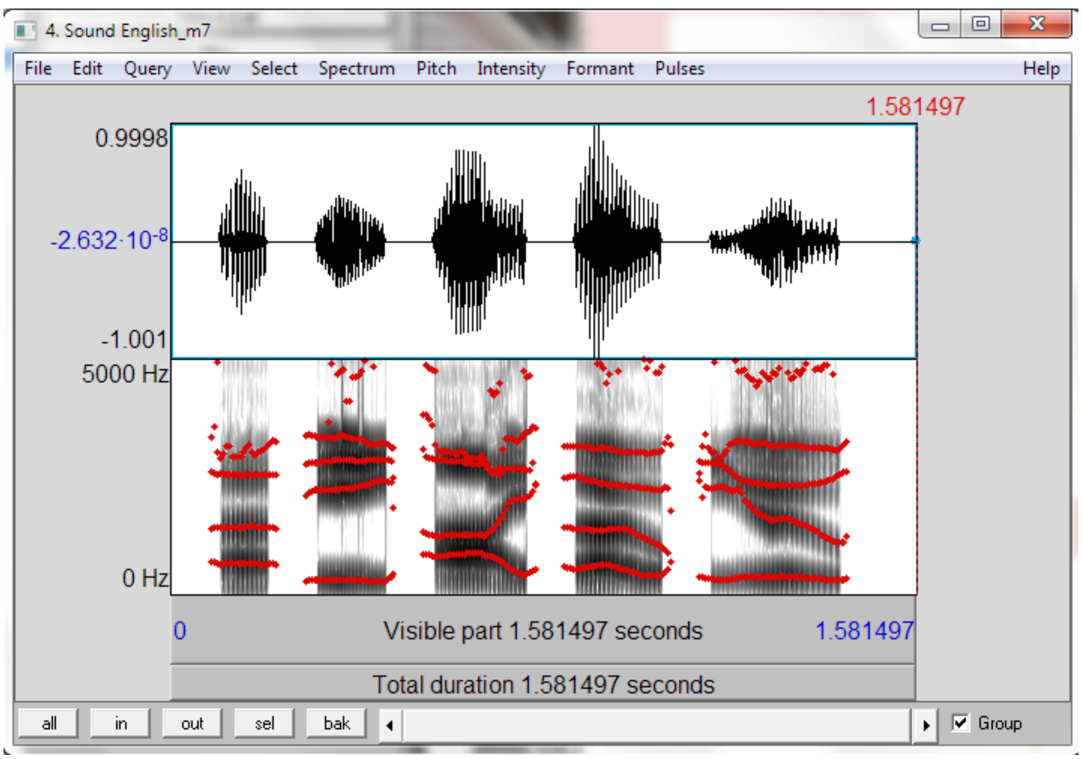

Fig. 1. Upper portion, left to right: intensity-vs.-time plot of the vowels a, e, i, o, and u (US English pronunciation). Lower portion, left to right: frequency-vs.-time plots of the same vowels a, e, i, o, and u (US English pronunciation), with darker shading corresponding to higher intensity (and the formants) and lighter shading corresponding to lesser intensity.

Figs. 2a and 2b indicate the frequency components of the 'a' alone and the 'e' alone, respectively. The frequency components are obtained by Fourier transforming the recorded amplitude-vs.-time data for the intonations of 'a' and of 'e.'

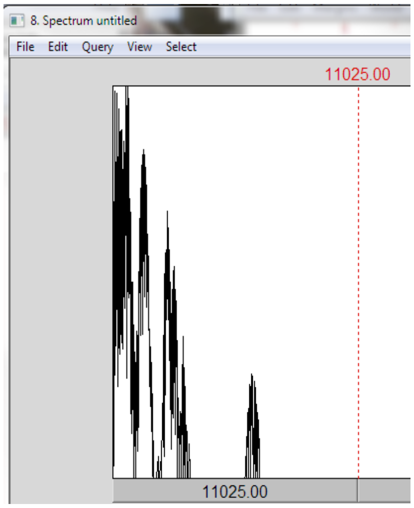

Fig. 2a. FFT of 'a'

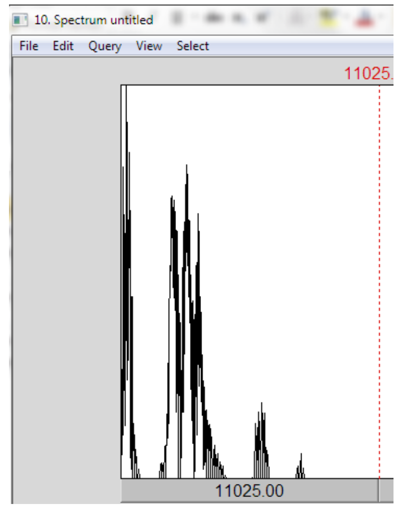

Fig. 2b. FFT of 'e'

Introduction

According to Rosicrucian teachings, certain sounds, when intoned, produce physiological, emotional, and psychic effects, including stimulation of various organs, glands, the central nervous system, and the autonomic nervous system. (Singh 1998, 61-62) Various traditions have associated mystical properties with given vowel and consonant sounds, and some of these associations have been nearly universal, extending across languages and cultures. This practice has been used by many different cultures since antiquity for healing and spiritualizing temples, including the Egyptian, Sufi, Hindu, Hebrew, Babylonian, Greek, and many more cultures. (Singh 1998, 56) Singh explains that these sounds or mantras have been regarded as sacred amongst the varying traditions because of power to resonate with the unified field. According to the quantum physicist John S. Hagelin, "There exists a unified field called Atman in the cosmos where all laws of nature are found together in a state of wholeness. This unified field is a self-interacting field of intelligent consciousness which is unbounded, all-pervading, unchanging and the self-sufficient source of all existing things." (Singh 1998, 57) Intoning these specific sounds, if done properly, can re-establish the harmony between the individual's vibratory field and the unified field, thereby leading to a cascade of therapeutic and healing effects.

Wide-ranging therapeutic effects have been found from intoning specific vowel sounds. For example, Singh found that "meditative intonations can increase melatonin levels and positively influence a person's mind-body-pineal systems." (Singh 1998, 65) Melatonin is considered one of the most important hormones because it can cross all cell membranes in order to protect sensitive DNA from damage. (Singh 1998, 27) It can treat sleep disorders, prevent heart disease, slow down the aging process, strengthen the immune system and sex drive, enhance one's overall quality of life due to its anti-stress properties, and it has the ability to minimize the risk of developing cancer. (Singh 1998, 22) Therefore, vowel intonations can have an enormous healing power potential by the production of melatonin alone. Goldman and Goldman compiled a body of research to determine what other healing effects vowel intonation and "toning" practices can produce. (Goldman and Goldman 2017, 6-18) They found studies that indicated these practices could decrease blood pressure and heart rate, increase nitric oxide levels and lymphatic circulation, and increase endorphin and oxytocin levels. Khalsa and Stauth found that particular vibrations through mantra sounds can stimulate several glands in the endocrine system to produce therapeutic effects, including the pituitary gland and the hypothalamus, and can have therapeutic effects for Alzheimer's and improved neural activities. (Khalsa and Stauth 2015, 28-29) They also note that different mantras produce different effects in the endocrine system. Since different vowel sounds have the potential to produce different effects in the mind and body, this analysis was conducted to set the foundation to identify the acoustic similarities and differences in a variety of intonations.

A study of the spectral properties of these vowel sounds can provide a scientific underpinning to Rosicrucian vowel sound chanting and can also support follow-up studies of physiological and psychic phenomena. The acoustical vibrations associated with vowel sound chants (or other vocal sounds) can be represented as plots of intensity-vs.-time (the time domain representation), intensity-vs.-frequency (the frequency spectrum or frequency domain representation), and frequency spectrum-vs.-time. The vibrations consist of several frequency components, including harmonics, and this is consistent with a fundamental Rosicrucian teaching that everything is vibration. In general, the frequency components will vary from individual to individual, as human voices are generally unique and distinguishable. However, since many Rosicrucians experience the effects resulting from the vowel sound intonations, it is believed that each vowel sound also has unique spectral characteristics that do not vary from person to person. A primary objective of this research is to identify these invariant or nearly invariant characteristics. One generally accepted principle in the science of phonetics is that vowels can be distinguished by their characteristic formant frequency patterns.

Fourier analysis is a widely used approach to identify spectral characteristics (harmonic content) of signals, including acoustical signals such as vowel sound chants. For present purposes, the intensity-vs.-time plot can be represented as a sum of a sufficient number of sine and cosine terms of the appropriate frequencies, amplitudes, and phase shifts. This sum is known as a Fourier series, and representing a curve in this manner is known as Fourier analysis. In this case, a Fourier analysis transforms the signal (vowel sound chant) from the time domain to the frequency domain.

In the 1980s, the Rosicrucian Order investigated the Fourier characteristics of several vowel sounds, and the useful insights obtained were documented in Mindquest articles published in the *Rosicrucian Digest*. (Waggener and McDavid 1983, 20-23) However, the studies were based on a very small number of participants, in some cases on only one woman and one man. For this reason, some of the findings were inconclusive. Furthermore, this prior research was performed using a digital oscilloscope together with a microphone, a computer with Fourier analysis software, and tuning forks to ensure that the chants were intoned at the proper frequencies.

Technology now permits the data analysis of sound recording at substantially reduced and perhaps negligible cost. A digital oscilloscope is no longer required, as inexpensive computer graphics programs can provide the same capability. Pitch pipes, available at many music stores, can be used in place of the more expensive tuning forks. The sound capabilities (software and microphone) on many home computers can provide the needed recording capability, provided that the quality of the recording is sufficient to support Fourier analyses. Recent findings in the field of phonetics also make the spectral analysis of chant formants within reach. The improved computational and signal sampling ability available today is an additional reason to return to this research.

In particular, two gold standard computer programs, The Multi-Dimensional Voice Program (MDVP) and PRAAT, have been used for the acoustic analysis of voices and sound in clinical and research settings. PRAAT was a preferred program for the current study for many of its attributes over MDVP. PRAAT is free open source software while MDVP is commercial software. Furthermore, a study comparing MDVP to PRAAT found that PRAAT had significantly less jitter, shimmer, noise-to-harmonic ratio (NHR), and degree of unvoiced (DUV) segments. (Amir 2009, 202-205) Lower errors of these types are integral to analyses, as these errors can cause a misinterpretation of the data, especially when analyzing samples of several seconds. When using PRAAT it becomes possible to detect the difference in the details of a person's voice and the difference in sounds produced, and even indicate the emotional state of a person. This study was done by Kumbhakarn and Sathe-Pathak using vocal acoustic features such as pitch, formant frequencies, intensity, standard deviation, energy, and duration. They extracted emotional categories that could be recognized and classified into neutral, angry, happy, or sad emotional states. (Kumbhakarn and Sathe-Pathak 2015, 763-767) In theory they would be able to create a speech recognition system for human emotional states using PRAAT.

When applied to understanding the Rosicrucian intonations, PRAAT software can enhance the capabilities to explore very fine acoustical differences among chants. This may unlock a complex physical representation of each Rosicrucian intonation and perhaps even pave the way toward an acoustical classification method. The current study used the PRAAT software to analyze the variances between one vowel sound and another during a Rosicrucian intonation.

This is similar in methodology to previous studies that have used older methods, such as in Trainor, Clark, Huntley, and Adams. (Trainor et al. 1997, 383-396) They analyzed the acoustic basis of preferences in infants by recording using a Comptech 486 computer with a Tucker Davis AP2 processor card and the Computerized Speech Research Environment (CSRE) software package. Within the same study, they also compared digitized recordings using an Audiomedia II card in a Macintosh IIci computer running the Signalyze 3.09 speech analysis software program. These previous programs and hardware combinations had difficulty with large amounts of data and were not capable of multiple simultaneous tasks, nor was the quality of the recordings comparable to that of today's technology. This meant they were generalizing on relatively sparse data points of voice sounds. With today's PRAAT software, it is possible to analyze many variables of the voice to create much more complex and representative categorical and analysis models.

Research Questions

This study addressed two research questions:
1. What acoustical spectral characteristics exist, if any, that do not vary from one vowel sound to another? Can these be classified in the traditional formant limits assigned to vowels?
2. In what ways does the pitch influence these general spectral characteristics?

Methodology

General Procedures

1. Selected Rosicrucian vowel intonations were pre-recorded onto Dr. Ranjie Singh's "Self-Healing" CD. (Singh 2008) The recordings were recorded in a professional recording studio as to secure sufficient quality to ensure accurate Fourier analyses.

2. A series of analyses was conducted using PRAAT software for selected vowel intonations, specifically AUM, OM, and OOM. These intonations are shared with other traditions and are not exclusive to Rosicrucian teachings. A baseline analysis using the same methods was conducted for the sound MM. All four of these sounds available in MP3 format from the "Self-Healing" CD were converted to WAV format using open source software.

    a. For every vowel chant, Fourier analyses were performed with the PRAAT computer software. The Fourier analyses were done not only over the entire chant but also on selected portions of the chant to account for variation in damping times of different frequency components and the general delimiters of syllables.

    b. The selected portions of the chant were given a definition of "segment," which was defined by a manual inspection of the time-domain waveform. A PRAAT scripting program was developed to extract single utterances of a chant from a CD recording of several chants, and another PRAAT scripting program was written by modifying an available PRAAT script from an open source repository. This second script was used to find the average and standard deviation of the frequency (Hz), Pitch (F0), and the first four Formants (F1, F2, F3, and F4) during that segment. The formant frequencies that were measured were compared to the theoretical formant frequencies of the International Phonetic Alphabet (IPA), which is a phonetic notation that has its origins in the late 19th century. IPA is a standardized representation of sounds in spoken language including those outside of English. (International Phonetic Association, 1999)

Instrumentation

The phonetics research program PRAAT (Version 6.0.28) was developed by Paul Boersma and David Weenink of the University of Amsterdam. (Boersma 2001, 341-345) The analysis was done on an iMac running macOS Sierra (Version 10.12.6) with a 3.2 GHz Intel Core i5 processor and 8 GB Memory. Lossless conversion of the audio files from CD format (MP3) to WAV format was done using Free WMV AVI Converter v. 6.2.15. (OKWare 2018)

Data Collection Procedures

The MP3 audio of track 02 of the CD accompanying *Self-healing: Powerful Techniques*, which was professionally recorded by an AMORC member, was converted to WAV format compatible with the PRAAT software. (Sample rate 44,100 Hz, 415.9 MB, duration 39:18 sec)

Three vowel sounds were studied: OOM_1, OM_21, and AUM_2. The end number designates WAV file order on the CD. One consonant was studied: MM_3. The upper portions of Figs. 3, 4, and 5 show the intensity-vs.-time (time domain representation) of each recorded vowel intonation. The figures on the left-hand side (black font) represent arbitrary intensity units. The lower portions of Figs. 3, 4, and 5 indicate the pitch (F0) in Hz as a function of time. Note the near-constant F0 pitch seen in blue for each of the vowels.

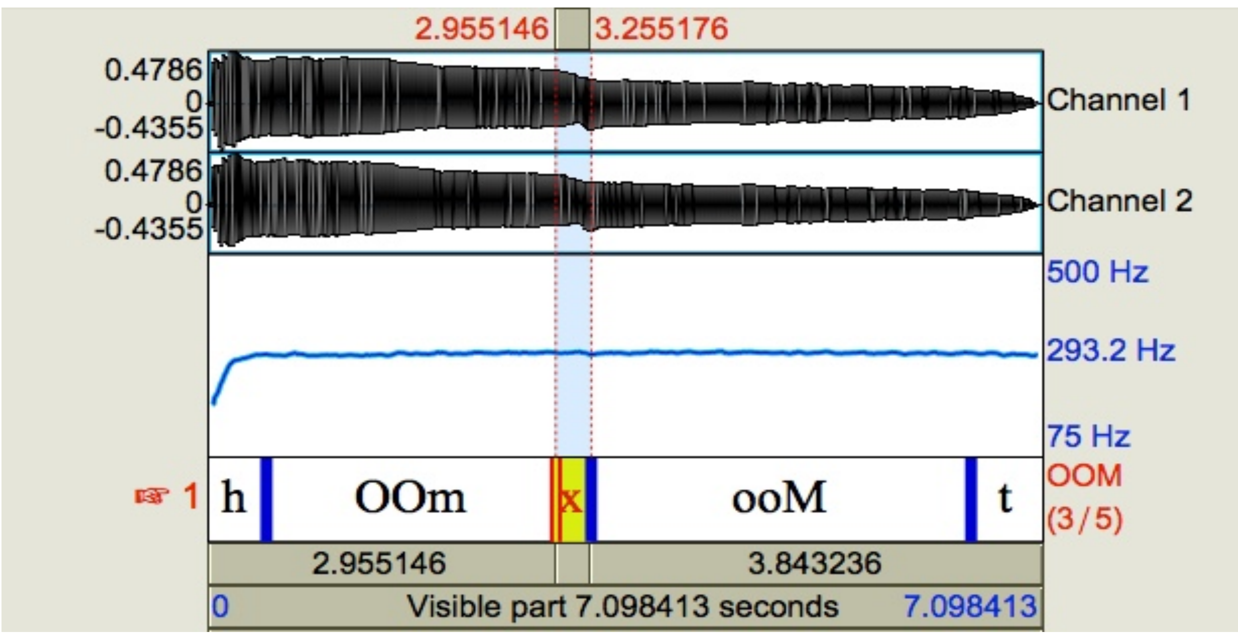

Fig. 3. OOM_1 (Channel 1 & 2; Pitch; Vowel Segments: OOm, ooM)

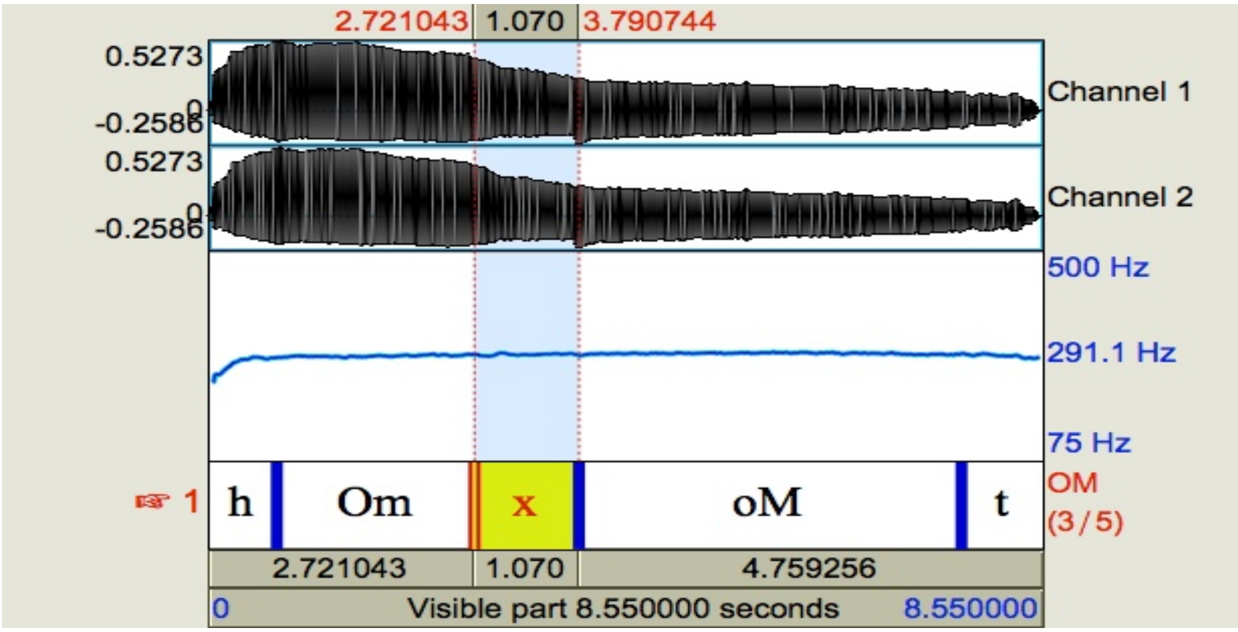

Fig. 4. OM_21 (Channel 1 & 2; Pitch, Vowel Segments Om, oM)

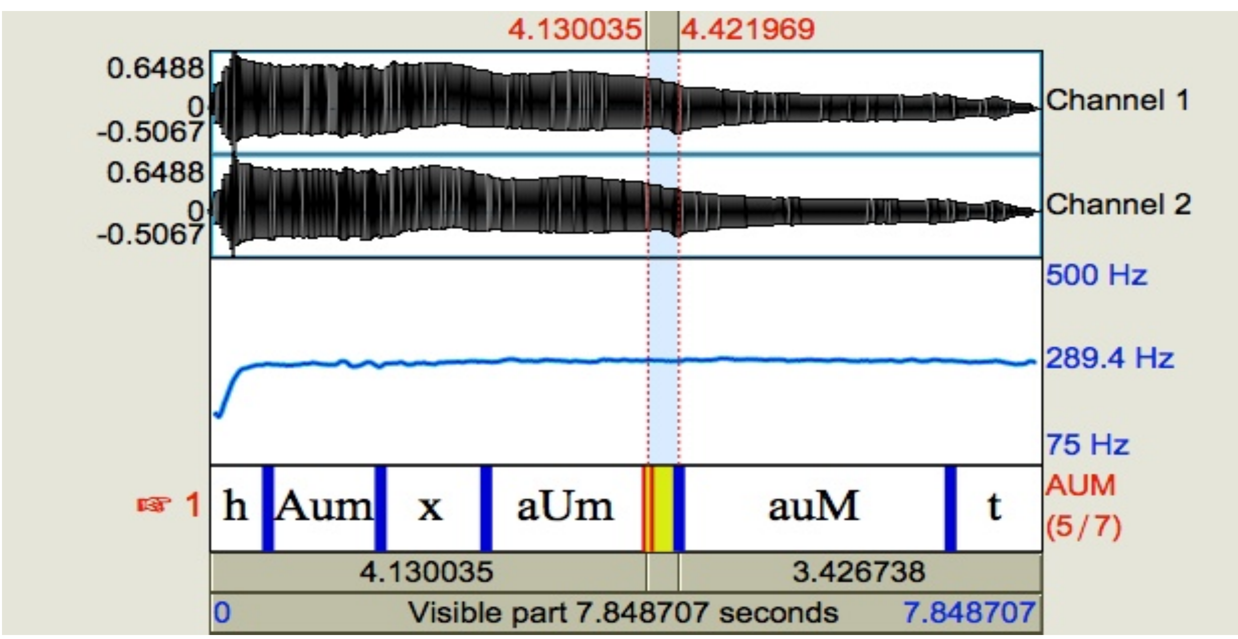

Fig. 5. AUM_2 (Channel 1 & 2; Pitch; Vowel Segments: Aum, aUm, auM)

Fig. 6 displays similar data for the intonation of the consonant MM.

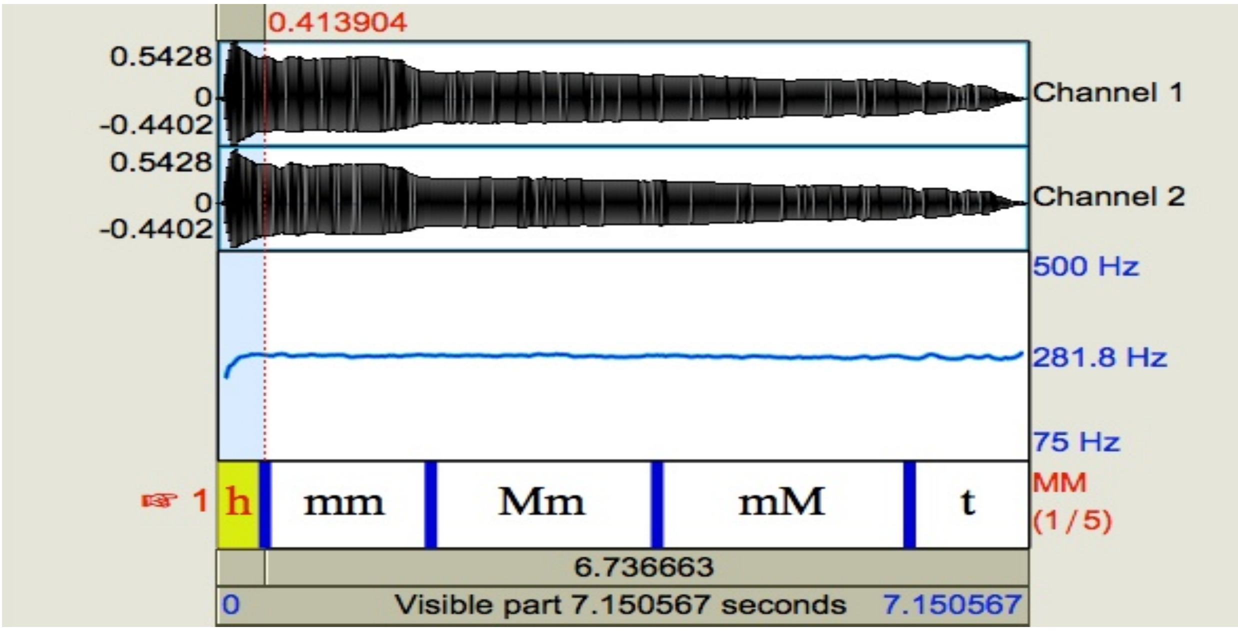

Fig. 6. MM_3 (Channel 1 & 2; Pitch; Vowel Segments: mm, Mm, mM)

Data Analyses

Two PRAAT code scripts were written to analyze the vowel intonations. This was a four-step process:

1. Converting the CD MP3 sound file to WAV format.

2. Splitting the file into isolated intonations using a PRAAT script that the author (Schwonek) coded. These scripts were divide.sh and divide.praat, and the split times that were manually chosen were listed for the 21 chants on the CD in the file divide.list.txt. (Schwonek 2018) Three vowels (OOM, OM, AUM) and one consonant (MM) were studied.

3. Further segmenting the three vowels above on the time domain thus, for example, being able to examine the three distinct sub-sounds of AUM as Aum, aUm, and auM where the capital letter indicates the prominent part of the sound being analyzed. In a similar way, the segment boundaries of OOM into OOm and ooM, and of OM into Om and oM, were chosen.

4. Researching available PRAAT scripts, finding PRAAT script resources online, (UCLA Phonetics Lab 2009), and modifying a formant logger script authored by Katherine Crosswhite. (Crosswhite, 2009) The author (Schwonek) changed the script from calculating midpoint formants segments delimited by labeled markers in a text grid to finding the

averages and standard deviations of the segments. This modified script is formant_averaging_sigma.praat. (Schwonek 2018)

Results

Table 1 indicates the formants F1, F2, F3, F4 frequency measured as well as the pitches F0 and the duration for the three vowels OOM, OM, and AUM along with a reference of the intonation of MM from the member chanting on the CD. For visualization purposes, the middle portions of Figs. 7, 8, 9, and 10 display the formants as functions of time for the respective intonations.

Vowel Segment	Formant F1	Formant F2	Formant F3	Formant F4	Pitch F0	Duration (msec)
OOm	331+/-9.4	896+/-41	2501+/-293	4115+/-69	290+/-2.4	2460
ooM	294+/-1.3	1033+/-52	2109+/-337	3475+/-201	294+/-1.3	3230
Om	524+/-90	992+/-70	3023+/-71	3766+/-27	288+/-1.7	2024
oM	298+/-1.9	1173+/-168	2082+/-427	3540+/-360	295+/-1.4	3917
Aum	624+/-18	1129+/-10	2965+/-68	3900+/-71	282+/-2.6	1062
aUm	347+/-7.8	866+/-12	2735+/-370	3920+/-166	288+/-1.6	1526
auM	296+/-3.2	1021+/-35	2085+/-251	3516+/-174	291+/-1.3	2561
MM	291+/-1.9	1180+/-55	2087+/-277	3355+/-221	285+/-1.6	2224

Table 1. Measured formants F1, F2, F3 and F4 for the intonations of OOM, OM, AUM, and reference intonation MM, together with the pitches F0 and the durations. The standard deviations for the measured pitches and formants are also indicated.

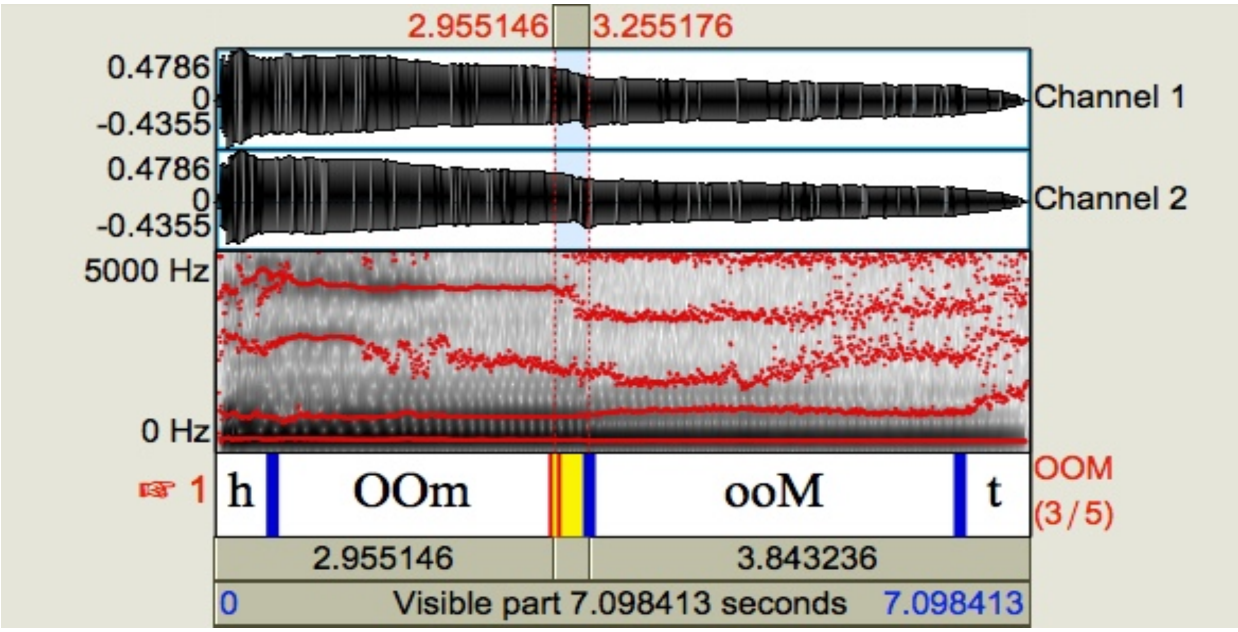

Fig 7. OOM_1 (Channel 1 & 2; Spectrogram and Formants; Vowel Segments: OOm, ooM)

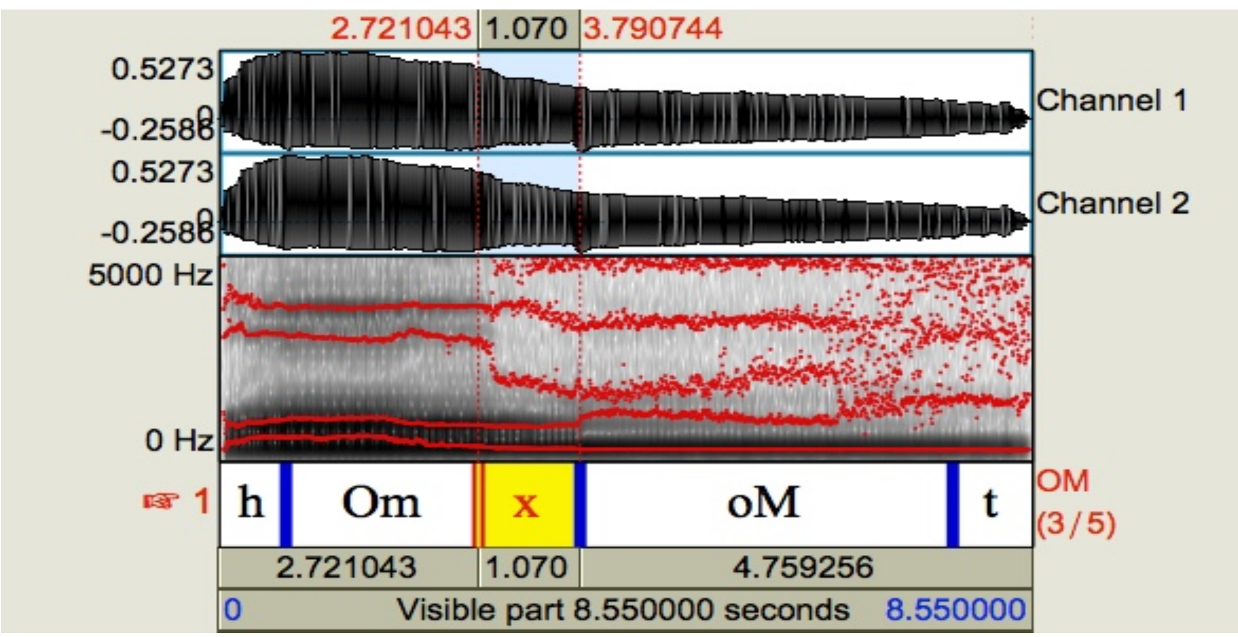

Fig 8. OM_21 (Channel 1 & 2; Spectrogram and Formants; Vowel Segments: Om, oM)

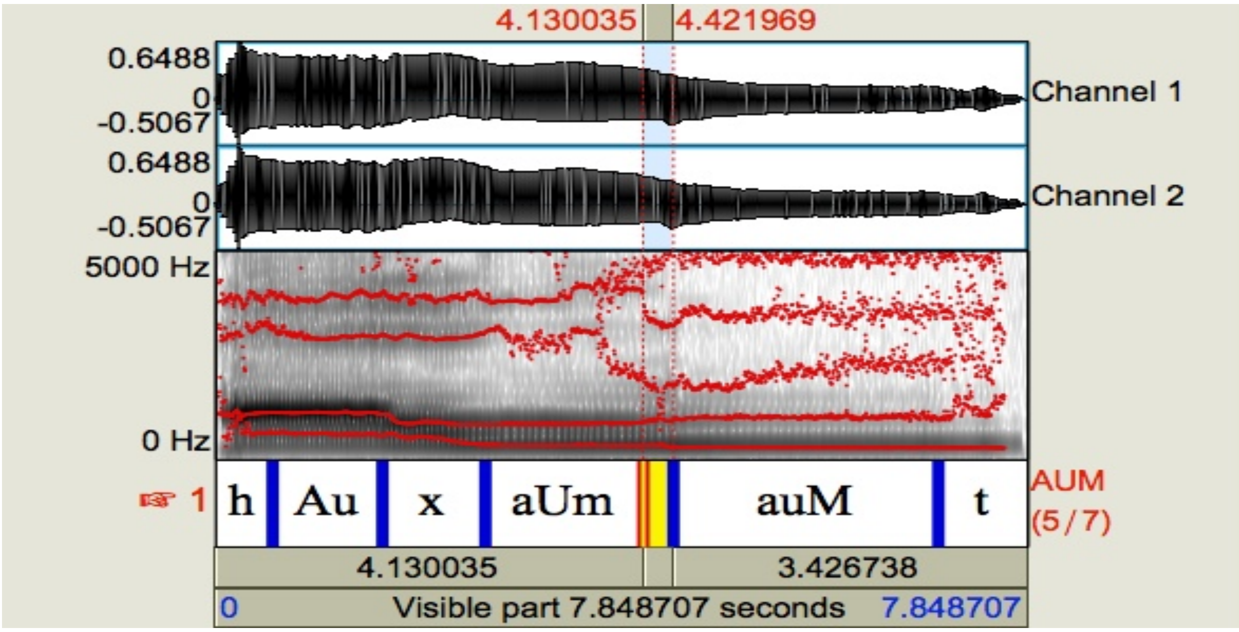

Fig 9. AUM_2 (Channel 1 & 2; Spectrogram and Formants; Vowel Segments: Aum, aUm, auM)

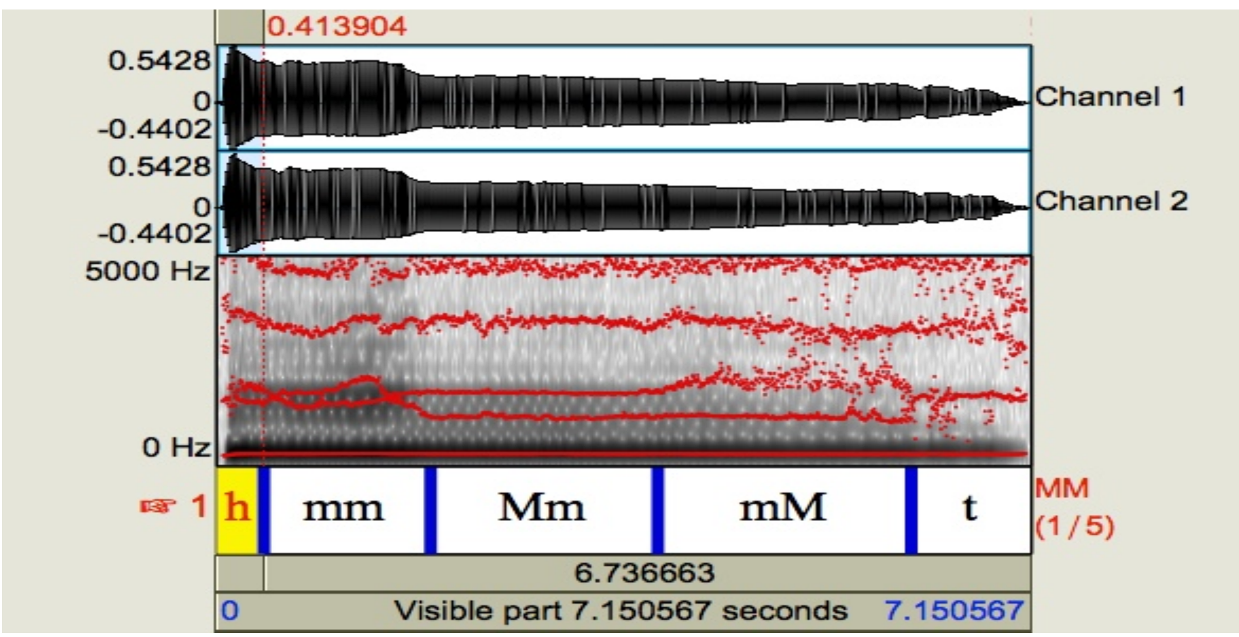

Fig 10. MM_3 (Channel 1 & 2; Spectrogram and Formants; Vowel Segments: mm, Mm, mM)

Discussion

One comparison that was done was to determine the relationship between the evaluated intonations of OOM, OM, and AUM and the standard IPA vowel sounds. Table 2 compares the standard IPA vowel sounds based on their values of formants F1 and F2. F1 is a measure of the width of the oral cavity at the back of the throat and the vertical position of the back of the tongue, and F2 is a measure of the length of the oral cavity (mouth) and the horizontal position of the tongue. (Hillenbrand 1995)

As shown, the upper right of the chart has vowel sounds with Low F1 and Low F2, such as the <u> sound in "boot." On the lower left of the chart, the vowel sounds with High F1 and High F2, such as the <a> sound in "hat." To round out the chart, the upper left of the chart has Low F1 and High F2, such as the <i> sound in "meet," and the lower right of the chart has a High F1 and Low F2, such as the <ɒ> sound in "not." Both English and non-English languages have had their vowels studied by many researchers, and the IPA alphabet is the gold standard for classification of phonetics.

Once the values of F1 and F2 from the IPA table are known, the frequencies may be graphed onto what is typically known as an IPA vowel chart as shown in Fig. 11. (IPA 2005) Traditionally, the chart is graphed inverted with the frequency origin in the upper right as F1 (y-axis) vs. F2-F1 (x-axis). A scatter plot of the F1 and F2-F1 values from Table 2 yields the trapezoidal shape of the vowel chart that is clearly seen in Fig. 12.

Low F1/High F2 **Low F1/Low F2**

Tongue	Front	Front	Central	Central	Back	Back	
	Unrounded	Rounded	Unrounded	Rounded	Unrounded	Rounded	
	i	y	ɨ	ʉ	ɯ	u	IPA Symbol
Upper High	meet	few	rude	choose	goose	boot	Sound
	294	283	293	383	329	295	F1
	2343	2170	2186	1482	1806	750	F2
	3251	2417	2507	2232	2723	2342	F3
	ɪ	ʏ				ʊ	IPA Symbol
Lower High	bit	foot				hook	Sound
	360	401				394	F1
	2187	1833				910	F2
	2830	2241				2300	F3
	e	ø	ɘ	ɵ	ɤ	o	IPA Symbol
Upper Mid	play	bird	nut	foot	ago	go	Sound
	434	462	415	519	605	406	F1
	2148	1659	1955	1593	1657	727	F2
	2763	2127	2421	2187	2596	2090	F3
	ɛ	œ	ɜ	ɞ	ʌ	ɔ	IPA Symbol
Lower Mid	bed	Non-Eng	bust	Non-Eng	gut	thought	Sound
	581	546	557	581	707	541	F1
	1840	1604	1696	1439	1354	830	F2
	2429	2032	2423	2186	2289	2221	F3
	æ		ɐ				IPA Symbol
Upper Low	cat		bet				Sound
	766		688				F1
	1782		1446				F2
	2398		2314				F3
	a	ɶ	ä		ɑ	ɒ	IPA Symbol
Lower Low	hat	Non-Eng	cot		hot	not	Sound
	806	572	784		781	652	F1
	1632	1537	1211		1065	843	F2
	2684	1802	2702		2158	2011	F3

High F1/High F2 **High F1/Low F2**

Table 2. Tongue positions and formants for various vowels as catalogued by the International Phonetic Association (IPA). The vowels are denoted by the standard IPA symbols.

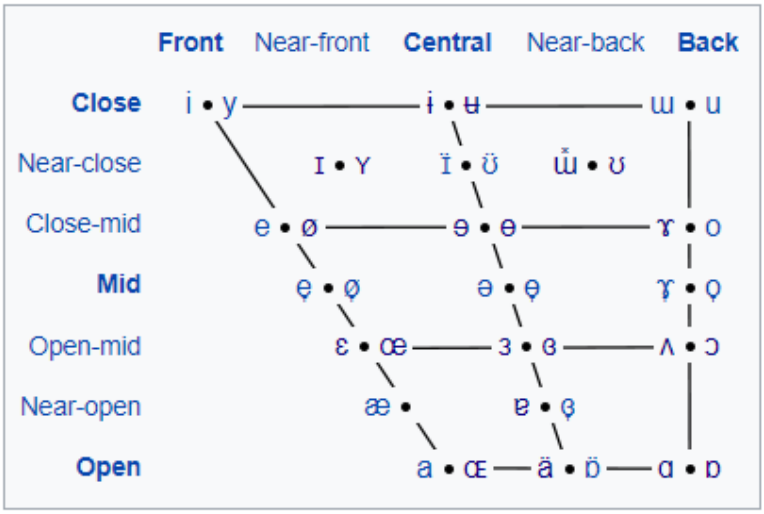

Fig. 11. International Phonetic Alphabet (IPA) standard vowel chart (Keating 2018).

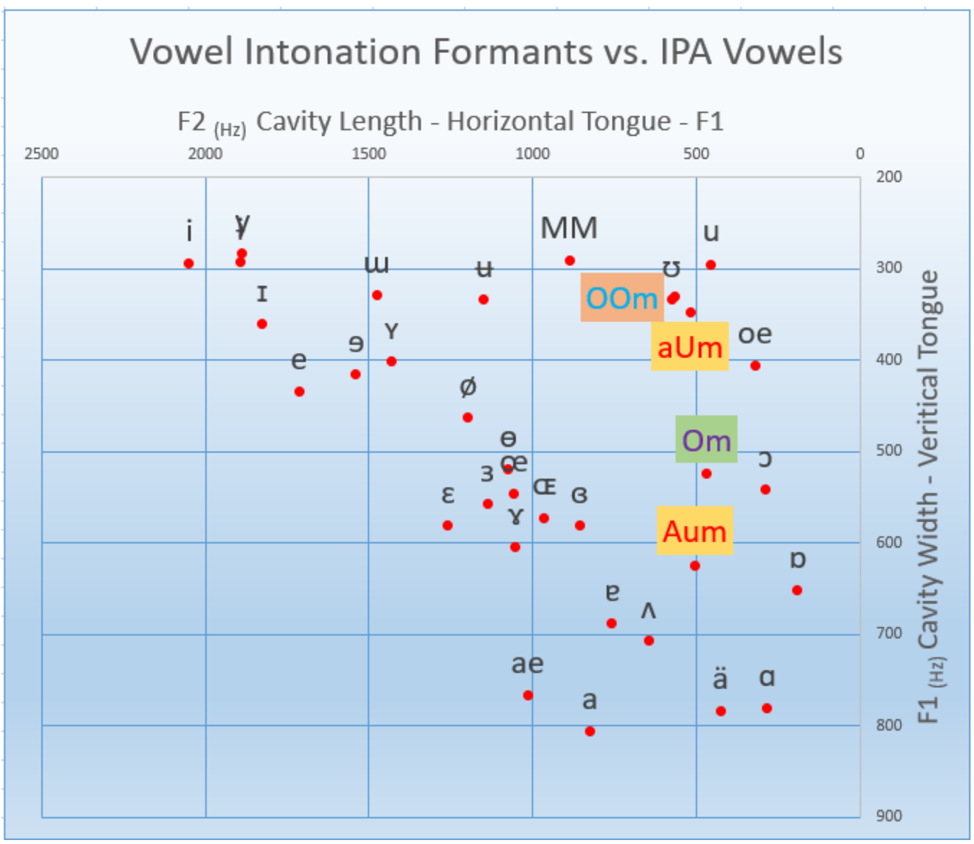

Fig. 12. Comparison of vowel intonation formants F1 and F2-F1 vs. IPA standard vowels. Note the similar values for F2-F1 obtained for Aum, aUm, and Om.

The experimental F1 and F2 values for OOM, OM, AUM, and MM from Table 1 can now easily be added to Fig. 12 to gauge where they occupy in relation to standard vowels. Astonishingly, all three vowels OOM, OM, and AUM line up vertically on the F2-F1 scale, thus showing that the shape of the pharyngeal cavity with the position of the tongue is quite similar for all three. Noting on Table 3 that Aum and aUm seem to have their F2-F1 values straddle that of Om, it turns out that the average of the two Aum and aUm points matches closely with Om for both F2-F1 and F1. However, Table 4 emphasizes how the vowels are seen to have interchanged F2-F1 and F1 values, which begs a dualistic interpretation of the relationship between the vowels: Is OM the inverse of AUM? Does that make any sense in the mystical context of the sound in Rosicrucian or other traditions?

Vowel	F2-F1	F1
Om	468	524
Aum	505	624
aUm	519	347
AUm Avg	512	486

Table 3. F2-F1 and F1 values for Om, Aum, aUm, and AUm average.

Vowel	F2-F1	F1
Om	468	524
Aum	505	624
aUm	519	347
AUm Avg	512	486

Table 4. Possible duality between Om and the AUm average.

The first research question about the classifications of the vowel formants now moves to the experimentally derived values for the consonant part of the intonations. The "MM" segments that exist in the latter half of OOM, OM, and AUM can also be subjected to formant analysis. Recall that the formants are the maxima of the sound spectrograms. As seen in Figs. 7, 8, and 9, the intonations of OOM, OM, and AUM all end with the utterance of the "MM" sound of the intonation. Fig. 10 is a formant analysis of "MM" in isolation, that is, without a starting vowel.

The F1 average of the values for ooM, oM, auM, and MM have a very small standard deviation (294 +/- 2.6 Hz) while the F2-F1 values have a larger spread (807 +/- 75 Hz). Recalling that the F1 is characterized by the width of the pharyngeal cavity and the vertical position of the back of the tongue, it can be said that the conformation of this shape is invariant across all four intonations. The fact that the standard deviation of the F2-F1 is relatively 11 times that of the F1 indicates that the choice of starting vowel varies the length of the oral cavity (mouth) and the horizontal position of the tongue more substantially.

Note that although F3 and F4 values were measured as well, they can be neglected in the disambiguation of the vowel sound because the amount of power in those higher harmonics is so much less than that of F1 and F2. This can be seen in the relatively light grey of the left top two red vowel formant lines (F3 and F4) in Fig.7, 8, 9, and 10 compared to the dark grey and black of the spectrogram in the left bottom two F1 and F2 red vowel formant lines. On the right side of the spectrogram is seen the "MM" sound, which shows an even greater reduction of power than is observed for the formants F3 and higher. The fact that the "MM" formants' standard deviation is so large, as seen in the scattering of the red lines, turns out to be inconsequential to this analysis.

Finally, this research addressed the question of the influence of pitch on the spectral characteristics of the vowel intonations. The pitch F0 as seen in Table 1 denotes a near-constant set of values averaging 289+/-4.0 Hz. The small value of this standard deviation is a result of the intonation sound files being professionally recorded by an AMORC member. The measured intonation, therefore, for all four vowels is nearly correct with its 4 Hz standard deviation.

Conclusion and Future Research Direction

This study endeavored to perform Fourier analyses of selected mystical vowel sounds, professionally recorded on a CD, using PRAAT software. The sounds of OOM, OM, and AUM that are present in many esoteric and mystical traditions were used as a starting point to establish a foundation for future research using a quantitative measurement methodology. Although the findings are based on chants by a lone woman member, a sound methodology has now been developed. A follow-on study involving several men and women will crosscheck the findings and determine which findings are of a general nature.

It was found that the analysis required the creation of scripts to customize the onboard formant calculation modules of PRAAT. This was followed by research into how the science of phonetics classifies vowels, after which the IPA vowel space was charted as a function of formants F1 and F2. A chart of F2-F1 vs. F1 was created, thus confirming the trapezoidal distribution of the IPA vowels, and this provided a cross-check of frequency accuracy and understanding of phonetics.

The F1 and F2 formant frequencies of OOM, OM, and AUM (divided into its two syllables Aum and aUm) were then plotted on this IPA vowel chart. It was found that the F2-F1 formant value was very similar for all three vowels, leading to the conclusion that the length of the oral cavity during these intonations and the horizontal position of the tongue are invariant for them. A seemingly unexpected conclusion was a possible duality or inverse relationship between OM and AUM, with the F1 value of one closely approximating the F2-F1 value of the other. It would be interesting to understand this in the context of the utility and symbolism of OM and AUM.

It is envisioned that this research will spawn further quantitative investigation of other Rosicrucian vowel sounds as well as chants from other traditions such as Gregorian, Templar, Buddhist, Hindu, and Shamanic. While certain Rosicrucian vowel sounds cannot be published in open literature, a comprehensive review of them may be undertaken to produce a total picture of the sounds on a Fourier analysis level and determine if there are other "inversion pairs" such as OM and AUM.

Other follow-on research will explore the physiological, psychological, and psychic effects of vowel intonations. The tools developed in this paper can be leveraged to provide a quantitative view into the known effects of vowel intonations and perhaps suggest other characteristics and uses. Finally, from this holistic approach to analyzing vowel intonations, a segue into the connections of the vowels to Sacred Geometry can be attempted.

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