Archaeoacoustic analysis of an ancient hypogeum using new TRV camera (Variable Resonance Camera) technology

New advancements of archeaoacoustic analysis for archaeological knowledge

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Abstract— **Combined with research on the effect of acoustics on the human body, archaeoacoustics is an interesting method to reanalyse ancient sites. As well as broadening our understanding of the ancient world, this multidisciplinary approach seeks to recover "ancient knowledge" that affects the emotional sphere of human consciousness,. In this study, we have examined the relationship between the resonance effect present in Cividale del Friuli hypogeum and the altered state of consciousness of volunteers using TRV technology. The results showed that after eight minutes of exposure to resonance within one of the hypogeum chambers, both volunteers and the chamber itself become attuned to the same frequency. This represents an unexpected result. On the one hand it would appear the volunteers adapt themselves to the vibrations of the chamber, whilst the environment seemingly adapts itself to the state of mind of the subjects. It is almost as if some sort of bidirectional influence is at play**.

Keywords: archaeoacoustics; hypogeum; Cividale del Friuli; resonance; TRV technology; SB Research Group

I. INTRODUCTION

Archaeoacoustics is a new interdisciplinary field that combines the study of archaeology and sound to analyse ancient sites, using different parameters to examine a forgotten technology operating on the human emotional sphere. Generally speaking. archeology mainly focuses on visual history through studying physical objects and placing them in a historical context. Clearly the past was not a period of silence, and without acoustics archaeology could be considered deaf, likewise without archaeology acoustics could be considered blind. With four years experience using new technologies, we have stimulated the resonance phenomenon at a number of ancient sites both with a male voice (1,2,3,4,5) and more recently using percussion instruments (6), demonstrating that a female with a drum could stimulate the resonance effect achieving the same outcome as that of a male voice. The purpose of this scientific paper is to verify the intention of the ancient builders to manipulate sound at the archaeological site of Cividale del Friuli Hypogeum (Italy) as well as the physiological impact from the acoustic phenomena by using new technology that has never been used to undertake archaeoacoustic analysis at an archaeological site.

The resonance characteristics of this hypogeum were established over several sessions during research that began in early 2013 and later published in the international scientific literature (3,6). The results seem to confirm the ritual origin of the conformation of the Hypogeum, our hypothesis is that the underground structure is connected to a Mother Goddess cult (14), given the strong influence on the local population of the rites originating from Balkan immigrants since Neolithic times (15) and potentially backdating the construction of this ancient temple considerably. We decided to conduct further research of the altered states of consciousness that can be achieved through the resonance phenomenon most likely sought by the builders of the hypogeum. For this reason, a collaboration with IPERLAB forensic laboratory of Bologna (Italy), which has a wide experience in the use of TRV technology (Variable Resonance Camera), was begun. The results from this technique will be particularly useful to compare with the research by EEG we are doing in this moment in collaboration with the service of Neurophysiology of the General Hospital of Trieste, which has already been published in the international literature (5).

(*) Note. SB Research Group (SBRG) is an international and interdisciplinary project team of researchers (Italian, Croatian, English and Finish members) researching the archaeoacoustics of ancient sites and temples in Europe (www.sbresearchgoup.eu).

II. THE CIVIDALE DEL FRIULI HYPOGEUM

Cividale del Friuli is an ancient town in the North-East of Italy founded by Julius Caesar with the name of *Forum Julii*. At one time, it was the capital of the Longobard Kingdom after the fall of the Roman Empire. In this area there were various settlements dating from the Neolithic period [15].

Some historians believed that during the Iron Age, the Hypogeum was used as a depository for funerary urns, others say it was used as a prison during the Roman or Lombard period. Of interest to archaeoacoustic researchers is that this hypogeum has some unexpected acoustical properties similar to the Hal Saflieni hypogeum in Malta (6).

Cividale del Friuli Hypogeum has a number of underground spaces on three different levels carved out of the conglomerate. Its shape looks rough to a careless eye, but despite the alterations over the centuries, the builders made full use of the shape of the rooms to enhance its acoustical properties, which for example could be utilized during prayers and mystic songs.

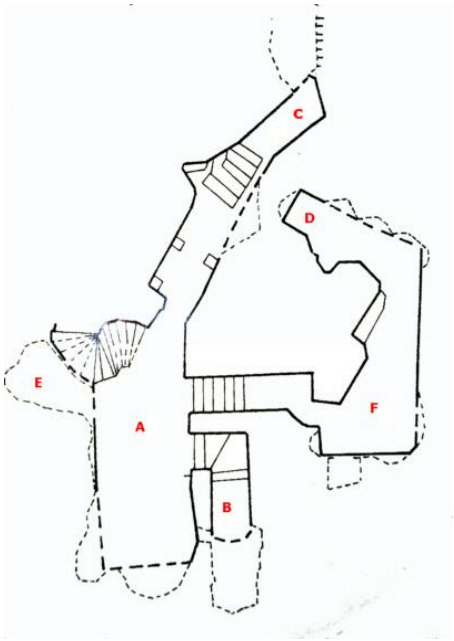

Figure 1. Map of the hypogeum of Cividale del Friuli

It is possible this underground complex could have been derived from a natural cavity running along the rocky riverbank of the Natisone river.

Figure 2. The riverbank of Natisone river, the hypogeum is located under the houses.

There are three big and disturbing masks carved on its walls in the style of the Gallic civilization, similar to the remains of sculptures found in Gallic graves in France known as *têtes coupées*. There are also niches carved by different builders that are perfectly dry, which may well have been used as a mortuary at a later date (other chambers are wet and would therefore have been unsuitable for such use). It is assumed that some of the hypogeum's chambers functioned as water tanks and used for ceremonial rites of uncertain origin. However, the true function and origin of this underground structure unique in Friuli, remains a mystery. It is certain that it has been remodeled over successive periods, however none of the other hypotheses have been supported by historical evidence.

The structure consists of a tall central chamber that is reached through steep descending steps, at the beginning of which is the only window that looks out to the Natisone riverbank, the rest of the structure sits completely underground. Three corridors lead off from the central chamber and contain niches and seats of various heights, many of which appear to have been dug with a pick at a later period.

Figure 3. The stairs leading to the first level (chamber A of the map)

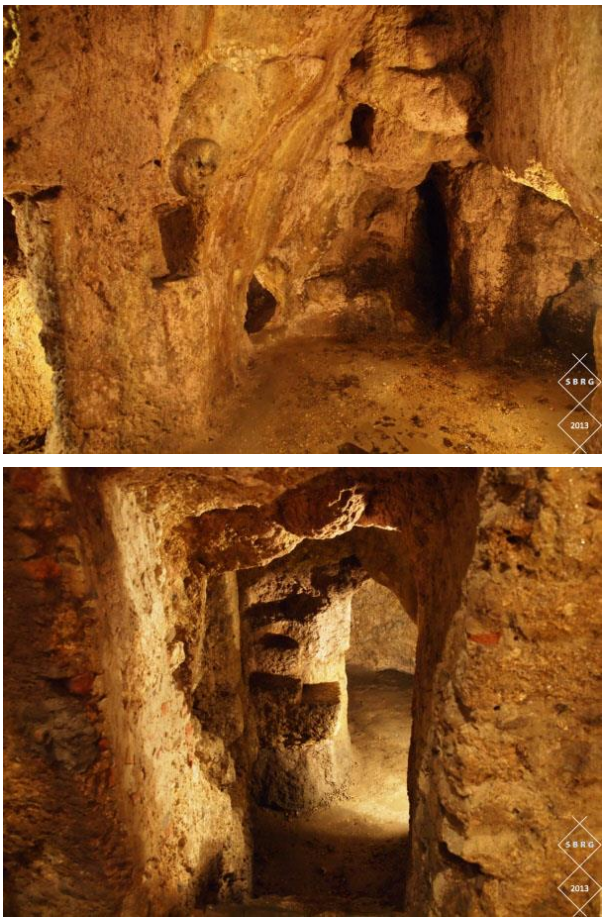

Figure 4. Some aspects of the hypogeum

In the Iron Age this region was inhabited by the Veneti population (in Latin Heneti), an Indo-European people who lived throughout North-Eastern Italy [15]. During this period the area surrounding Cividale del Friuli was strongly influenced by the Illyrian people and other ancient populations from the Balkans [15]. It is therefore plausible that some of their customs were adopted by local people, such as the Mother Goddess cult [14] and other rituals connected with the esoteric underworld. The period in which the hypogeum was built is difficult to determine, but could be as far back as the Bronze Age or maybe before. Such a hypothesis is striking and in parallel with archaeoacoustic research conducted in Europe by SBRG [1].

III. MATERIAL AND METHODS

The "technology TRV" (Resonance Variable Camera) needs a little explaining in order to understand how it was applied in this experiment and how it might be applied within the archaeoacoustic field. As a premise, it is important to know that there is a direct correlation between emotional and functional states of the human body with the precise parameters of controlled motion reflection. Until recent times quantitative parameters and efficient information of the movement of the human body were not established. Bernstein and Mira Lopez (psychodiagnostic miokinetics) (18) studied the micro-mobility of the human body and found that it represented a sophisticated mathematical problem. For example, it has been shown that the vertical balance of the human head is controlled by the vestibular system, described as a reflex function. But the balance of the human head controlled by the vestibular system can also be considered as an extension of locomotor activity (micro-mobility of the head). The analysis of micro-mobility of the head and of other types of reflexes which control the motility of the human body are able to provide a lot of information on the state of consciousness of the examined subject. From the physical point of view, the mechanical oscillations of the head are a vibrational process, whose parameters provide a quantitative correlation between energy and mobility of the object. Information on the integral parameters of mobility of the head can be obtained by using video analysis TRV (Variable Resonance Imaging Camera) technology, which provides quantitative information of the periodic movements of any part of the imaged object.

In the image provided on the primary monitor (represented by pseudo-colours), each point represents the parameters of mobility in the frequency of the examined subject. As in other biomedical imaging (ultrasound, NMR, IR, X -ray), the TRV is a method of image analysis that is based on data of micro-mobility models and introduces a new term, emotional vestibular reflex or "*reflection of vestibular energy*" (RVE). This indicates that the coordination of the movement depends on the emotional and physiological state of mind and that is affected by these factors. To date, the system has primarily been used in the security and anti-terrorism field. People in an agitated or stressed state of mind have a different color around them as seen in the video image, which helps to identify them amongst a group of people.

The same principle is already used in medicine for the early diagnosis of certain diseases which imperceptibly alter the general state of the patient. The human vestibular system receives information from almost all districts of the physiological organism, from the cardiovascular system to body temperature. This information is used to support the physiological homeostasis of the human body, and any significant signal given by some diseases or emotional stress disturbs this equilibrium. The software program connected to the TRV technology allows analysis of stress or other levels of biological parameters, which are important for regular monitoring of mental/emotional balance. The algorithm of the stress equation includes different filters, settings and adjustments which can be configured within the system software. In particular by exploiting the perception of the system of micro-movements of the left and right part of the body and how its correlates to vibrations in the examined subject. A high level of stress in the subject corresponds to particular states of asymmetrical vibrations in the body which are clearly detectable by the system and signaled to the operator.

Figure 5. The TRV system used in the experiment

The TRV image analyser system is used to monitor vibrations in normal or altered states of consciousness, the so-called Human Energy Field (Human Energetic Field - HEF). In a little square on the PC screen the image of the subject is shown using a spectrum of false colours, a graph corresponds to the initial position. Later the software shows, through the variation of colors in the image, a transition to an altered state of consciousness, sometimes reaching up to the total disappearance of the image itself or to a change of colour to a single color tone. The change from the initial multicoloured to a single color state indicates that the vibrations are passed by a wide spectrum of frequencies to a narrow spectrum, indicating a situation of coherence of the examined subject. So we can say that the detected spectrum of frequency changes completely when the examined subject enters into an altered state of consciousness. All the parameters are analysed and stored from moment to moment by the cameras software. At the end of the trial a "report" can be generated showing the spectrum of vibrations, which shows the depth of meditative state achieved along with any fluctuations of intense vibrations in the body of the subject examined. In the pictures below there is a distribution of horizontal colored stripes around the vibrating objects (rows represent obtained individual frequencies). These represent the spectral distribution of vibrations in a band between 0.1 and 10 Hz according to a scale of pseudo colors from purple to red (shown below).

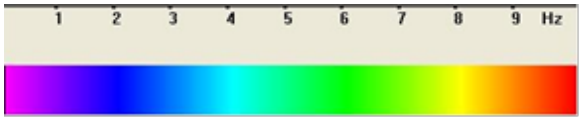

Figure 6. Images converted to a scale of pseudo colours in relation to the frequency in Hz

The vibrations generated throughout the human body vary continuously both in amplitude and in frequency. On the PC screen a large panel shows someone with horizontal coloured lines of varying lengths surrounding them, showing the vibrations detected (figure 5). The frequency is represented according to a colour scale (figure 6). Another panel in the bottom left of the screen, shows the spectral characteristics on three graphs.

The TRV system aims to study the functional state of the human body through recognition and mapping of the emotional state. The algorithms for determining this are based on a system of mathematical statistics, principles of coordination of movement, and the logic of behavioral psychology and comparative tests.

This experiment was carried out on April 13th 2014 in chamber D of the hypogeum (see figure 1).

Two singers, one male and one female positioned themselves within chamber D to provide coverage of the entire frequency range. However, as noted in our previous research only the male voice was able to activate the chambers resonant frequency (around 103Hz) using a mantra chanted in a monotone.

The audio recording was performed following the SBRG Standard for archaeoacoustics (4). In this case the equipment consisted of a high dynamic range recorder, extended both in the field of ultrasound and infrasound with a sampling frequency rate of 192 kHz (Tascam DR-680).

Condenser microphones with a wide dynamic range and flat response at different frequencies (Sennheiser MKH 3020, frequency response of 10Hz to 50,000 Hz) with shielded cables (XLR Mogami Gold Edition) and gold plated connectors.

The microphones were placed on opposite the singers and mounted on two tripods (see Figure 5). Given the small size of the chamber D, the recording volume was adjusted to a value of -9dB to avoid recording distortions.

The TRV systems camera has a common CCD backlit, with a three MegaPixel sensor. The protective anti-aliasing filter was removed to extend its vision beyond visible light into the infrared (IR) and ultraviolet (UV) range. It has a system of rotating LEDs from infrared to visible which generates ultraviolet light and synchronises with the rotation of the light at will from 1 Hz to 10 KHz. It is connected to a PC, but videos can also be saved to internal flash memory. The lens is a 25 mm quartz-fluorite with passband from 200nm to 1800nm.

Figure 7. The camera used in the experiment

The camera apparatus was placed at the same side of the microphones on a tripod, while the system software has been loaded on a laptop PC positioned at the side of the chamber.

Figure 8. In the image are the subjects situated in the resonance nodes along with the TRV operator on his computer.

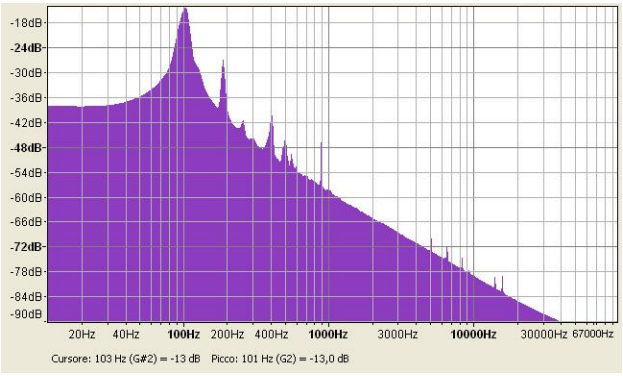

Figure 9. The frequency graph recorded during the experiment. There is a high peak of around 101-103Hz caused by the voice that is reinforced by the resonance phenomenon. The other harmonics of the voice are at a significantly a lower level.

Figure 10. The TRV camera positioned on a tripod opposite the singers. It generates IR and UV in front of it.

IV. RESULTS

At the beginning of the experiment the TRV system, placed in front of the examined subjects, reported a normal baseline situation in front of the camera.

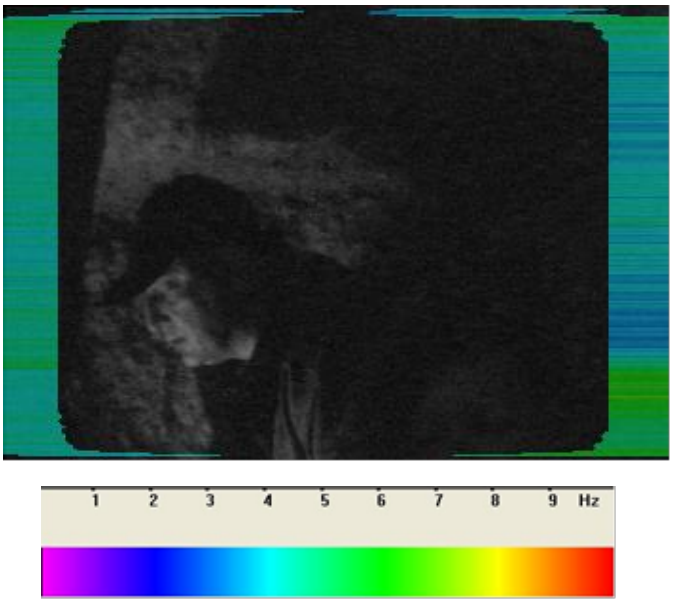

Figure 11. The basic aspect at the beginning of the experiment before chanting the mantra. In the foreground the female singer, the male singer is in the background.

A few seconds after beginning the experiment when the vocal resonance was triggered, a background noise of between 2Hz and 7Hz, saturates the measurement of the environment.

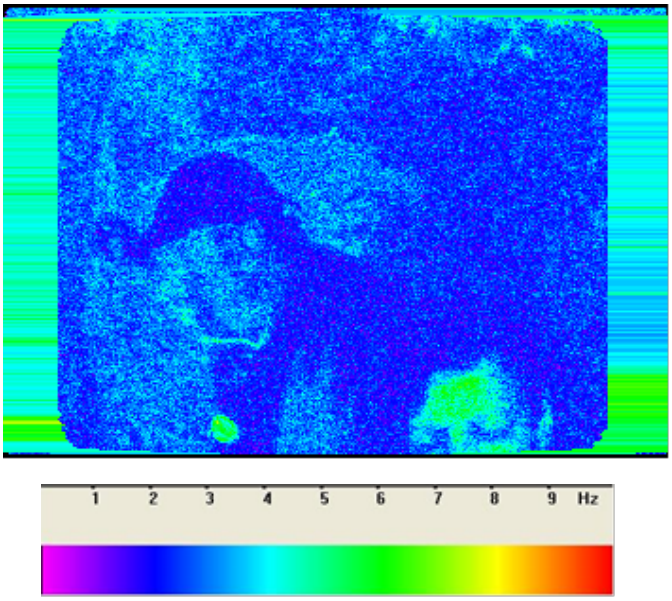

Figure 12. The background noise (2-7 Hz) after the resonance phenomenon begins (few minutes) which saturates the environment of chamber D

Subsequently, the frequency decreases (0.1 Hz and 4Hz) signaling the balance and homogeneity of the entire body of those subjects positioned in chamber D. This led to a gradual disappearance of the figure at the end of the chamber, with the figure closest to the camera (more easily detectable) starting to become opaque.

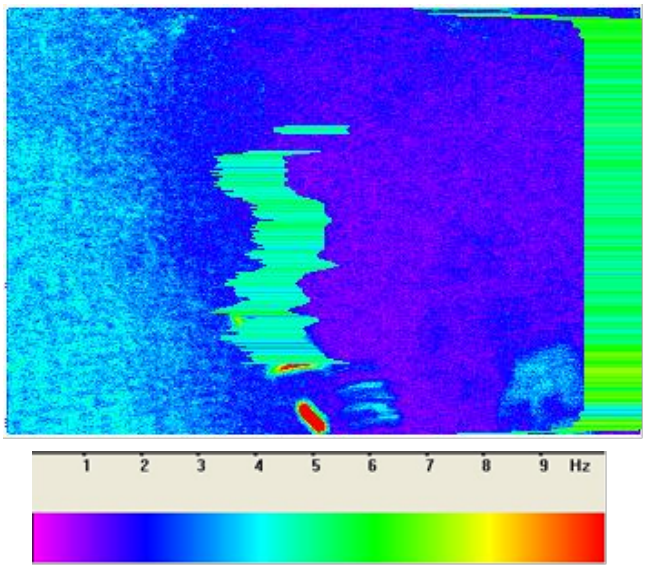

Figure 13. In these images is evident the progressive inability of the system to distinguish the figure at the bottom of the chamber from its surrounding environment, that is vibrating in a synchronous manner with the subjects.

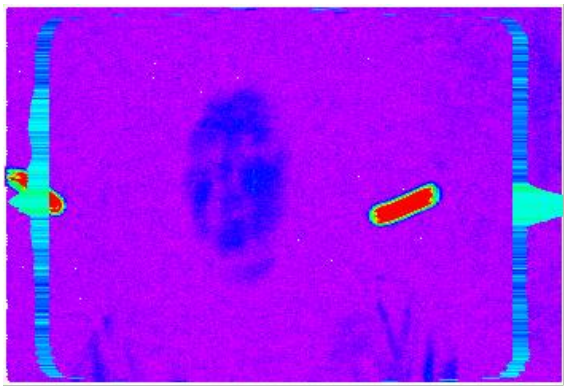

Figure 14. The homogeneity of vibration between 0.1 Hz and 4 Hz , present throughout the environment of chamber D

After a few minutes of the resonance phenomenon, the figure completely disappears from the monitor of the TRV camera. Only the red marks from the reflectors of the jacket worn by the same subject are visible due to the refractive effect and movement of the subject.

V. DISCUSSION

The TRV system recorded the transition to an altered state of consciousness, which occurred when the entire chamber began to vibrate at the same frequency as the subjects. Initially this was captured by the camera and software as a transition to one color, until the image of person in the foreground totally disappeared, indicative that the frequencies have moved from a broad range to a narrower range. This indicates a situation of coherence towards a contemporary altered state of consciousness of the examined subjects, accompanied at the same time by a vibration of the chamber tuned to the same frequency of vibration as the subjects under consideration.

This altered state of consciousness was achieved by simply repeating a mantra for approximately 8 minutes, as documented by an audio recording which was carried out at the same time. A similar test was carried out at a chamber on the first level (without the resonance phenomenon as verified in a previous study (3,6)), that did not result in any state of altered consciousness in the volunteers.

Previous researches demonstrates the real effect of resonance, found in ancient temples, on the human body (5, 7,8,9). We found in a previous research by EEG (5) why various Neolithic temples have different tuning resonances, but always between the ranges of 90Hz and 120Hz: initial findings suggest every person has their own personal sensitivity within this range with a different effect on brain activity. This could explain why in ancient times each chamber was tuned to different frequencies to extend the emotional involvement of every person participating in sacred rituals.

In Cividale del Friuli Hypogeum there are for example two chambers with different resonant frequencies. The other 4 chambers have been modified over the centuries it is therefore not possible to say with any certainty if these too had different or a similar range of resonance. Also Jahn and his collaborators (7) found different frequencies of resonance in different

temples in England and Ireland, often in different chambers of the same temple. Such frequencies create strong emotions in people during rituals.

VI. CONCLUSION

Archaeaoacosutics is an interesting method of analysing ancient sites to re-discover a forgotten technique that effects the emotional sphere of human consciousness. The Hypogeum of Cividale del Friuli still functions as a place where altered consciousness can be achieved when its resonance phenomenon is utilized. Either by a male voice (3) or by means of a percussion instrument (6), The objective findings observed by the TRV instrumentation represent something already detached from subjective perception of the people considered and variously reported with subjective sensations also by the protagonists of our previous research (3,6).

Ultimately the instruments used confirms that a "*mystical*" state can be reached after a few minutes by those who are subjected to the resonance phenomenon inside the chambers of the hypogeum.

When looked at alongside research on the effect of acoustics on the human body, we can say archaeoacoustics is a method to re-analyse ancient sites from another point of view. Indeed, its study presents a chance to recover "ancient knowledge" that affects the emotional sphere of human consciousness, as well as to broaden our understanding of the ancient world.

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