

# Systems of acoustic resonance at ancient sites and related brain activity

## Preliminary results of the research

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**Abstract** – Research was carried out in collaboration with the Head and Neck Department and the Clinical Neurophysiological Unit at the University of Trieste (Italy) to assess the effects of resonance phenomena on the human body. We worked with volunteers who underwent examination by EEG while listening to tones between 90Hz and 120Hz, similar to the resonant sounds found at some Neolithic structures in Europe (England, Ireland, Italy, Malta). As in the study by Ian Cook at the University of California (UCLA, 2008), all of our volunteers were subjected to a "comfortable" volume of sound whilst in the absorbing sound room. This is used for audiometric tests at the Otorhinolaryngology Clinic and has been modified with suitable software and hardware. This type of room is also protected by a Faraday cage to shield from any possible external electromagnetic interference that could affect the results. After two minutes of silence to evaluate the resting brain rhythm, the volunteers were subjected to the tones of 90, 95, 100, 105, 110, 115, 120Hz arranged in a random way for one minute each. At the end of every cycle they listened to a mantra of the same frequency for a period of two minutes. Technicians examined the EEGs to verify the data collected. They found there was a prevalence of frontal areas or occipital (posterior) areas with no predominance of one cerebral hemisphere (left of right) over the other during playing. Each volunteer had a different sensitivity to all the tones without one tone prevailing (i.e. 110Hz), with each exhibiting a strong response to a subjective and personal tone (90Hz, 105Hz, 120Hz ...).

**Keywords:** archaeoacoustics, EEG, brain activity

## Introduction

Archaeoacoustics is an emerging archaeological discipline that involves the study of ancient site using an interdisciplinary approach. In previous studies carried out, researchers found some Neolithic temples or hypogea had an interesting and particular resonance. SBRG group also found this to be the case in research carried out in Europe<sup>[2,3,4,5,6]</sup>; was it possible some temples were built not only as sacred places but also for acoustical resonance effects?

Such studies were first carried out by Princeton Engineering Anomalies Research Group (PEAR), University of Princeton, NY<sup>[8]</sup> under the directorship of Robert Jahn.

In 1996 PEAR published a paper titled "**Acoustical Resonances of Assorted Ancient Structures**"<sup>[8]</sup>. In it they found at six different Neolithic temples in England and Ireland an acoustic resonance of around 110Hz, frequencies that commonly fall within the male vocal range. They also found that the dominant standing-wave patterns at such frequencies are the principle of radial or longitudinal harmonics with little azimuthal or vertical variations. PEARs final conclusion was "*These ancient structures possessed resonant acoustical properties that may have contributed to their functional purposes*"<sup>[8]</sup>.

Research over three years by SBRG has also shown ancient people were able to influence their perception of the human body using sound to obtain different states of consciousness, without the use of drugs or other chemical substances<sup>[2,3,4,5,6]</sup>.

On the basis of PEAR's findings, a research group from UCLA (USA) directed by Cook, published a paper in 2008 with the title "**Ancient Architectural Acoustic Resonance Patterns and Regional Brain Activity**"<sup>[12]</sup>, in it they looked at the effect and correlation of the frequencies found by PEAR at English and Irish temples on brain activity using electroencephalography (EEG). In their pilot project, 30 healthy adults listened to tones of 90, 100, 110, 120, and 130 Hz whilst brain activity was monitored using EEG. In particular they found that the pattern of asymmetric activity

over the prefrontal cortex shifted from one of higher activation on the left side at most frequencies to right-sided dominance at 110 Hz. These findings are compatible with relative deactivation of language centres along with a shift in prefrontal activity that may be related to emotional processing. These results suggested that the acoustic properties of ancient structures may influence human brain function and that a wider study of these interactions should be undertaken.

From these results Cook hypothesised: “*The resonances of the chamber cavities might have been intended to support human ritual chanting. There is the possibility that tones at these frequencies might specifically affect regional brain activity*”<sup>[12]</sup>.

SB research group decided to collaborate with the Otorhinolaryngology Clinic at the University of Trieste (Italy) along with the Clinical Neurophysiological Unit at the Department of Neurology (University Hospital of Trieste) to assess these results in more detail with the help of the Department of Medical Science.

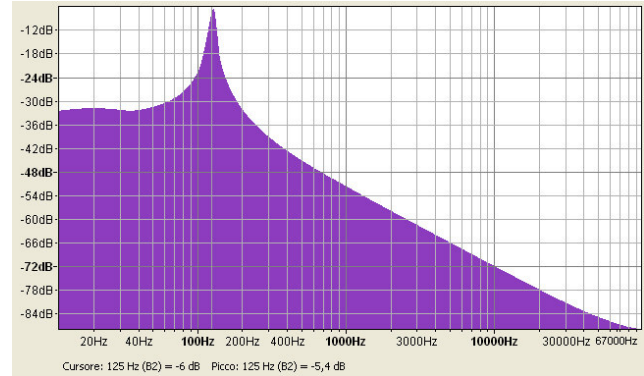
Volunteers underwent examination by EEG whilst listening to tones between 90Hz and 120Hz, similar to the resonant frequencies found in some Neolithic sites in Europe (England, Ireland, Italy, Malta) by PEAR and SBRG.

### Materials and methods

Italy was chosen to continue this research because there are several Neolithic temples in Europe at which the research can be carried out in the future, extending it beyond the University laboratories to “sacred” sites. For example the Cividale del Friuli Hypogeum in the North of Italy is one such ancient temple that can be used to test the resonance effect on the human brain. After two years of research, SBRG found two chambers in the hypogeum with their original shape and a strong resonance phenomenon at 94Hz and 103Hz respectively<sup>[4,6]</sup>.

Initially though it was decided to establish a base line of brain activity in our volunteer group, testing their response in the laboratory before carrying out test in the hypogeum.

All of our volunteers (4 male and 6 female) were subjected to the same tones of resonance as found in Neolithic temples. As in the study in the University of California (UCLA) in its laboratories (Laboratory of Brain, Behavior, and Pharmacology) by Professors I. A. Cook, S. K. Pajot and A. F. Leuchter<sup>[12]</sup>, we tested brain activity using EEG, playing tones of between 90-120Hz. Our volunteers were subjected to a “comfortable” volume in the absorbing sound room for audiometric tests in the Otorhinolaryngology Clinic at the University of Trieste. This room is shield from any possible external electromagnetic interferences that could affect the results with a fitted Faraday cage inside the walls. The room has also been suitably modified with suitable software and hardware.



*Fig. 1 – An example of the study with a tone of 125 Hz played. External frequencies are not a factor, only the sound peak emitted by the equipment is heard*



*Fig. 2 - The control desk placed close to the absorbing sound room*

At the beginning of the test volunteers choose the volume of sound (from high-fidelity speakers) which was comfortable for them. The same subject remained in silence with closed eyes while the device recorded their resting brain rhythm electroencephalographic.

The EEG equipment necessary for the examination was an electroencephalograph device mod. EB Neuro, set at 12 channels and assembled in bipolar longitudinal way (for better performance because every sensor has its channel), installation M2 (possibility to record 20 channels) and Galileo PC Software. The signal was recorded with a sensitivity of 7 microvolt per mm with sampling rate of 512 Hz.



*Fig. 3 - A large number of electrodes was on the head of the volunteers*



*Fig. 5 - The computer tone generator (visible in the foreground) provided the necessary frequencies for the experiment*



*Fig. 4 - The operators at work at the control desk during the experiment*

After two minutes of silence to evaluate the resting brain rhythm, the volunteers were subjected to a total of 7 tones (90, 95, 100, 105, 110, 115, 120Hz) arranged in a random way for one minute each. At the end of every cycle they listened to a mantra tuned up to the same frequencies for a period of two minutes. This test was slightly different from Cooks experiment, who used only 5 frequencies from 90 to 130Hz with 10Hz intervals (90, 100, 110, 120, 130Hz). The 130Hz was not used in our study because it was not found in any of the Neolithic temples examined. Throughout the



*Fig. 6 – One volunteer in the absorbing sound room before starting with the test*

Much of the preparation time was used to place electrodes on a specific cap on the head of the volunteer under examination, this maneuver was carried out outside the acoustic room.

examination the door was closed and the volunteer remained alone in the room with faint light.





Fig. 7 - Preparatory work fitting the headset with electrodes

## Results

Given this was a pilot study with a small number of volunteers, the results proved to be interesting.

Skilled technicians from the Department of Life Sciences at the University of Trieste examined all the EEGs to verify the collected data. Each EEG record was divided into 16 areas indicating different brain activity. For analysis they used a filter pass-band from 0.5 to 30Hz (to remove spurious frequencies). Cordance measure was used, as it is more highly correlated with regional brain blood flow than other EEG spectral power measurements as in the study by Ian Cook<sup>[12]</sup>. It may also reflect cortically projected rhythms from activity deep in the limbic structures relating to emotional experience.

For simplicity the 16 areas were grouped in 6 areas of activity:

- frontal right (Fdx): average of channels Fp2, F4 e F8
- frontal left (Fsx): average of channels Fp1, F3 e F5
- central right (Cdx): average of channels C4 e T4
- central left (Csx): average of channels C3 e T3
- rear right (Pdx): average of channels T5, P3 e O1
- rear left (Psx): average of channels T6, P4 e O2

Brain tissues generate an electric field when active, as a side effect of the electrochemical processes used by neurons for signals. When large numbers of neurons show synchronized activity, the electric fields generated can be large enough to detect outside the skull, using electroencephalography (EEG). EEG activity therefore always reflects the sum of the synchronous activity of thousands or millions of neurons that have similar spatial orientation.

The parietal, temporal, and occipital lobes - all located in the posterior part of the cortex - organize sensory information into a coherent perceptual model of the environment centred on our body image. The occipital lobe contains the primary visual cortex. The frontal lobe or prefrontal association complex is involved in planning actions and movement, as well as abstract thoughts (often emotional memories). The frontal lobe modifies those emotions to generally fit socially acceptable norms.

In half of the volunteers there was a prevalence of frontal areas or occipital (posterior) areas, but there was no predominance of one cerebral hemisphere (left of right) over the other during playing. Each volunteer had a different sensitivity to all the tones without one tone prevailing (i.e. 110Hz), with each exhibiting a strong response to a subjective and personal tone (90Hz, 105Hz, 120Hz ...).

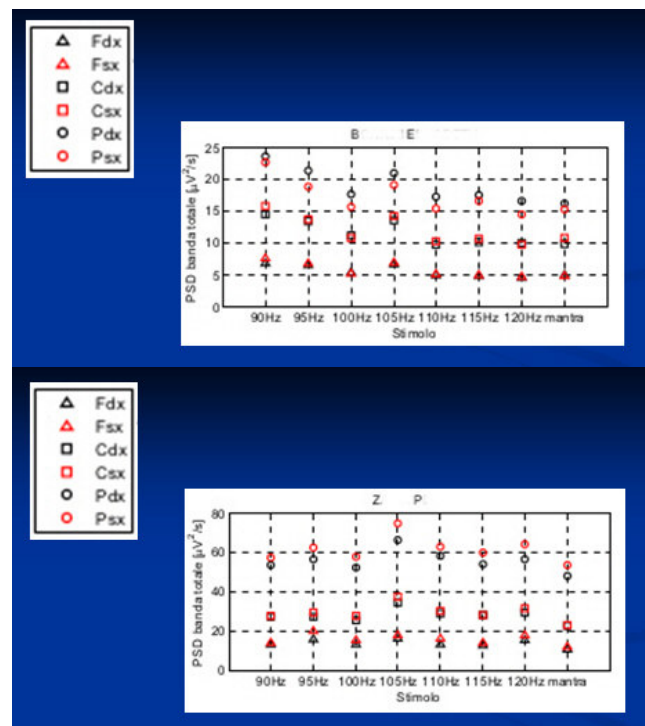


Fig. 8 – Example of a pattern of response to the test from two volunteers

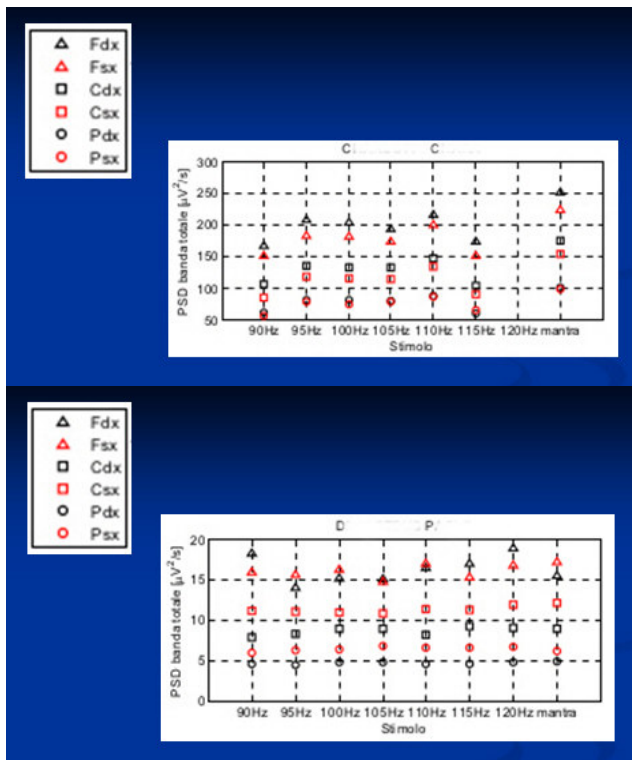


Fig. 9 The different EEG aspects in other 2 volunteers. Each looks to have their own frequency stimulating emotions (F= frontal, C= central, P=Posterior; dx=right hemisphere, sx=left hemisphere)

### Discussion

Our research was influenced by the works by Cook, Pajot and Leuchter<sup>[12]</sup>, who examined the response of the range of resonance phenomenon in ancient temples (90-130Hz) on the human brain using an electroencephalogram (EEG) while test subjects listened to tones within the same frequency range. In this study, they were trying to establish if patterns of brain activity changed during a brief exposure to these sounds. The results were amazing: the activity in the left temporal region was found to be significantly lower, closer to 110 Hz than other frequencies. Additionally, the pattern of asymmetric activity over the prefrontal cortex shifted from one of higher activity on the left at most frequencies to right-sided dominance at 110 Hz.. Our results showed that each volunteer has their own individual frequency of activation that can be significantly different from 110Hz, but always between range of 90-120Hz.

Further those volunteers with a frontal lobe prevalence during the toning received ideas and thoughts similar to what happens during meditation, whilst those with an occipital lobe prevalence during the toning visualized images.

This could explain why in Cividale del Friuli Hypogeum there are two chambers tuned to different resonant frequencies of 94 Hz and 103Hz<sup>[4,6]</sup> respectively, instead of 110Hz. Also both these frequencies are capable of activating emotional processing. Achieving this emotional state was an important component of ancient rites so that a real sense of mystical elevation. It is possible some areas of the brain are effected without the sound actually passing through the acoustic organ (ear).

As a result of this study, the protocol has been modified introducing a series of questions for each volunteer following exposure to the tones (*Have you seen images? Have you interesting thoughts during the sounds? Did some frequencies disturb you?*). Volunteers will also be invited to raise their arm if they received some sensations during a tone (left arm for images, right arm for thoughts) and a little pause (20 sec) will be inserted between each tone.

Future research will examine the same volunteers in the underground structure of Cividale del Friuli (Italy), using a portable EEG. The volunteers will be subjected to the resonance frequencies present, theoretically making a comparative assessment with our laboratory study.

### Conclusion

This research demonstrates the real effect of resonance, found in ancient temples, on the human body. Archaeoacoustics is an interesting method of analysing ancient sites to re-discover a forgotten technique that effects the emotional sphere of human consciousness.

Moreover this research offers a possible explanation of 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 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.

We agree with the thesis by Ian Cook that the resonances of the chamber cavities might have been intended to support human ritual chanting, along with the possibility that tones at these frequencies might specifically affect regional brain activity. However, we didn't find that only the frequency of 110Hz could trigger such a response.

All volunteers were a little sensitive around 105Hz, but their higher and personal sensitivity to tones was between 90-120Hz at different frequencies. Moreover some were really disturbed by other frequencies in respect of their frequency. Probably the lesson from Ian Cooks research was to not consider too much the average of all frequencies. If almost all volunteers are sensitive at 105-110Hz the optimal sensitivity is different for everyone. Cooks higher average of 110Hz (105Hz for us) was most likely because the optimal individual sensitivity is spread between the frequency range of 90-120Hz, making the 110Hz alone unreliable for this research.

### Acknowledgment

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