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## **Quantitative acoustic measurements of Upper Palaeolithic rock art sites**

SIR -- Neither the location nor subject matter of prehistoric rock art has yet been satisfactorily explained<sup>1</sup>. Quantitative data from sites sampled in France, plus experience on two other continents, now lead to a possible explanation for both the location and subject matter of Upper Palaeolithic parietal art.

Open-air art sites as well as deep decorated caves from the Upper Palaeolithic were found to give reflected sound levels significantly above ambient. For example, at the open air site of l'Oreille d'Enfer, echoes were measured at  $53 \pm 3$  dB vs a background of  $45 \pm 2$  dB ( $p < 0.0003$ ). Furthermore, in the deep caves of Font-de-Gaume and Lascaux, the images of horses, bulls, bison and deer are found in regions with high levels of sound reflection, whereas feline art is found in regions of the caves with poor acoustics (see Figure 1). The difference between reflected sound levels at ungulate vs feline art locations is statistically significant at  $p < 0.0004$  within Font-de-Gaume and  $p < 0.0001$  within Lascaux. These results suggest an acoustical influence on both the placement and content of the art.

It has been previously observed that the shape of a cave exerted some general influence on the placement of species<sup>2</sup>. Indeed shape is one important determinant of cave acoustics. However, the highly sound-reflecting Axial Gallery decorated with ungulates and the acoustically dead Chamber of Felines in the same cave of Lascaux are both narrow dead-end tunnels, suggesting that the cave shape was influential only to the extent that it does affect the acoustics.

Echoes have been mentioned as a phenomenal attribute of certain rock art sites<sup>3</sup>, and a correspondence has been

suggested between deep cave painting placement vs locations that resonate at particular musical notes<sup>4</sup>. However, no prior investigator has presented objective quantitative acoustical data, nor has a comprehensive theory been forthcoming that understandably relates acoustics to the rock art content.

Statistical tabulations of the content of European Palaeolithic parietal art<sup>2</sup> can be reinterpreted as showing that greater than ninety percent (>90%) of the individual subjects depicted fall into the biological classes Artiodactyla, Perissodactyla and Proboscida, collectively grouped as ungulates. Why might prehistoric humans have chosen to make images of hoofed mammals in sound-reflecting environments?

It is known that some ancient cultures considered echoing a supernatural phenomenon. Experimentation with the sound reflection at rock art sites has revealed that percussion noises (from clapping or producing stone tools) can yield echoes that sound similar to the galloping of a horse, and that reverberation of percussion noises can sound like the thundering of a buffalo stampede. This phenomenon of hoofbeat-like echoes thus relates to the ungulate images as well as to the sound-reflecting canyons and caves where the art is typically located.

These measurements and observations lead to the speculation that the Palaeolithic artists produced the ungulate art in response to percussive sound reflections perceived as hoofbeats. The production of hoofbeats via sound reflection could have served quite usefully as a sympathetic magic ritual intended to summon up game. This new acoustic theory is therefore harmonious with previous speculations of Hunting Magic.

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Figure 1. Comparison of reflected sound levels in  
different regions of Paleolithic caves.

Experiments with a sound-burst device were recorded using a PMD420 Marantz cassette recorder equipped with a Dynamic LOZ Shure SM57 omnidirectional microphone, and analyzed using a Brüel and Kjær model 2232 precision sound level meter. The intensity of reflected sound is expressed on the value axis as decibels above background noise levels.

Error bars represent one standard deviation of two to four replicate tests. Abbreviations are, respectively: pre-rubicon (entrance tunnel), main galleries, grand carrefour (intersection) and lateral gallery, cabinet de bisons, terminal fissure with feline; rotunda (hall of bulls), axial gallery, nave/apse area, and chamber of felines.