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Acoustics of the West Kennet Long Barrow, Avebury, Wiltshire

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ABSTRACT

Continuing on from a 2011 preliminary study, this paper investigates further the acoustical properties of one of Wiltshire's best-known monuments, the West Kennet long barrow, in the Avebury complex. Its two pairs of transepted chambers resonate at frequencies that are musically a 'perfect fourth' apart – a ratio of 4:3. The frequency of the resonances is dictated by the size of the chambers, which in plan are also proportioned 4:3. Several other Cotswold-Severn tombs contain chambers with this 4:3 ratio. Furthermore, the central passage of West Kennet resonates at an extremely low frequency that can produce certain psychological effects; other Neolithic tombs are similarly-proportioned. It is possible that these effects were employed for some ritual purpose in West Kennet and other monuments.

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Introduction

The West Kennet long barrow (WKLB) in the Avebury complex is a Cotswold-Severn chambered tomb, with a mound 104 m long; its primary burials have been dated by Bayesian statistical analysis to 3670–3635 cal. BC (Bayliss, Whittle, and Wysocki 2007, 85). Inside the mound are five burial chambers connected to a 7.5 m- long passage, arranged symmetrically with two transepted chambers either side of the passage and one at its end. The structure is roofed with large slabs of sarsen stone, some of which are rough and uneven; in three places there are instead concrete slabs incorporating thick glass roof lights and set slightly higher than the stone-roofed areas. The transepted chambers are sub-rectangular while the chamber at the W end is sub-circular. The outer two chambers are larger than the inner two; the chamber at the end of the passage is largest of all. Although the monument was restored by Piggott in 1955–56, its four transepted chambers are essentially unchanged. All are made of sarsen stone slabs, with infills of oolite dry walling that has been largely replaced. Three of the capstones were *in situ*; the SE capstone had been dragged aside and has been reset. Most of the other capstones had been disturbed, broken or damaged, with only one *in situ* over the W chamber and

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another over the W end of the passage. Thurnam had already dug down into the W chamber in 1859, clearing it and part of the passage; however, he failed to notice the transepted chambers, which had been completely filled up with chalk rubble containing secondary deposits. Below this, on the original ground surface, were primary deposits of human bone, which showed evidence of periodic movement and rearrangement (Bayliss, Whittle, and Wysocki 2007, 95).

Resonance of the chambers

Each of the transepted chambers will resonate at a specific frequency when the air inside it is excited (the effect should be familiar to anyone who has sung in a bathroom!). My first experiments in 2011 were simply to make vocal sounds at different pitches inside the chambers and tune in to their resonances. When the resonant frequency is sung as a note, the chamber amplifies it and continues to ring on for some time after the note has ended. The resonances were then recorded *in situ* and their frequencies more accurately determined by matching them to an adjustable oscillator that produces a

Figure 1. West Kennet Long Barrow, entrance facade. (Author)

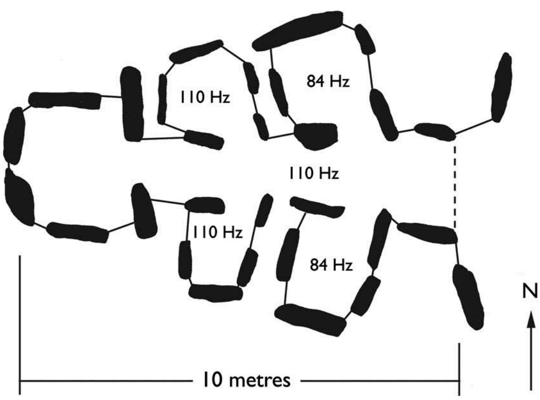

Figure 2. Approximate resonant frequencies of the WKLB. The stones of the forecourt are not shown. (Author)

sound and displays its frequency. Frequencies are measured in *Hertz* (Hz) – a unit known previously as *cycles per second* (cps).

These early investigations were reported in *Time & Mind* (Marshall 2011). I have recently refined and slightly modified my findings by making impulse recordings inside the monument and analysing their audio spectra, using open-source software that was not available in 2011.

The barrow entrance faces almost due east, with a sarsen forecourt open to the sky. A short distance inside the roofed central passage, on either side, are the first two chambers, the NE and SE. Both chambers were found to resonate at the same frequency of around 84 Hz. This is approximately the note E2 in western music, lowest open string of the guitar, and at the lowest limits of the Bass vocal range.

Moving along the passage, to the right is the NW chamber which resonates at about 110 Hz: the note A2. This is the second-lowest open string of the guitar, and at the low end of the Baritone vocal range. On the opposite side of the passage is the SW chamber, which is significantly smaller with a lower ceiling. This chamber is very rough and uneven, producing a comparatively weak resonance also around 110 Hz (A2). I had initially thought that the SW chamber had a higher resonance, but recent measurement has determined that it matches the frequency of its opposite partner.

At the end of the passage is the W chamber. Almost hemispherical, half of its ceiling is 2.2 m high and made of sarsen stone; the rest is a concrete slab with roof lights, set half a metre higher. The chamber is quite uneven; consequently, there seems to be no single resonant frequency. It is extremely resonant, but across a wide range of frequencies.

There is one more strong, clear resonance of about 110 Hz in the WKLB – another A2. It can be found in just one small area of the passage, between the first two chambers and only at head height. It is the most powerful of all the audible resonances in the monument.

Pitch and proportion

A blown bottle functions as a Helmholtz Resonator: its resonant frequency can be calculated using a formula in which the variables are the volume of the bottle and the proportions of its neck. Some small rooms resonate in this way but more commonly, they contain a collection of resonances at different frequencies known as ‘Room Modes’. These frequencies can also be calculated, as they are produced by standing waves of vibrating air that form between parallel walls; the longer the waves are, the lower their frequency (Alton Everest 1994, 265–294). A rectangular room will thus contain three fundamental resonances, dictated by the room’s length, breadth and height; there will also be higher resonances, harmonics of the fundamentals. The shape and unevenness of the WKLB's chambers makes it difficult to determine whether their resonance is produced by room modes or Helmholtz resonance, but a combination of the two seems likely.

Small rooms, such as bathrooms, commonly have resonances within the male vocal range, centred broadly around 100 Hz; these can enrich and amplify the sound of the voice significantly. This may have been exploited in the ritual use of prehistoric monuments. Resonances of 110 Hz in particular have been identified in several chambered tombs, a fact that has been widely reported (Devereux 2001).

In the WKLB the first pair of chambers resonate at a low note E2; the second pair of chambers and part of the passage resonate at the note A2 above it. This is a musical interval known as the *perfect fourth* – a pitch ratio of 4:3. (The hymn *Amazing Grace* begins with a perfect fourth.) This could be entirely coincidence, but may be worth investigating further. Stuart Piggott (1962, 15), who excavated and restored the WKLB in 1955–56, wrote: 'It is clear that some kind of a regular plan was envisaged, presumably to definite units of measurement and with a knowledge of ratios.'

Piggott may not have been thinking of audible ratios, but it is conceivable that the 4:3 ratio was recognised by the tomb builders and perhaps regarded with significance. The perfect fourth and its mathematical ratio can easily be found by anyone with an enquiring mind and a tensioned string such as a hunting bow. If a moveable bridge, perhaps a stone, is used to divide the string's length by 3/4 it will produce a note that is a perfect fourth above that of the open string. Similarly, division of the string by 2/3 will produce a perfect fifth, and division by 1/2 produces the octave. These three ratios are the basis of all ancient musical scales. As natural harmonics, they can also be produced by blowing a wind instrument at different intensities. The modern diatonic scale (do, re, me, fa, sol, la, ti, do) contains four intervals of a perfect fourth and was used in the tuning of Chinese flutes over 8000 years ago (Harrington 1999). The diatonic scale and a system of tuning using perfect fourths and fifths was already in use in Mesopotamia when written records began around 3000 BC (Drafkorn Kindler 1971).

It is clear that the size and shape of a chamber dictates the frequency and intensity of its resonance: the WKLB's two inner chambers are less resonant because their walls are not so parallel as those of the outer chambers. It may be that the resonant frequencies were not deliberately chosen or even recognised, but the fact is that there is a clear 4:3 ratio between the resonant frequencies of the two pairs of chambers. Whether this is the result of deliberate acoustical design, or an accidental product of the chambers' proportions is unknown, but, as I have already said, worthy of further investigation. Significantly, the floor areas of the inner and outer pairs of chambers also correspond closely to the 4:3 ratio.

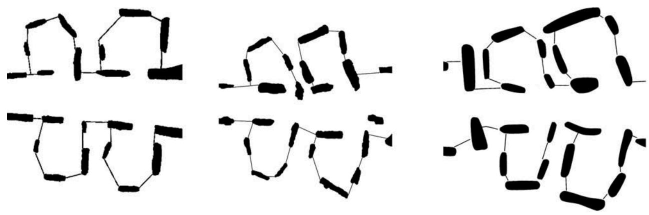

Figure 3. The transepted chambers of three similar long barrows, shown to a common scale. (Author)

The floor area of chambers in other monuments of the Cotswold-Severn long barrow group also show this 4:3 ratio in their design. Stoney Littleton, in Gloucestershire, appears in plan as a three-barred cross with two equal-sized cross bars and one bar that is longer: from measurements taken inside the monument, the ratio of their lengths is exactly 4:3. (4.4 m and 3.3 m) The Luckington barrow in Wiltshire had no passage, only side chambers: two of their lengths were again proportioned 4:3.

Two broadly contemporary Gloucestershire long barrows, Notgrove and Burn Ground, correspond closely to the design of West Kennet (Figure 3) – each had a central passage and two pairs of transepted chambers, with the inner pairs smaller than the outer, and both barrows were aligned with their entrance facing almost due east, as is West Kennet.

Unfortunately, Burn Ground was levelled in 1934 and the exposed stonework of Notgrove was covered with soil in 1976 to prevent damage, so neither monument can be investigated for resonances. The height of their ceilings is not known, so the resonant frequencies cannot be calculated. However, a comparison of the above ground plans shows that Notgrove and Burn Ground both have close to a 4:3 ratio in the relative floor area of their inner and outer chambers. It seems possible therefore, that both monuments had pairs of chambers that resonated at frequencies a perfect fourth apart.

Resonance of the central passage

From several initial tests it was apparent that the WKLB's central passage has a low resonance of below 20 Hz: these frequencies are below the 'threshold of hearing' and are known as infrasound. Most people cannot hear infrasound, although we can be aware of it as the low vibrations affect our bodies. Without specialist equipment it is difficult to record or quantify, as most microphones and loudspeakers also have a reduced response below 20 Hz; however, a sound level meter will give indications of infrasound.[1] In 2011, I derived the resonant frequencies of the passage by calculation alone.

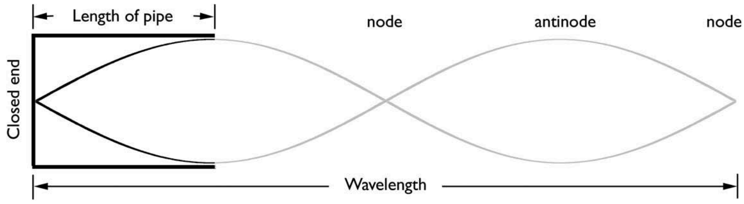

Figure 4. Fundamental resonant frequency of a pipe closed at one end; only a quarter of the fundamental standing wave is contained within the pipe. (Author)

The central passage is 10 m long, if the chamber at its W end is included. Using a simple formula, its resonant frequency can be calculated to around 8 Hz. The actual frequency depends on the velocity of sound, which varies considerably with temperature and to a lesser extent with humidity.[2] If the column of air in the passage oscillates only eight times each second, this is a frequency so low that it could be regarded more as a rhythm than a note. Air is elastic; in a pipe closed at one end, the air can be made to oscillate longitudinally. At the pipe's closed end will be a 'node' – a region of minimum movement, and at the open end a region of maximum movement – an 'antinode' (Figure 4).

A large pipe has a fundamental frequency that may be so low in frequency as to be inaudible; it will also produce higher frequencies that are naturally-occurring *harmonics*, or multiples of the fundamental frequency. In a vibrating string, or a pipe that is open at both ends, there would be a harmonic for every integer multiple of the fundamental frequency *f*: *f* x 2, *f* x 3, *f* x 4, *f* x 5, and so on. This continues on to infinity, with each harmonic decreasing in intensity. But a pipe closed at one end has no even-numbered harmonics, so the next resonances in

Figure 5. The WKLB's central passage, looking into the W chamber. (Author)

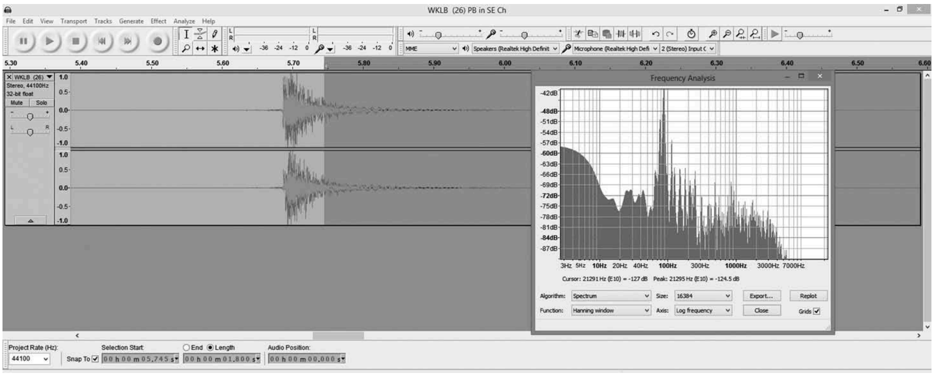

Figure 6. Recording of a ‘paper-banger’ impulse made inside the SE chamber. The spectrogram seems to show that as well as the expected chamber resonance of around 84 Hz, the infrasonic passage resonance has also been excited. (Author)

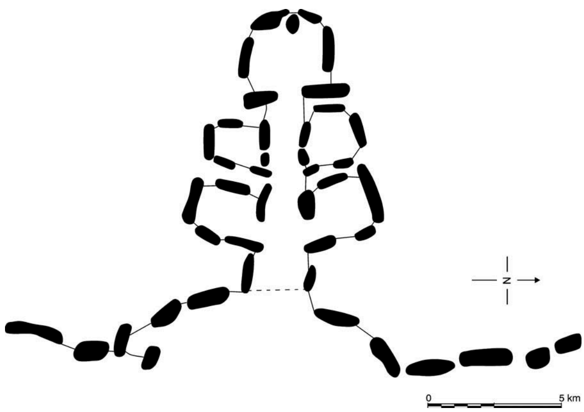

Figure 7. West Kennet long barrow in its original form, showing forecourt without the later blocking stones across the entrance. (Author)

the barrow passage will be the third and the fifth harmonics (*f* x 3 and *f* x 5). Both are very low in pitch but audible, and it is these two frequencies that can be heard when the passage is made to resonate.

Altered mind states

It is possible that very low frequencies, such as those of the WKLB’s central passage, may affect mentation. The billions of neurons in the human brain electrically fire in sequence, with a periodic wave motion that can be detected by an EEG machine. The speed of this oscillation varies, and certain frequencies are associated with particular mental states. The frequency of brainwaves can be deliberately manipulated by stimuli such as flashing lights (strobing), oscillating magnetic fields, and sound – the brain will ‘lock in’ to the frequency of the stimulus and begin to ‘entrain’ or oscillate in sympathy with it. Some shamanic drummers can allegedly produce trance states by simply beating a drum at the required brainwave frequency (Vitebsky 1995, 80).

Theta brainwaves oscillate at between 5 and 8 Hz – they are associated with daydreaming, meditation, creativity and pre-sleep. *Alpha* waves, between 8 and 13 Hz, are produced by those skilled in deep meditation techniques. *Alpha* waves are claimed to promote creativity and accelerated learning, as well as a relaxed and pleasant state of awareness. Since the WKLB can produce low frequency sound, it can potentially also produce altered states of consciousness when resonated.

Resonating the passage

In practice, the resonant frequency of the WKLB's passage is not so easy to calculate precisely. For a round pipe, 10 m long and closed at one end, the resonant frequency is around 8 Hz: this may be applied to West Kennet if we assume that the W chamber is part of the passage. But the chamber is sub-circular and more than twice as wide as the passage, so it could be regarded more as a Helmholtz resonator than a pipe: it likely functions as a combination of the two. Both chamber and passage are very uneven, and the rectangular passage is slightly conical, so the resonant frequency cannot be calculated with just a simple formula.

My early experiments involved playing drums inside the structure. The passage's resonant frequency is so low that it is possible to play it as a rhythm. (The synthesiser pulse of Donna Summer's *I Feel Love* gives a rough indication of its periodicity.) Recent analysis of impulse recordings suggests that the resonant frequency is likely 9 Hz.

Quantifying the resonant frequencies

In October 2015, I made a number of recordings inside the WKLB which were later used for spectral analysis. A Zoom H1 flash recorder was mounted on a tripod, set to approximately the height of a person sitting on the floor (1 m) and also used at standing height. Balloons were burst and bullroarers whirled in the forecourt, just outside the barrow's entrance, and recorded from different positions inside the monument. More impulse recordings were made using a 'paper banger' next to the microphone, inside each of the chambers. The recordings were analysed using open source software (the Audacity sound-editing programme).

On the day the recordings were made there was a strong wind blowing from the north, across the east-facing open mouth of the WKLB. This is highly unusual, as the wind in that area is almost always from the west. Although the wind lessened over the two hours or so spent recording, it appeared to be resonating the passage, particularly at the start of the session. Spectrograms of what was first assumed to be silence inside the barrow suggest there was actually a high level of infrasound, though this is difficult to ascertain absolutely.

Recording and identifying infrasound is fraught with difficulty, since its frequencies are below 20 Hz – the lower limit of almost all audio equipment. The Zoom H1 is a high quality recorder and microphone unit, but its frequency response tails off below 20 Hz; any software used to analyse sound spectra will also not be designed for use below 20 Hz. Consequently, extreme caution is advised when attempting to interpret spectrograms of low frequency sound: the self-noise of the equipment and of the digital sampling process can produce anomalous peaks that closely resemble the resonances being studied.

Spectral analysis seems to indicate that the WKLB's passage actually resonates at 9 Hz, rather than the 8 Hz derived by calculation. However, this is not absolutely certain and the passage resonance will be examined again at some future time, when specialised low frequency equipment can be obtained. From recordings made in the WKLB it seems that the infrasonic resonance of the passage is easily activated, by even such slight sounds as footsteps. Recordings made in the four transepted chambers indicate that infrasound permeates the entire structure.

Spectrograms of the audible resonances are more reliable, and they reveal that each of the four transepted chambers simultaneously resonates at several different frequencies. The resonant note E2 that is perceived in the two largest chambers is actually midway between two strong resonances found in both chambers – there are peaks of 77 and 86 Hz in the SE chamber, and 77 and 87 Hz in the NE chamber. The two smallest chambers (SW and NW) resonate at the note A2; there are other frequencies present but the dominant resonances of the SW and NW chambers are 112Hz and 113Hz respectively. The A2 resonance found in one small area of the central passage has now been identified as 111 Hz.

At the time of writing (November 2015) the WKLB is undergoing work to repair several leaks, install glass roof-lights and replace some of the replica dry stone walling that has rotted since the 1955 reconstruction. It will be interesting to see whether these modifications have any impact on the acoustics.

Use of the passage resonance in ritual

Whilst the chambers of the barrow were certainly used as an ossuary, the precise function of this and other long barrows remains to be determined. Certainly ritual and/or ceremony is to be expected. In many traditional cultures, coming-of-age ceremonies involve terrifying and disorienting those who are initiated (van Gennep 1960, 124–125); the chambers of the WKLB would have been ideally suited to this. Dark and reeking of death, they would have contained human bones and partially-decomposed corpses, some perhaps arranged in a sitting or squatting position (Darvill 2010, 150). This, combined with the acoustical effects, must have been overwhelming for initiates who had been ritually prepared and primed for an extraordinary experience, including perhaps by deprivation of food, water and sleep, and ingestion of plant hallucinogens.

All of my first experiments in the WKLB in 2011 involved making sounds in the chambers and listening for effects in the passage; eventually I came to realise that this was the wrong way around. If the monument was used for rituals of initiation, then it is more likely that sounds would have been made outside the passage, with initiates occupying the chambers. The monument may have been made to resonate by drumming, chanting or perhaps whirling a bullroarer from the forecourt. Widely associated with coming-of-age rituals, the bullroarer produces low frequency infrasound that inside the long barrow can evoke altered states, producing fear and the strong sense of a 'presence' (Tuzin 1984). In traditional cultures the bullroarer is often described as 'the voice of the ancestors'.[3]

When a bullroarer is whirled in the WKLB, its effect on the acoustics is spectacular. As soon as the bullroarer begins to spin, the entire barrow comes alive with sound and the impression of movement. Most people who experience this have instant and similar reactions, which include goose-bumps and shivering, a sense of excitement and danger, mild panic and impressions of a 'presence'. For myself, alone in the dark on a winter's night, the impression that there was another person in the chamber was overwhelming. These are natural responses to infrasound, with the low, inaudible frequencies triggering an innate flight instinct.

Further experiments showed that any sound made in the WKLB's forecourt causes the passage to resonate: the shape of the forecourt helps to 'funnel' sound into the passage. Whirling two bullroarers together in the forecourt was found to be particularly effective, producing a booming sound throughout the entire structure.

In 2011, in order to study the possible effect of the passage resonance on a young initiate, an enthusiastic 14-year-old boy was used as a test subject. Late one summer evening, he sat alone in the W chamber in near darkness, as the passage was resonated. In the forecourt a skilled drummer played a miniature bass drum loudly with sticks, at a constant tempo of just over eight beats per second. The boy later reported that with eyes open, he could just make out the end stones of the W chamber, which at first appeared to be moving slightly. On one stone of the back wall a small black circle appeared, which grew in size; it took on the appearance of a passage leading to another chamber, which he thought he could see in to. He then continued to listen with eyes closed and was convinced that on two occasions someone had joined him the chamber, but he had been entirely alone. Later, an adult sat in the W chamber in total darkness as the drums continued to play. After 10 minutes he felt disoriented and confused, unsure of exactly where he was in the chamber.

I then experimented on myself using 'binaural beats'. Two identical audible tones were fed to a pair of headphones, one tone to the left ear and the other to the right. The tones were tuned apart by 8.5 Hz, producing a regular beat frequency of 8.5 Hz between my two ears. After listening with closed eyes for about 10 minutes I suddenly had the powerful sensation of rising rapidly into the air! This was unexpected and very alarming. After only a second or so I panicked and dropped quickly to earth from what seemed to be a height of about 4 m. I resumed listening with eyes closed and after five minutes I felt myself ascending once more. The sensation was much milder, since I was prepared for it, and quickly passed.

These findings suggest that sounds made in the forecourt can indeed produce changes in the brainwave patterns of someone in the W chamber. Although drums seem to be an efficient way of resonating the chamber, particularly drums with powerful low frequencies, drumming at a tempo to exactly match the resonant frequency of the passage is not necessary. In fact, in attempting to produce altered states by infrasound, using drums at all may be regarded as using a sledgehammer to crack a nut. There is research indicating that loud sounds are not essential for brainwave entrainment, as the brain will respond to extremely low levels of infrasound (Leventhall 2003, 9.1). It is possible that in the WKLB vocal chanting, or under the right conditions even footsteps, may be enough to produce an effect: this may explain the many reports of strange experiences inside the monument.

The WKLB is not entirely unique in respect of the resonances of the chambers: it is likely that brainwave entrainment could be produced by other monuments, when made to resonate. There is great variation, even among those classified as Cotswold-Severn long barrows. Not all have a central passage: the Lanhill barrow for instance, not far from Avebury, has only small chambers accessed from outside. However, there are at least a dozen other Neolithic tombs around Britain with passages that have the potential to influence brainwaves.

In order to test this further I whirled a bullroarer outside the entrances of several other chambered passage graves, including Newgrange and Fourknocks in Ireland, Barclodiad-y-Gawres in Anglesey[4] and the three dolmens of Antequera, southern Spain. In all cases infrasound could be clearly felt by the people inside.

Discussion

It takes little imagination to see how the WKLB's unusual sound properties may have been regarded as 'magical' to Neolithic people. The idea of using the WKLB as a 'performance space' for drums, bullroarers or vocals may, of course, have been anathema to its builders; it was, after all, the tomb of 36 individuals (Bayliss, Whittle, and Wysocki 2007, 86) and entering for any other reason than to deposit or arrange remains may have been taboo. Yet there are indications that it was intended for use by the living as well as the dead. The roof is just over 2 m high, unnecessarily tall for its purpose as a tomb, and making it easy for anyone to move around inside; also, the deposited bones were arranged against the back walls of all the chambers, suggesting that there was a space in each allocated to the living.

Long barrows are intrinsically liminal. Widely thought to have functioned partly as tribal or clan boundary markers sited at the edge of territories, they are also a place where two worlds coincide – those of the living and the dead. The chamber resonances are at the lower limits of two male vocal ranges: if they were used ritually, by chanting or singing at their resonant frequencies, the sound would have been impressive. A2 is at the lower limit of the Baritone (the most common range) and E2 at the lower limit of the Bass range. Voices generally deepen with age: I could not sing an E2 with any power until I reached my 50s. It is possible that in prehistory, only a male 'elder' would be capable of resonating the two eastern chambers by voice.

The separation of the senses is a modern concept: in Neolithic times it is likely there was only 'sense'.[5] The WKLB's central passage produces resonances that are midway between a note and a rhythm; barely detectable as sound, they are felt rather than heard. These resonances can produce feelings of fear and panic, and strong impressions of a presence. To the tomb's builders and their descendants, the unusual acoustics may have been perceived as the literal presence of dead people or their spirits. Finally, the lowest resonances of the tomb have the power to induce sleep or trance – that mysterious region between waking and sleeping, between life and death, where the material world and the spirit world meet.

Acknowledgements

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Notes

1. Standard sound level meters are switchable between A-weighting or C-weighting: each mode is sensitive to a different range of frequencies. If the sound levels measured by both modes differ by more than 20dB, there is likely to be infrasound present (Leventhall 2003, 8.2.7). In 2011, when drums were played in the W chamber of the WKLB, A and C-weighted readings taken in the passage differed by up to 30 dB.
2. The resonant frequency of a 'closed pipe' (open at only one end) can be calculated by the formula f = c/4L where c is the velocity of sound and L the length of the pipe. Because the interior of the WKLB is usually cool and damp, the velocity of sound used

throughout this paper for calculations is 337.8 m/s. This assumes a temperature of 10 deg C and relative humidity of 50%, as recorded many times inside the structure during the early spring of 2012.

3. Widely claimed to be the world's oldest musical instrument, the bullroarer is usually a thin slat of wood or bone shaped like a fish; when tied to a string and whirled it spins, producing a low humming sound, as well as other frequencies too low to hear. Almost every culture in the world has independently invented the bullroarer; curiously, the mythology and tradition surrounding it is also universal. Associated particularly with male initiation rituals, women are often not allowed to see or hear the bullroarer, or even to know it exists. It is so ubiquitous that it would be surprising if it was *not* used in Neolithic Britain. Examples have been found across Europe dating from as early as the Palaeolithic; a likely bullroarer made of antler from La Roche, Lalinde, Dordogne, is thought to be 15,000 years old (Bahn 1997, 85). No wooden examples from Britain have yet been identified, though it is possible that some may have been found but not recognised. Ponting in 1882 found "a singular piece of wood in the form of a knife" inside a round barrow on Overton Hill. Although deposited in Devizes, it has not survived (reported in *Wiltshire Archaeological Magazine*, 1882, Vol. xx, pp. 342–345). However, research has shown that knapped flint knives, ritually deposited in their thousands across Britain but showing no signs of use, will function as bullroarers when attached to a string. It may be that the flint versions, if that is what they are, symbolised wooden bullroarers, which are generally louder and less dangerous to use (Marshall 2010).
4. In October 2014, Paul Devereux conducted an acoustical resonance test inside Barclodiad-y-Gawres [Ed. see the Exhibition Review by Nicholas Usherwood in 8:4 (http://dx.doi.org/10.1080/1751696X.2015.1111565) that yielded acoustic resonance frequencies in the range relating to aeroforms such as bullroarers. He qualified his findings, however, in light of the fact that the monument is now covered by a protective concrete dome (Devereux, pers. comm. October 2015).
5. There are vague references to the senses in the later Vedic scriptures of India, dating from 1000 to 500 BC. The earliest detailed description of the separate senses is probably in Plato's *Timaeus*, written around 400 BC (Jütte 2005, 20–36).

Notes on contributor

For 30 years Steve Marshall was a professional musician and sound engineer, working for a time as a composer in the BBC Radiophonic Workshop. He now researches the monuments and landscape of Avebury. His book *Exploring Avebury: The Essential Guide* will be published by The History Press in May 2016. The spectrograms, the sound samples used to create them, and more information on the WKLB may be found on the author's website: www.exploringavebury.co.uk

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