

The acoustics of archaeological architecture in the Near Eastern Neolithic

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Abstract

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The analysis of acoustics in prehistoric architecture has generally been limited to extant structures, using experimental techniques to physically measure the acoustic properties of the space. These methodologies are not applicable in many prehistoric contexts though, as the structures are rarely preserved higher than the foundations. Using digital reconstructions of the spaces, it is possible to calculate the reverberation time as well as the proxemics, and deduce what type of event could have been accommodated. This methodology has been applied to a series of enigmatic structures at Near Eastern Neolithic sites, where archaeologists believe group gatherings may have occurred, to determine whether speech would have been comprehensible.

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Keywords

Acoustics; reverberation time; Pre-Pottery Neolithic; proxemics; Göbekli Tepe.

Sound is an integral part of human experience. The importance of sound in daily life means that the way spaces propagate sound and their acoustics have a large impact on the perception of events taking place within them. While there are many complex models available to calculate the precise way that sounds behave in particular environments (e.g. Brooks 2003; Mehta et al. 1999), these methodologies are not necessarily applicable archaeologically since in most cases ancient buildings are not preserved to any great height, making the complex calculations too speculative. This means that alternative methodologies have to be explored for the study of the acoustics of many archaeological structures.

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Sound has often been overlooked in modern Western culture, where sight is prized above all other senses (Ong 1991; Smith 2007, 8–11). While the dichotomy between sight and sound has been criticized (Ingold 2000), researchers have nonetheless continued to prioritize sight and vision, overlooking the other important ways in which people interact with their environment: sound, touch, smell, taste, temperature, balance and bodily awareness (Henshaw 2012, 7).

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Anthropologists therefore struggle to incorporate sensory perception into studies of other cultures. For example, when Stoller studied the Songhay in Niger, he was told he needed to hear, not just listen, as he was incapable of learning the Songhay way of life without perceiving the world as they did (1989, 15). This cultural aspect of sensory perception makes it difficult to explore the way senses and bodies mediated experiences in the past and archaeologists are only now beginning to examine and address these issues. 30

The human ear can hear sounds over a range of frequencies, from 20Hz to 20,000Hz, as well as a range of intensities over 120dB. Ears can compensate for changes in atmospheric pressure and temperature, function in water or air and can not only detect but locate sounds (Henshaw 2012, 139–40). The physical organ receives and transmits sound waves to our brains, where the sounds are interpreted. While the interpretation of these waves is cultural, the behaviour of the sound waves is not; therefore, the only sure way of examining the senses in the deeper past is through a focus on a purely physical analysis of the behaviour of sound in space. 35 40

Background

The oversight of sound in archaeological accounts of the past is now beginning to be addressed. Studies have particularly focused on quantifying acoustic phenomena at well-preserved enclosed, or partially enclosed, prehistoric structures, mainly in the UK (Devereux and Jahn 1996; Jahn et al. 1996; Watson and Keating 1999) but also including rock art locales in other regions (Boivin 2004; Boivin et al. 2007; Dayton 1992; Ouzman 2001). In most of these studies, the researchers used sound equipment to measure the resonance frequency of spaces, and, in some cases, Geographic Information Systems (GIS) reconstructed the way that sounds would have been perceived in the landscape (Mlekuz 2004). These methodologies have led to discussions about whether the acoustic properties of places were intentional. 45 50

That said, these phenomenological experiments, where the resonance frequencies of extant structures are measured, are not methodologies that can be used in many archaeological cases as most structures are not fully preserved and it is not clear what types of sounds may have been created in these spaces. This means that sound has been passed over, except in certain rare circumstances of excellent preservation. One area where sound has been overlooked due to poor preservation is in the Near Eastern Neolithic. In particular, there are a series of enigmatic structures found at a number of different sites across the region that are believed to be non-domestic, used for group gatherings, and often interpreted as ritual spaces (Kornienko 2009; McBride 2012; Verhoeven 2002). These structures are not well preserved, and generally consist of stone foundations only a few centimetres to a single metre in height. In this article, I develop a methodology to analyse the acoustics of such spaces using reverberation time, proxemics and digital reconstructions and apply it to the unusual structures found at three Neolithic sites: Göbekli Tepe, Nevalı Çori and Jerf el-Ahmar. 55 60

Case studies

Large communal structures have been found at a number of Near Eastern Neolithic sites, but there has been little consensus as to their function and use. Early interpretations assigned them a ritual role, but did not clarify what that would have meant for participants. More recent study 65

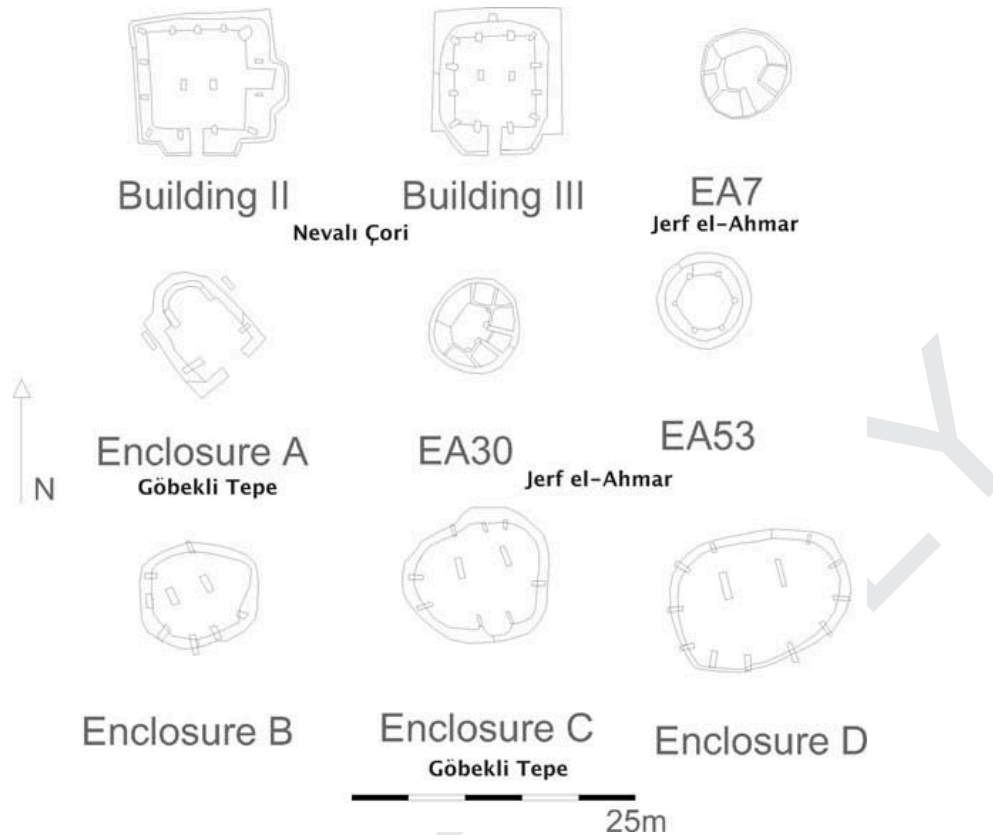


Figure 1 Case-study structures.

has shown that they would have provided excellent venues for group gatherings, but without elucidating what people were actually doing (Kornienko 2009). The structures themselves were left clean, so there are few artefacts to clarify their use, meaning that only the physical reality of the structures remains. Three Near Eastern Neolithic sites have been chosen as case studies to demonstrate how the calculation of reverberation time and proxemics can be used to enhance understanding of similar archaeological remains, in this case Göbekli Tepe, Nevalı Çori and Jerf el-Ahmar (Fig. 1). These structures have varying levels of preservation, and AutoCAD is used to reconstruct the missing architecture where required. The monumental architecture at each of these sites is described below, as well as evidence relating to the walls, roofing, doors and any other material that might affect the behaviour of sound within the buildings.

Göbekli Tepe is located 15km north-east of Urfa in south-eastern Turkey and has been dated to the Pre-Pottery Neolithic A (PPNA) period, with later levels dated to the Early Pre-Pottery Neolithic B (EPPNB) (Schmidt 2010, 240). The site had a series of monumental oval structures (Fig. 1) that have been interpreted as non-domestic and were lined with megalithic T-shaped pillars with two larger T-shaped pillars in the centre of the structure (Schmidt 2003, 2004, 2010). Many of these pillars were decorated with images, including arms, suggesting that the pillars themselves were anthropomorphic. The perimeter pillars were approximately 3m tall, while the central pillars were almost 5m tall. These pillars could have provided support for a roof, as well as a focus for attention, and appear to have been set into bedrock pedestals (Schmidt 2010, 243). There is also evidence for benches around the perimeter of the enclosures.

The way that these enclosures were roofed (and indeed *if* they were roofed) would have had a significant impact on their acoustics. However, roofing at these sites has proved difficult to determine archaeologically. While the excavators originally suggested that the Göbekli Tepe enclosures were unroofed (Schmidt 1999, 2001, 51), there is equally little to suggest that the interiors were exposed to the elements, especially as the excavators have described how fragile the mortar is, and how quickly rainwater washes it away (Schmidt 2010, 241). However, it has also been suggested that the structures might have been constructed, used, abandoned and then filled in quick succession, which would negate the effect of exposure to the elements (Schmidt 2001, 46). Yet there is imagery found at the site that suggests that the roofs of these structures were domed or had rounded openings, as well as evidence for preparation on the tops of the pillars that would have facilitated the installation of a roof (Banning 2011, 629–631). Additionally, the structures at Nevalı Çori had similar pillar arrangements and are believed to have been roofed (Hauptmann 1999, 75). Therefore, the calculations below have used a model where the enclosures were roofed, though the model can be modified easily should further information be forthcoming.

There is also little evidence for entrances to these structures. The excavators have suggested that enclosure C was entered from the south, along a causeway marked by a monumental U-shaped stone, porthole stone and stairway (Dietrich et al 2013, 2014, 11–12; Schmidt 2007). However, while there is a thinning of the wall of enclosure C at this point, no clear entrance has been found at any of the enclosures. This lack of evidence is not crucial though as the calculation of reverberation time relies on the size of the opening rather than the exact location. Therefore, the doors at Göbekli Tepe have been modelled as a similar size to the structures at Nevalı Çori (below), where there is better evidence for the entrances.

Jerf el-Ahmar is located in Syria 100km east of Aleppo, just south of the Turkish border (Stordeur 1999, 132). The excavators have identified five potential non-domestic structures: the Aurochs house, EA7, EA30, EA53 and EA100 (see Fig. 1). These structures were so identified as they differ radically from the typical structures found at the site. The Aurochs house and EA100 were very poorly preserved and are not studied in detail here (Stordeur 1999; Stordeur et al. 2001, 40).

The earliest non-domestic structures at Jerf el-Ahmar were multi-celled spaces: EA7 in the east and EA30 in the west. Both EA7 and EA30 were subterranean and circular, unlike the contemporary domestic architecture, which was built above ground and was sub-rectangular (Stordeur et al. 2001; Stordeur and Abbès 2002, 568). The buildings were accessed through the centre of the roof via a ladder which would have been a central feature of the structures, though the only evidence for such ladders is a small depression in the floor of the later EA53 (Stordeur et al. 2001, 35, 40).

EA30 was subdivided into small cells arranged around the eastern perimeter. There was a low step in the north-east and south-east corners of the central space, suggesting that the five perimeter cells had low walls to permit access (Stordeur et al. 2001, 35). The central cell had no step and was lined by the full-height support walls; however, in the front wall of the cell there was a small rectangular opening close to the floor perhaps to insert items (Stordeur et al. 2001, 35). Opposite the cells on the western edge of the structure were two bench sections, while the central area of the structure was open to accommodate the ladder.

EA7 was not as well preserved as EA30, and has therefore received less attention, but similar features were found. There were at least three small cells lining the southern wall, and a bench ran along the perimeter of the northern wall (Stordeur 1999, 141). It is unclear how high the dividing walls for the small cells were. Based on comparisons with EA30, the perimeter cell walls have been modelled as 1m high. As no evidence has been found for other roof supports, it

is likely that there were two full height walls, as was found in EA30, and the structures have been modelled as such below.

After the abandonment of EA7 and EA30, single-celled non-domestic structures EA53 and EA100 were constructed. EA53 was best preserved and consisted of a single round subterranean structure, 7m in diameter. EA53 was very different from the earlier structures as it was not subdivided into small cells. The space was lined with a 1m-wide stone bench, creating a hexagon around the perimeter of the building (Stordeur et al. 2001, 38). At each angle of the hexagon there was a plaster-lined wooden post to support the roof instead of the supporting walls found in EA30. The front of the bench was lined with stone slabs decorated with a hanging triangle motif (Stordeur 2000; Stordeur et al. 2001; Stordeur and Abbès 2002, 572–3). The bench also had wear impressions on the top, indicating where people sat, as well as some graffiti (Stordeur et al. 2001, 40).

Nevalı Çori is located in the Kantara Valley in Urfa province of Turkey, about 3km south of the Euphrates (Hauptmann 1999, 70; Mellink 1990). A total of twenty-nine houses, plus two larger non-domestic structures, were excavated (see Fig.1) (Hauptmann 1999, 70).

Cult building II was the earliest excavated non-domestic structure at Nevalı Çori. The structure was almost square and lined with a bench made of large stone slabs. A large niche was located in the eastern wall, and there were monumental pillars around the perimeter, possibly as roof supports. There also appear to have been two central pillars (Hauptmann 1999, 75).

Building II was replaced by cult building III, constructed inside the walls of the preceding building II. It was slightly smaller, and was also lined with a stone bench and standing stones around the perimeter. Remains of two standing stones were found set in the centre of the structure, matching the scars found in the earlier cult building II. These standing stones had depictions of bent arms on the long sides and fingers and hands on the narrow edge, prompting the suggestion that they were anthropomorphic. Finally, a niche was built into the back wall of building III, carefully placed to be visible between the two central pillars (Hauptmann 1999, 75).

In summary, these three sites all have evidence for structures that were significantly different from contemporary domestic architecture. In general, the structures were larger than the common architecture at the site, while also having features that marked them as distinctive, such as benches and monumental standing stones. This means that the builders deliberately chose different layouts and features, indicating that the spaces were perceived differently from domestic architecture. One way that we can determine how these structures were used is by determining how people could have interacted with them through analysis of what they could have heard and understood. This means calculating the reverberation time and examining the proxemics of the structures.

Methodology

Acousticians and engineers regularly model the behaviour of sound in spaces using computer and other methodologies (Brooks 2003; Lord and Templeton 1986; Mehta et al. 1999). These methodologies are very detailed, calculating the reflection of sound off every surface and angle within the space. This is impossible for structures that are not standing, as there are so many details missing concerning the construction and angles of the upper walls and roof that would have affected the behaviour of sound. Therefore less detailed methodologies are required to examine the acoustics of such ruinous structures.

The calculation of reverberation time is a less detailed methodology that can be applied to digital reconstructions of such structures. Reverberation time refers to the time it takes for echoes to die away in a space, and requires only information concerning the volume and surface areas of the space and the construction materials used (Cross and Watson 2006, 21; Kuttruff 1991). This measurement affects the clarity of sound within a space, ‘adding a warm glow and a sense of envelopment to music or interfering with speech’ (Brooks 2003, 21). Generally, it is understood that for speech, a reverberation time between 0.4 and 1.0 seconds is ideal (Long 2006, 585–6). When the reverberation time is longer than this, echoes smear following syllables, making speech unintelligible (Brooks 2003, 89; Lord and Templeton 1986; Mehta et al. 1999). These longer reverberation times would be best suited for sound sequences that have a slower pace or sounds where blending heightens their efficacy, such as non-lyrical music (Cross and Watson 2006, 110). Understanding the reverberation time of a space therefore gives us a better understanding of how people would have experienced speech and music within these spaces, and may have constrained how they used them.

The general formula for the calculation of reverberation time appears in Fig. 2. In short, reverberation time is calculated by multiplying the surface area of each material in a structure (including construction materials, soft furnishings and people) by its corresponding absorption coefficient to determine its absorption area, followed by multiplying the total of these absorption areas by a constant (0.16) and the total volume of the space (Kuttruff 1991). The absorption coefficient refers to how much sound is absorbed into the fabric of a particular material and, by extrapolation, how much sound would have reflected within the space (Kuttruff 1991, 270). In most cases, it was easy to find modern equivalents for the ancient materials found in the case-study structures (see Table 1), but the roofs of the structures proved difficult due to lack of evidence. I have assumed that the roofs of the non-domestic structures were constructed using wooden beams, organic material and mud plaster, and used the absorption coefficient of fibre-reinforced mudbrick to represent this (Binici et al. 2009, 1040). Additionally, as the number of people in the structures would have greatly affected the reverberation time, approximate numbers of people within the spaces are taken from McBride’s (2012) calculation of capacity.

AQ1 Digital reconstructions of the case-study structures are used to calculate the reverberation time, using AutoCAD to calculate their surface area and volume. These AutoCAD reconstructions require assumptions to be made. The roofing of all the case-study structures is assumed to have comprised organics, such as wood and reed, with mud or plaster. None of the structures is preserved to full height but the model assumed a height of 3m in each case. Access to the structures varied, with the subterranean structures at Jerf el-Ahmar accessed via a small hole in the roof and a ladder, while the structures at Nevalı Çori and possibly Göbekli Tepe were accessed by doors. The evidence for the entrances at Göbekli Tepe is not clear, as was discussed earlier, but the entrances at Nevalı Çori were very well preserved, with several paved steps down to the floor, indicating the width of the entrances. The doors have been modelled as 1.8m high, and these dimensions have been applied to Göbekli Tepe as well. Additionally, I have

$$\text{reverberation time} = 0.16 \times \text{volume of the room} \times \sum \text{absorption areas}$$

$$\text{absorption area} = \text{area (or number of people)} \times \text{absorption coefficient}$$

Figure 2 Formula for the calculation of reverberation time.

Table 1 Absorption coefficient for common PPN building materials

<i>Material</i>	<i>125Hz absorption coefficient</i>	<i>500Hz absorption coefficient</i>	<i>2000Hz absorption coefficient</i>
People	0.05	0.25	0.25
Stone	0.02	0.02	0.05
Hardwood	0.14	0.06	0.1
Plaster over organics	0.33	0.6	0.8
Plaster over solid walls	0.03	0.02	0.04

assumed that wooden doors stood in the entrances. Despite the uncertainty of the height of the walls and doors, as well as the nature of the roofing, the digital models are easy to modify as new information and evidence becomes available.

Reverberation time is not the only factor that affects the intelligibility of speech within a space, as the human body limits the distances over which people can interact. Hall (1969) studied the way people used space in communication, a methodology referred to as proxemics. He determined that there were defined distances at which people interacted, with differing levels of communication possible at each one: personal, social, close public and far public (see Table 2). Personal distance is generally close enough for people to reach out and touch each other or clasp hands and a fine level of detail is perceptible, particularly around the eyes, and subjects of personal involvement can be discussed at this distance. At social distances, people do not expect to be touched and conversations can proceed at a normal volume. At close public distances, speaking volume must be raised and subtle facial expressions are lost, while at far public distances gestures must be exaggerated and speech must be amplified. Public distance is the distance of public address or theatrical performance, rather than conversation, and much communication takes place through gesture and body stance (Hall 1969, 119–25). Clearly, the distance at which people interact greatly influences the types of activities they can participate in. Measurement of these non-domestic structures clarifies the way that participants *could* have interacted, refining our understanding of the types of events that may have taken place within them.

Analysis

Calculation of the reverberation time of these structures is straightforward using a digital reconstruction of the spaces. AutoCAD provides easy calculation of the surface areas and volumes of the spaces, while archaeological evidence provides information concerning the

Table 2 Interaction distances (adapted from Hall 1969, 126–7)

	<i>Personal</i>	<i>Social</i>	<i>Close public</i>	<i>Far public</i>
Distance	0.45–1.2m	1.2–3.6m	3.6–7.6m	7.6m+
Interaction	Touching	Normal conversation	Raised-volume conversation	Exaggerated gestures and amplified volume

materials used. Using the formula discussed above in Fig. 2, the reverberation times of the structures can be determined. In each case, reverberation time has been calculated three times, once as if the structure was empty, once as if full of people and once as if with the structure two-thirds full. This gives a realistic range of reverberation times. All the reverberation times are recorded as a range, as different frequencies have different behaviours. One example of the calculation can be found in Table 3, while the rest of the results are in Table 4. 240

The reverberation times of all of the case-study structures would have fallen generally within the range that was ideal for speech, between 0.4 and 1.0 seconds. The exception is Göbekli Tepe, where there were longer reverberation times that were over the ideal range for speech intelligibility, between 1.0 and 1.6 seconds. These longer reverberation times were found mainly in the lower frequencies, around 125Hz. As human speech generally falls in the range 80–500Hz (Raphael et al. 2011, 30), the longer reverberation time for the lower frequencies in these enclosures might have impeded the intelligibility of male voices more than female voices. 245

Table 3 Calculation of the reverberation time in building II, Nevalı Çori

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Volume, m ³	Full	$\frac{2}{3}$		
People:	80	53		
Surface	Area, m ²	125Hz absorption coefficient	500Hz absorption coefficient	2000Hz absorption coefficient
Floor	74.05	0.03	0.02	0.04
Ceiling	134.89	0.33	0.6	0.8
Door	2.38	0.14	0.06	0.1
Walls	137.97	0.03	0.02	0.04
Bench	53.32	0.02	0.02	0.05
Reverberation time (empty)		1.1	0.7	0.5
Reverberation time ($\frac{2}{3}$ full)		1.1	0.6	0.4
Reverberation time (full)		1.0	0.5	0.4

Table 4 Reverberation time in seconds of 125–500Hz in the non-domestic structures at Jerf el-Ahmar, Göbekli Tepe and Nevalı Çori

Building	Time – empty	Time – $\frac{2}{3}$ full	Time – full
EA7	0.6–1.0	0.5–0.9	0.5–0.9
EA30	0.6–0.9	0.5–0.9	0.5–0.8
EA53	0.6–1.0	0.5–1.0	0.5–0.8
A	0.9–1.5	0.8–1.4	0.7–1.3
B	1.0–1.5	0.8–1.4	0.7–1.4
C	1.0–1.6	0.8–1.5	0.7–1.4
D	1.0–1.6	0.8–1.5	0.7–1.5
II	0.7–1.1	0.6–1.1	0.5–1.0
III	0.7–1.1	0.6–1.0	0.5–1.0

Table 5 Measurement of the case-study structures

<i>Building</i>	<i>Length</i>	<i>Width</i>	<i>Radius</i>
EA7	7.47	7.03	4.01
EA30	7.19	6.26	3.63
EA53	6.1	6.1	3.24
II	9.79	9.46	5.25
III	8.71	7.73	5.68
A	8.36	6.01	4.25
B	9.33	7.84	4.84
C	11.13	10.06	5.85
D	14.63	10.24	6.67

Regardless, the four structures from Göbekli Tepe might have reverberated sufficiently in the lower frequencies to impede clear conversation. Interestingly, the proxemics analysis discussed below also suggests similar conclusions. 250

While the reverberation times generally show that speech would have been intelligible within the structures, this does not mean that all participants were speaking and conversing. Here, the size of the spaces is relevant, dictating likely distances between participants and affecting the way people could have interacted. Below, we can see the measurements of the size of the various case-study structures across their length, width and radius (see Table 5). The structures at Jerf el-Ahmar were small enough that the structures fell entirely within the close public distance range and participants would have been able to carry on conversations with little difficulty. However, the structures at Nevalı Çori and Göbekli Tepe were very different, with opposite sides of the structures further than 7.6m apart, thus in the far public range. Therefore, participants sitting on benches on opposite sides of the structures would have had difficulty conversing with one another as they were too far apart. By contrast, the centres of the structures were all within close public distance of the perimeter, where interaction was easier than across the diameter of the space. This suggests that the centre was the focus of attention, with participants around the perimeter perhaps watching and listening to a central speaker or performer. 255 260 265

Discussion

All of the case-study structures had reverberation times that were roughly within the ideal range for speech comprehension, but they varied widely in size, meaning that some of them were so large that conversation would have been difficult across the breadth. The buildings at Nevalı Çori and Göbekli Tepe were so big that communication would have been easy only from the centre of the structures. This suggests that participants in activities at these structures would have been focused on a speaker or activity in the centre. There is additional evidence for a central focus at these two sites, with standing stones framing the centre of the structures at Nevalı Çori and Göbekli Tepe. 270 275

The larger structures at Nevalı Çori and Göbekli Tepe were perhaps more likely used as venues for performances, with participants in the middle speaking or performing an activity, while those around the perimeter watched and listened. As the structures are often described as

ritual structures, with no further discussion of how they were used, this analysis of acoustics highlights how important performance might have been within the larger structures, at Göbekli Tepe and Nevalı Çori. 280

Evidence for a central speaker or performance could also suggest the existence of hierarchical relationships within Pre-Pottery Neolithic communities, which is a particular point of debate (Bar-Yosef 2001; Kuijt 2002). However, the layout of audience members around the entire periphery of the spaces argues for the relationship between performers and audience not being hierarchical. Instead, this could indicate the existence of specialist ritual practitioners; or the space may have been more fluid with many different participants taking a turn in the centre of the structure in a community-in-council model; or perhaps these structures were venues for elaborate dramatic performances with many different performers and activities taking place at once. 285 290

The structures at Jerf el-Ahmar were smaller than those found at Göbekli Tepe and Nevalı Çori, and here participants could easily have held conversations across the entire space. The structures at Jerf el-Ahmar were likely used for small-scale discursive events or participatory rituals, while the larger structures could not have been used in this way. These small structures have proxemics indicating a small group of people all participating in a single conversation instead of a central performer or speaker. A small group of people conversing in a dedicated space may indicate a council or decision-making group. 295

Conclusion

The use of reverberation time and proxemics allows archaeologists to examine the way people would have experienced the acoustics of any space, including those that are poorly preserved or even incomplete. The case studies examined here, the non-domestic structures of Neolithic Göbekli Tepe, Nevalı Çori and Jerf el-Ahmar, did not have any evidence for particular sounds that might have occurred within them. Simple application of a general calculation of reverberation time and proxemics to them showed that there was little differentiation between the structures in reverberation time, with all the structures falling roughly within the ideal range for speech. This result is limited though without the perspective of proxemics. Proxemics of the spaces shows that the structures at Göbekli Tepe and Nevalı Çori would have been too large to hold conversations across the width and, instead, participants would most likely have been watching and listening to a central performer or activity. Conversely, the structures at Jerf el-Ahmar were small enough that they might have been venues for small-scale discursive events. 300 305 310

Generally, discussions of acoustics in the archaeological record have focused on determining whether acoustic phenomena were intentionally created and used in the past. This analysis demonstrates how acoustics can further inform our understanding of the past. Even sites and structures with poor preservation can be examined to determine whether it would have been possible to understand speech and hold conversations. This moves the focus away from determining intentionality and back to the way that people would have experienced and used the acoustics of space. 315

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References

Banning, E. B. 2011. "So Fair a House: Göbekli Tepe and the Identification of Temples in the Pre-Pottery Neolithic of the Near East." *Current Anthropology* 52 (5): 619–660. doi:10.1086/661207

Bar-Yosef, O. 2001. From Sedentary Foragers to Village Hierarchies: The Emergence of Social Institutions. In *The Origin of Human Social Institutions*, edited by W. G. Runciman, Proceedings of the British Academy 110: 1–38. 330

AQ2 Binici, H., O. Aksogan, Bakbak D., Kaplan H., Isik B. 2009. "Sound Insulation of Fibre Reinforced Mudbrick Walls." *Construction and Building Materials* 23: 1035–1041. doi:10.1016/j.conbuildmat.2008.05.008 335

Boivin, N. 2004. "Rock Art and Rock Music: Petroglyphs of the South Indian Neolithic." *Antiquity* 78: 38–53.

AQ3 Boivin, N., A. Brum, Lewis H., Robinson D., Korisettar R. 2007. "Sensual, Material, and Technological Understanding: Exploring Prehistoric Soundscapes in South India." *Journal of the Royal Anthropological Institute* 13: 267–294. doi:10.1111/j.1467-9655.2007.00428.x 340

Brooks, C. 2003. *Architectural Acoustics*. Jefferson: McFarland and Company Inc.

Cross, I., and A. Watson. 2006. "Acoustics and the Human Experience of Socially-Organized Sound." In *Archaeoacoustics*, edited by C. Scarre and G. Lawson, 107–116. Cambridge: McDonald Institute for Archaeological Research: 107.

Dayton, L. 1992. "Rock Art Evokes Beastly Echoes of the Past." *New Scientist* 28 (November): 14. 345

Devereux, P., and R. G. Jahn. 1996. "Preliminary Investigations and Cognitive Considerations of the Acoustical Resonances of Selected Archaeological Sites." *Antiquity* 70: 665–666.

Dietrich, O., Ç. Köksal-Schmidt, et al. 2013. "Göbekli Tepe: A stairway to the circle of boars." *Actual Archaeology Magazine*. Istanbul, Rezan Has Museum: 30–31.

Dietrich, O., Ç. Köksal-Schmidt, et al. 2014. "Göbekli Tepe. Preliminary Report on the 2012 and 2013 Excavation Seasons." *Neo-Lithics* 1/14: 11–17. 350

Hall, E. T. 1969. *The Hidden Dimension*. New York: Anchor Books.

Hauptmann, H. 1999. *The Urfa Region. Neolithic in Turkey: The Cradle of Civilization*. M. Ozdogan and N. Basgelen. Istanbul, Offset Yapimevi. 1: 65–86.

Henshaw, J. 2012. *A Tour of the Senses: How your Brain Interprets the World*. Baltimore: John Hopkins University Press. 355

Ingold, T. 2000. *The Perception of the Environment: Essays in Livelihood, Dwelling and Skill*. Oxford: Routledge.

- Jahn, R. G., P. Devereux, et al. 1996. "Acoustical Resonances of Assorted Ancient Structures." *The Journal of the Acoustical Society of America* 99 (2): 649–658. doi:10.1121/1.414642 360
- Kornienko, T. V. 2009. "Notes on the Cult Buildings of Northern Mesopotamia in the Aceramic Neolithic Period." *Journal of Near Eastern Studies* 68 (2): 81–102. doi:10.1086/604671
- AQ4 Kuijt, I. 2002. Reflections on Ritual and the Transmission of Authority in the Pre-Pottery Neolithic of the Southern Levant. In *Magic Practices and Ritual in the Near Eastern*, edited by Neolithic. H. G. Gebel, B. Hermansen, and C. Jensen, Studies in Early Near Eastern Production, Subsistence and Environment. 8. 365
- Kuttruff, H. 1991. *Room Acoustics*. London: Elsevier Applied Science.
- Long, M. 2006. *Architectural Acoustics*. New York: Elsevier Academic Press.
- Lord, P., and D. Templeton. 1986. *The Architecture of Sound: Designing Places of Assembly*. London: The Architecture Press.
- McBride, A. 2012. Multi-sensual analysis of near eastern neolithic communal architecture and the implications for communities. Unpublished PhD, University of Liverpool. 370
- Mehta, M., J. Johnson, et al. 1999. *Architectural Acoustics: Principles and Design*. New Jersey: Prentice Hall.
- Mellink, M. 1990. "Archaeology in Anatolia - Nevalı Çori." *American Journal of Archaeology* 94: 125–128. doi:10.2307/505528 375
- Mlekuz, D. 2004. "Listening to the Landscapes: Modelling Soundscapes in GIS." *Internet Archaeology* 16(Accessed on 09/11/07): http://intarch.ac.uk/journal/issue16/mlekuz_toc.html.
- Ong, W. J. 1991. "The Shifting Sensorium." In *The Varieties of Sensory Experience: A Sourcebook in the Anthropology of the Senses*, edited by D. Howes, 25–30. Toronto: University of Toronto Press.
- Ouzman, S. 2001. "Seeing is Deceiving: Rock Art and the Non-Visual." *World Archaeology* 33 (2): 237–256. doi:10.1080/00438240120079271 380
- Raphael, L., G. Borden, et al. 2011. *Speech Science Primer: Physiology, Acoustics, and Perception of Speech*. 6th ed. Baltimore: Lipincott Williams & Wilkins.
- Schmidt, K. 1999. "Boars, Ducks, and Foxes - the Urfa Project 99." *Neo-Lithics* 3/99: 12–15.
- AQ5 Schmidt, K. 2000. "Göbekli Tepe, Southeastern Turkey a Preliminary Report on the 1995–1999 Excavations." *Paléorient* 26 (1): 45–54. doi:10.3406/paleo.2000.4697 385
- Schmidt, K. 2003. "The 2003 Campaign at Göbekli Tepe (Southeastern Turkey)." *Neo-Lithics* 2/03: 3–8.
- Schmidt, K. 2004. "Göbekli Tepe Excavations 2005." *Kazi sonuçları Toplantısı* 28 (2): 97–110.
- Schmidt, K. 2007. *Sie bauten die ersten Tempel: Das rätselhafte Heiligtum der Steinzeitjäger*. München: Deutscher Taschenbuch Verlag. 390
- Schmidt, K. 2010. "Göbekli tepe - the Stone Age Sanctuaries. New Results of Ongoing Excavations with a Special Focus on Sculptures and High Reliefs." *Documenta Praehistorica* 37: 239–256.
- Smith, M. 2007. *Sensing the Past*. Berkeley: University of California Press.
- Stoller, P. 1989. *The Taste of Ethnographic Things: The Senses in Anthropology*. Philadelphia: University of Pennsylvania Press. 395
- Stordeur, D. 1999. "Organisation de l'espace construit et organisation sociale dans le Néolithique de Jerf el-Ahmar." In *XIXe Rencontres Internationales D'archéologie et D'histoire D'antibes*, edited by F. Braemer, S. Cleuziou, and A. Coudart, 131–149. Antibes: Éditions APDCA.
- Stordeur, D. 2000. "New Discoveries in Architecture and Symbolism at Jerf el Ahmar (Syria), 1997–1999." *Neo-Lithics* 1/00: 1–4. 400

Stordeur, D., and F. Abbès. 2002. “Du PPNA au PPNB : Mise en lumière d’une phase de transition à Jerf el Ahmar (Syrie).” *Bulletin de la Société Préhistorique Française* 99 (3): 563–595. doi:10.3406/bspf.2002.12712

Stordeur, D., M. Brenet, et al. 2001. “Les Batiments Communautaires de Jerf el Ahmar et Mureybet Horizon PPNA (Syrie).” *Paleorient* 26 (1): 29–44.

405

Verhoeven, M. 2002. “Ritual and Ideology in the Pre-Pottery Neolithic B of the Levant and Southeast Anatolia.” *Cambridge Archaeological Journal* 12 (2): 233–258. doi:10.1017/S0959774302000124

Watson, A., and D. Keating. 1999. “Architecture and Sound: An Acoustic Analysis of Megalithic Monuments in Prehistoric Britain.” *Antiquity* 73: 325–336.

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410